

MASTERING THE ART OF STAGECRAFT



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TABLE OF CONTENTS

Licensing

1: Production Organization

- 1.1: Theatre- A Collaborative Art
- 1.2: Organizational Structures

2: The Stage

- 2.1: Theatre Spaces
- 2.2: Navigating the Stage

3: Equipment Through History

4: Drafting

- 4.1: The Language of Drafting
 - 4.1.1: The Language of Lines
 - 4.1.2: Visualization
 - 4.1.3: Technical Sketching
 - 4.1.4: Dimensioning
 - 4.1.5: Sectional Views
- 4.2: Mechanical Drafting
 - 4.2.1: Drafting Tools and Materials
 - 4.2.1.1: Tools
 - 4.2.1.2: Computer drafting printing
 - 4.2.2: Use scale rulers to determine actual dimensions from drawings
 - 4.2.2.1: Prelude to Scales
 - 4.2.2.2: Using an Architects Scale Ruler
 - 4.2.3: Interpreting scale drawings
 - 4.2.3.1: Basic layout of a drawing

5: Tools and Materials

- 5.1: Hand and Power Tools
 - 5.1.1: Tool Choices and Applications
 - 5.1.2: Measuring, Marking, Leveling and Layout Tools
 - 5.1.3: Nails, Hammers and Pneumatic Nailers
 - 5.1.4: Threaded Fasteners, Drivers, Pliers and Wrenches
 - 5.1.5: Saws
 - 5.1.6: Drills and Accessories
 - 5.1.7: Grinders, Sanders, and Accessories
- 5.2: Construction Materials

6: Production and Construction Techniques

7: Props

- 7.1: Categorizing Props
- 7.2: Props and Effects

8: Design

- 8.1: Design and Collaboration
- 8.2: The Design Process

9: Color

10: Painting

11: Electricity

- 11.1: Electrical Safety
- 11.2: Electrical Fundamentals

12: Lighting Design and Production

- 12.1: Lighting Design
- 12.2: Lighting Equipment and Control Systems

13: Projection

14: Sound Design and Production

15: Stage Management

- 15.1: The Psychology of Stage Managing
- 15.2: Stage Management
- 15.3: Blocking Notation
- 15.4: Production Reports
- 15.5: Cueing Scripts

[Index](#)

[Glossary](#)

[Detailed Licensing](#)

[Detailed Licensing](#)

Licensing

A detailed breakdown of this resource's licensing can be found in [Back Matter/Detailed Licensing](#).

CHAPTER OVERVIEW

1: Production Organization

[1.1: Theatre- A Collaborative Art](#)

[1.2: Organizational Structures](#)

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1.1: Theatre- A Collaborative Art

Updated and re-authored by:

Among the arts, theatre is unique in that at its very core it is **collaborative**. Unlike authoring a book or painting a great masterpiece, a piece of theatre has not come from the mind of a single creator, but from a large group of people working toward a common goal. The theatre collaboration is similar to the function of a sports team, or even a military unit, in that many people are doing a variety of things that all contribute to the group success. This group of artists collaborates to conceive and construct a performance that endeavors to entertain its audiences. Each of the artists involved in this process contributes uniquely to the final product. Some of these contributions are obvious, some are more hidden but no less important to the creative whole.

There is an art, or at least a skill, to successful collaboration. Many of you have participated in group activities and team sports and can identify with both the power of group (team) work and the common struggles within groups to adopt a single vision. These factors exemplify both the challenge and the strength of theatre collaborations.

When working within a group, we must navigate differences of opinion, entertain varying perspectives, and rise to the challenge of maintaining clear communication. Learning to listen is an important skill in this scenario. Being clear in thought, exact in language, and deliberate in choice of illustrative examples can be key to success.

Theatre artists must learn the difference between giving up on our ideas when a strong voice is advocating for something different and defending our views to the point that we become an obstacle to consensus. I have found when artists listen closely and truly attempt to understand one another they are often able to find solutions that incorporate and even enhance seemingly disparate ideas.

In theatre we must channel our ideas in support of the direction in which the entire production is moving. Falling silent when you have a solution or shutting down when your ideas cannot be incorporated does a disservice to the entire production. A skilled collaborator will find an appropriate opportunity and use a productive tone to offer their opinions.

For many of us, our sense of how a theatrical production is put together stems from our experiences with theatre in our schools. For example, many students have participated in a drama program at their high school. These experiences may lead us to the conclusion that all productions are created under a system wherein the show's **director** makes virtually every decision and everyone else involved is trying their best to carry out the director's plan. It is easy to understand why we might have that impression when many of our schools have theatre programs in which the director is the only permanent staff and designers and other specialists are only brought in when required or when their talents can be afforded.

Many small community theatres and even college theatres, may, due to their limited staffing for productions, leave us with a similar impression that top-down management is the only style used in theatres. However, the way most **professional** theatre companies produce their shows constitutes more of a shared-responsibility model. In these companies, an entire team works together toward a cohesive solution that incorporates everyone's expertise.

This is not to say the director's influence on the production is diminished or that they do not carry an overarching responsibility for all elements of the production, but more that they are usually surrounded by other artists working on the production who bring their own experience and imagination to ensure it can be realized to its fullest extent. A director's job includes unifying the artistic vision of the entire **company**. When looking at the reporting structure for most theatre organizations you see designers and other production staff do maintain a reporting relationship to the director.

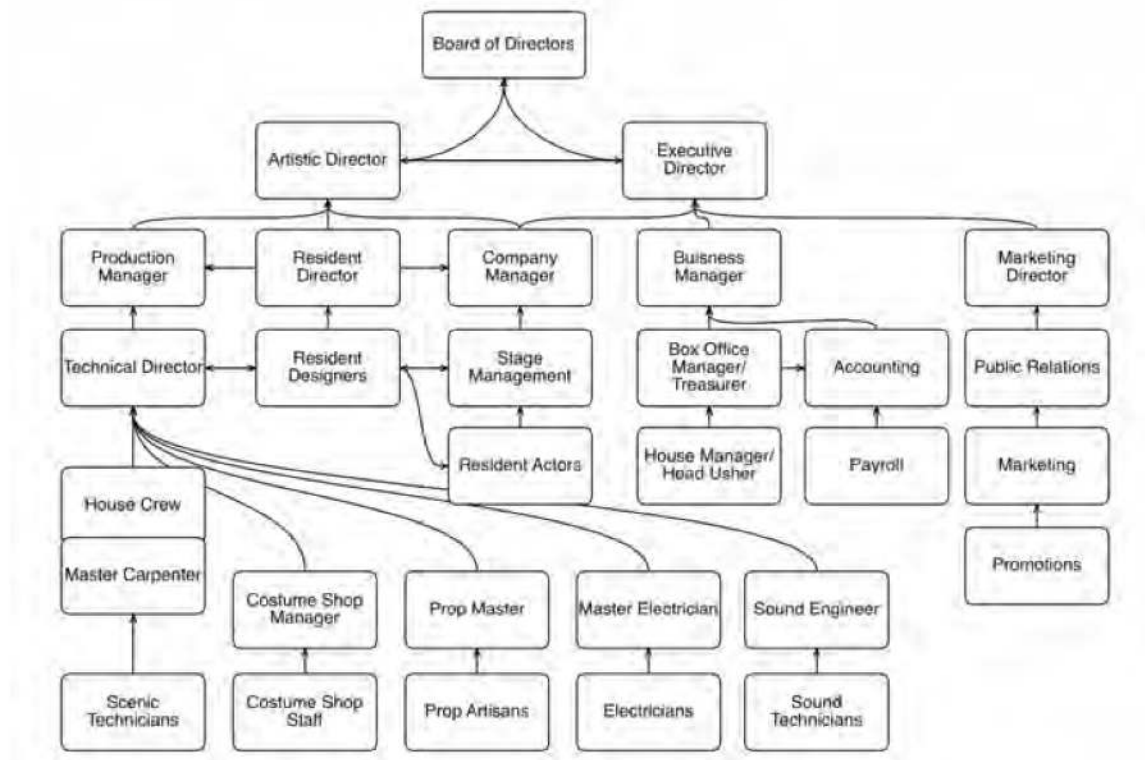
An inclusive spirit is at the center of a productive and successful collaboration. When carried through all levels of production and performance—from the producers and director to the stage manager and technicians—these individuals work together, bringing their best so the end product will be a piece of art worthy of their collective investment.

Those who have participated in theatrical productions understand this environment fosters a special camaraderie among the cast and crew of a show and the experience of being part of a production often feels like having joined a new “family.”

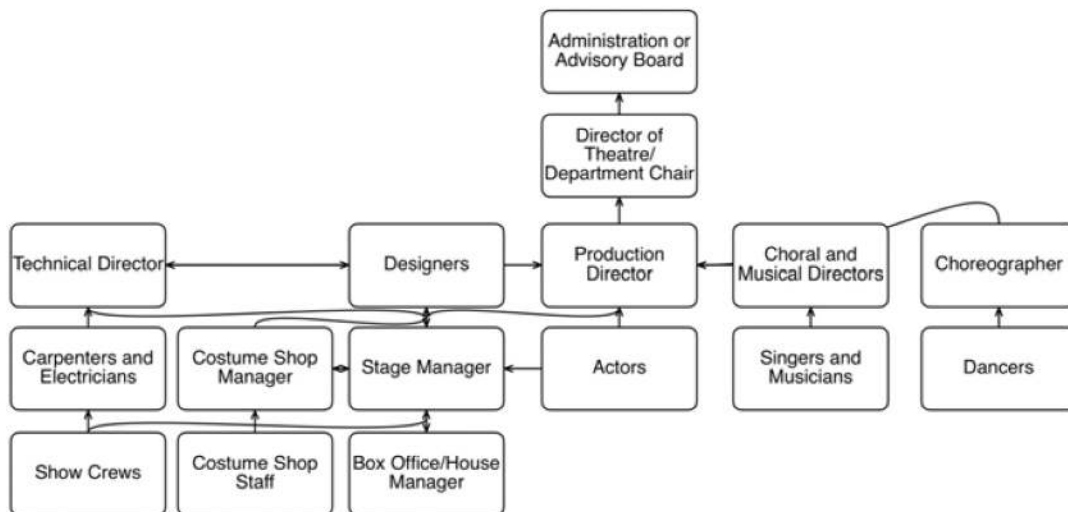
Smaller theatre companies and educational theatre programs have a comparatively small staff doing multiple jobs. Much like the high school director mentioned earlier, in these situations a few individuals may wear multiple “hats” required to fulfil the roles in the production.

In a typical professional theatre organization, each individual would hold only one job listed on the company's organizational chart. It is important to think of these models as upward trending lines of artistic responsibility rather than a downward trending workflow chart.

As you can imagine, in many smaller organizations the duties of all thirty job categories listed here must be fulfilled by just a few people. A scaled down organization such as a **community theatre** or educational theatre program might have an organizational chart that is simpler.



Example of a professional theatre organization model



An educational or community theatre organization model

Although all of the duties are still covered here, you can see a relatively small number of people make up the organization's creative staff. Notice the show's director is not at the top of the chart, but rather maintains a reporting relationship to those above. In educational theatre, the show's director may report to the department chair, director of theatre, or even a school principal. In a community theatre, the director may report to and artistically satisfy an artistic director or a board of directors.

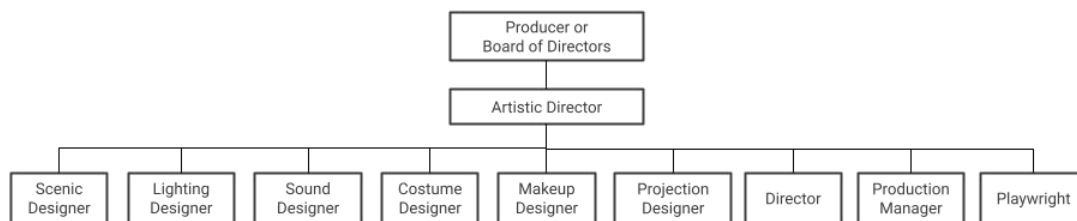
Job titles and duties are covered in chapter 1.2, but it may be useful now to illustrate a typical scenario of how this theatrical collaboration functions:

A theatre company, school program, or community theatre has decided to produce a play or a season of plays. Each company will have its own reasons for producing the play(s) it chooses, as well as for its desire to produce play(s) at all.

There's More to Know

How are plays selected for production? A school program might choose plays based on educational opportunities, topical stories, or strong roles that provide growth opportunities for acting students. A community theatre may produce plays that provide lots of opportunities for involvement and tend towards large cast shows. A professional theatre may consider a group of plays that fits together as a season, peaks public interest, and has good potential to sell tickets. Original theatre productions are often mounted based on the reputation of the playwright. Regardless of the criteria for choices, the people responsible for programming read many plays in order to choose appropriate material for production.

Often plays are chosen with a specific director in mind. The director may have a particular style or resume of experience that makes them a good match for both the script and audience. They may have a great track record of working with a particular theatre group. Whatever the criteria for selection of the director may be, once selected, they are often asked to help form the rest of the **creative team** (sometimes also referred to the **Production Design Team**) for the production. This team includes the producer, director, designers, choreographers, and musical directors. Some companies utilize **resident designers** who, as employees of the company, are assigned to a particular production based on their talents and experience. In other productions the director may be asked if they prefer to work with a particular designer or other creative team member and, possibly, if they have preference for a particular stage manager. Once assembled, this team develops an artistic approach to the production known as a **production concept**. This concept expresses the unifying vision that each individual strives to support in creating the production elements.



The Creative Team (Also referred to as Production Design Team)

The production concept is arrived at through careful consideration of the **script**, the reason to produce a specific story for a specific audience, the **production resources**, and the inspiration and insights of the particular creative team.

Consider This

If you are asked to play a part in a production either on stage or behind the scenes, consider the commitment you are making. It will consume more than just your time. You are agreeing to be part of the collaboration and will have to do your very best at your task to uphold the commitment to the entire production.

Once the creative team has agreed on a production concept, each designer develops their portion of the staging design through a series of meetings and discussions. Meeting both as a group and individually, but always in conversation with the director (who is tasked with carrying the concept forward through rehearsals), the creative team then begins to interact with an entire **production team**. Designs are delivered according to scheduled deadlines, and a process of budgeting funds and other resources commences. Actors are **auditioned**, and **cast** and rehearsals begin: Sets and costumes are constructed; music, projections, and lighting are created; and the entire production team is engaged in the movement toward opening night.

At this point, the creative team is busy supervising and revising their creative work to ensure a cohesive production. Usually, the designers on this team are working an opposite schedule from those directly involved in rehearsals. Designers work closely with the technical director, costume shop manager, or master electrician as their designs are being realized, attending acting rehearsals only occasionally.

There's More to Know

Three types of technical rehearsals are common to most theatres. A **dry tech** might be the first of these rehearsals. At a dry tech no performers are present, and time is allowed for crews to become familiar with the show elements and rehearse cues and shifts. The second rehearsal is often a **wet tech**. It includes performers and allows everyone to learn the traffic patterns imperative to the timing of cues and shifts. A director may also call for a **cue-to-cue** technical rehearsal, where both crew and cast work together on shifts and cues but dialogue in between these actions is not performed in order to allow for more technical rehearsal in a shorter amount of time. All show elements must be adequately rehearsed and finessed. During these rehearsals, remember to be present, attentive, quiet, and prepared to both jump forward and go back to repeat actions in order to perfect cue timing.

Still, good theatre professionals realize the most important element of collaboration is how the creative work relates to what happens in the **rehearsal room**. This collaboration is where the production comes alive—where the rubber meets the road, where concept meets reality, and inspiration is tempered by practicality. It is where new ideas born from the rehearsal process can inspire opportunities.

The collaborative process continues, now including performers, choreographers, musicians, stage management, and the director—all bringing their own creative energy to the production—throughout the rehearsal process, into the **technical rehearsals**, and all the way to opening night. During this time, the stage manager maintains daily communication to the entire production team, reporting what happens in the rehearsal room. The director continues to meet with the creative team both as a group for **production meetings** and individually with designers and production personnel in order to keep all efforts moving in support of the developing production.

Once construction of the elements is completed, whether built off-site and **loaded in** or built onstage, the next step in the rehearsal process can begin: technical rehearsals. Technical rehearsals occur when all of the various elements of the final production are brought together and can be integrated into a single piece of art ready for an audience. It is during these rehearsals that the elements of sets, lights, projections, costumes, props, music, sound effects, and atmospheric effects are added. This is also when a whole new group of collaborators join the production: the **stage crew**.

During technical rehearsals the creative team is busy refining the production elements into a whole. They work with the director to shape an experience for the audience. Meanwhile, the stage crew works under the direction of the stage manager, rehearsing **scene shifts** and **cues** so that timing of these is both precise and repeatable. These rehearsals can be difficult and taxing as so many elements and people need to be coordinated. Many theatres conduct the bulk of the technical rehearsals over a weekend or two-day period. Often these days are run as ten-out-of-twelve days, meaning that ten hours of the required twelve-hour day are worked in rehearsal. I have heard people describe the technical rehearsal process as similar to “watching paint dry.” It is true these rehearsals can seem long and boring if the sequence or cue being worked on doesn’t involve you. If the cue does involve you, you may be asked to repeat the same movement or cue multiple times as the coordination is developed. All the efforts of these rehearsals are rewarded when the technical elements and the actions of the actors are seamlessly married into an effective presentation.

After the initial technical rehearsals, dress rehearsals incorporating wardrobe and costume changes begin, followed by preview performances, and, finally, opening night followed by the performance run. Up to opening night, the director and the creative team continue to work toward the best production possible within the given circumstances and time available. Most creative team members move on to their next production once a play opens and their services have been rendered. Even the director’s work is now complete, and the stage manager takes on the responsibility of delivering a consistent show that preserves the director’s vision throughout the production’s run.

For many productions, this entire process takes about 8-12 weeks, though it may be longer for a new or complex production. Generally the rehearsal process takes about 4-6 weeks of that time, and performance runs take approximately 1-3 weeks. The rest of the time is typically spent in **preproduction**.

 For Further Exploration

Schumacher, Thomas. 2008. How Does the Show Go On: An Introduction to the Theater. New York, N.Y: Disney Editions. Behind the Emerald Curtain:<http://www.emeraldcurtain.com/>

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1.2: Organizational Structures

The task of theatrical production requires many specific skills. These skills may be found in a few individuals or delivered by some highly and specifically trained artists and artisans. The collaborative nature of the art of theatre coupled with the need to produce on a specific timeline makes it necessary for theatre organizations to maintain and follow an organizational and communication structure. This Module breaks down that structure, reporting order, and typical duties. Every organization has its own particular distinctions between job titles, duties, and reporting structures, but the descriptions below are fairly standard in the theatre industry.

The Art of Storytelling

As technicians, designers, performers and administrators, we all share one goal: to tell a story as best we can. In his seminal acting text, *An Actor Prepares*, Konstantin Stanislavski wrote "*Great art, conceals art.*" To truly transform a theatre and an audience - to bring them to a new place or time - it is the goal of all theatre artists to create art that is so moving and well made that audience members forget that they are watching theatre at all. All artists, theatre included, strive for transformative experiences that, as Stanislavski says, conceal the fact that the viewer is watching theatre at all.

A Full organization model listing most jobs in a theatre company.

There's more to know

People are often struck by the number of jobs it takes to operate a theatre successfully. This list of job titles might have any number of employees working under them depending on the size of the producing organization. Many people who work in the arts are not directly involved in the on-stage work of a stage production, but rather work in support areas that may include audience services, finance, educational outreach, play development, and many others. A number of people have worked their way into production through other related jobs in support areas of theatre companies.

Administration

Board of Directors: Steers and guides the organization. Provides funding and leadership.

Producer (commercial theatre): Secures the performance rights to stage a production, hires the artistic staff, secures the performance space, and provides financial backing for the production.

Artistic Director/Head of Theatre: Provides artistic guidance, chooses the plays that will be performed during the season, hires production directors, and is responsible for the artistic vision and direction of the theatre or organization. Reports to board of directors.

Executive Director/Managing Director: Responsible for the operation and development of the organization. Oversees the day-to-day operations of the theatre including outreach or educational programs, finances, and community relations. Reports to the board of directors.

Production Management

Production Manager: Responsible for the overall technical operation of a theatre company and maintains season budgets and resource allocations. Supervises all technical staff. Reports to the artistic director and executive director.

Technical Director: Responsible for the oversight of technical operations of a theatre, including scenery, lighting, sound, projections, and construction. Works with designers to ensure requirements are achievable, safe, and within budget parameters. Supervises scene shop staff. Dual reporting relationship with both the artistic director and production manager or managing director.

Master Carpenter: Oversees scene shop and show build.

Carpenters: Construct scenery.

Costume Shop Manager: Responsible for the day-to-day operation of the costume facilities. Supervises costume shop workers. Reports to the technical director or production manager.

First Hand: Assists the costume shop manager in day-to-day operations and builds costumes.

Cutter: Cuts fabrics, plans patterns, and builds costumes.

Draper: Drapes garments and builds costumes.

Stitcher: Builds costumes.

Milner: Builds hats.

Master Electrician: Responsible for the day-to-day operations of the electrical department. Supervises electricians. Reports to the technical director or production manager.

Electricians: Hang, focus, and maintain lighting equipment.

Programmer (lights/video): Operates the light board before and during tech rehearsal. Works with the lighting or video designer to program the systems to match the designers vision for the show.

Prop Master: Responsible for the construction or acquisition of all show props. Works with prop designer, scenic designer, stage manager and performers. Reports to director and production manager.

Prop workers/carpenters: Build and maintain show props.

Scenic Artist: Responsible for all painted scenic finishes. Works with scenic designer and technical director. Supervises painters.

Paint Crew: Works with scenic artist to create all painted finishes.

Creative

Playwright: Creates and develops the play script. On an original production, may assist the director in interpreting the work and may supply rewrites of script elements.

Production Director: Sets a vision for and brings together the many complex aspects of a theatrical production, including the script, performers, design, and music into a unified production. Reports to the artistic director and executive director.

Assistant Director: Facilitates the director's work on a production. This may include research, blocking notation, taking notes, and working with an ensemble or chorus. Reports to the director.

Musical Director: Responsible for the arrangement and reproduction of live music for a production. Reports to the production director.

Choreographer: Responsible for creating the style and form of dance and movement routines in a production. Works under the production director.

Fight Choreographer: Responsible for creating safe and repeatable action and fight sequences. Works under the production director.

Scenic Designer: Responsible for the development and design of all scenic elements of a production. Reports to the production director and production manager.

Costume Designer: Responsible for the design of all costume elements for a production. Works with the costume shop manager. Reports to the production director and production manager.

Lighting Designer: Responsible for the design and cueing of lighting for a production. Works with the master electrician. Reports to the production director and production manager.

Sound Designer: Responsible for all audio production elements. Reports to the production director and production manager.

Projections Designer: Responsible for all projected elements of a production. Reports to the production director and production manager.

Prop Designer: Responsible for the design of all properties for a production. Works in concert with the scenic designer. Reports to the production director and production manager.

Makeup Designer: Responsible for the design of all makeup worn by the actors, be it as simple as fashion face makeup for full body makeup. Often only needed for large productions or ones that have a large makeup requirement. On smaller productions this role is assumed by the costume designer.

Show Management

Production Stage Manager: Supervises all stage management activities including management personnel and interns. Maintains master schedules for the company. Reports to the production manager.

Stage Manager: Provides practical and organizational support for a production team, including the director, designers, actors, and technicians. Facilitates productive rehearsals, runs technical rehearsals, and represents the director's vision throughout a production's run. Reports to the production director and production manager.

Assistant Stage Manager: Provides production support to the stage manager. Reports to the stage manager.

Crew

Production Sound Engineer: Responsible for the running the sound console for live microphone mixing. Works with the sound designer. Ultimately reports to technical director. Directly report to stage manager during production run.

A2 (Audio 2): Responsible for the fitting of mics on performers and sometimes also responsible for running the monitor console for live microphone mixing what the performers hear. Works with the sound designer and Production Sound Engineer. Ultimately reports to technical director. Directly report to stage manager during production run.

Sound Crew: Responsible for the fitting of mics on performers and all audio maintenance through the production. Works with the Production Sound Engineer. Ultimately reports to technical director. Directly report to stage manager during production run.

Wardrobe Crew: Responsible for the preparation and maintenance of production wardrobe. Work with costume shop manager. Ultimately report to the technical director. Directly report to stage manager during production run.

Makeup Crew: Responsible for the application of actor makeup for the production. Work with costume shop manager and makeup designer. Ultimately report to the technical director. Directly report to stage manager during production run.

Shift Crew (Stage Crew): Responsible for the movement and daily maintenance of show scenery. Work with scenic designer. Ultimately report to technical director. Directly report to stage manager during production run.

Props Crew: Responsible for setup, storage, and maintenance of prop elements for a production. Work with prop designer and scenic designer. Ultimately report to technical director. Directly report to stage manager during production run.

Dressers: Responsible for setup and assistance of costume dressing and quick changes for performers. Work with wardrobe crew, costume designer, and performers. Ultimately report to technical director. Directly report to stage manager during production run.

Board Operators (Light, Sound, Video, etc.): Responsible for the running of cues during performances via lighting, sound, and video consoles. Work with designers. Ultimately report to technical director. Directly report to stage manager during production run.

Follow-Spot Operators: Operate moveable spotlights during a production. Work with lighting designer and master electrician. Ultimately report to technical director. Directly report to stage manager during production run.

Fly Crew: Responsible for the movement and daily maintenance of all flying scenery be it automated or conventionally rigged on a counterweight system. Work with scenic designer. Ultimately report to technical director. Directly report to stage manager during production run.

Automation Operator: Responsible for the movement and daily maintenance of all automated scenery. Work with scenic designer. Ultimately report to technical director. Directly report to stage manager during production run.

For Further Explanation

Volz, Jim. 2011. *Working in American Theatre: A Brief History, Career Guide and Resource Book for over 1000 Theatres*. New York: Bloomsbury Methuen Drama.

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CHAPTER OVERVIEW

2: The Stage

[2.1: Theatre Spaces](#)

[2.2: Navigating the Stage](#)

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2.1: Theatre Spaces

Western European theatre spaces have been evolving since the early days of Greek theatre. Built into hillsides and taking advantage of natural canyons, early Greek theatres allowed for many patrons to comfortably see and hear the presentations, a primary function of all theatre spaces. The Roman theatre adapted the Greek spaces and added features including a large ornate backing wall (skene) and a framing structure adapted from the Greek *proskene* that has evolved into our modern **proscenium arch**. The Renaissance period brought theatre indoors by adding roofs to some auditoriums and developed a heavy reliance on elaborate scenery. A variety of styles of performance spaces have been developed since that time, each with its own achievements in creating comfortable and flexible spaces that nurture a strong relationship between the performers and the audience.

Proscenium Theatre

The most familiar type of performance space is the proscenium style theatre. It is essentially two rooms: the auditorium holding the audience, and the stage where the performance takes place. A wall joins these two rooms with a picture frame opening allowing the audience to see into the stage. This picture frame opening is the proscenium arch and is often elaborately decorated. The strength of the proscenium arch is that it focuses the audience's attention on the performance area and blocks the audience from seeing backstage areas so the “magic” of the presentation can be preserved.



Figure 2.1.1: The Garvin Theatre at Santa Barbara City College - A Proscenium Theatre

Proscenium style theatres often allow for the greatest audience capacity; large auditoriums with multiple balconies are possible with this configuration. The potential downside to this type of space is there is a physical and aesthetic boundary created by the proscenium arch. Physically, the performers framed by the arch are at a distance from the audience, which forces their actions to be enlarged so audience members who are further away can read them. The audience may also feel an aesthetic distancing in that the performances seem less immediate as they are happening to someone “in the next room.”

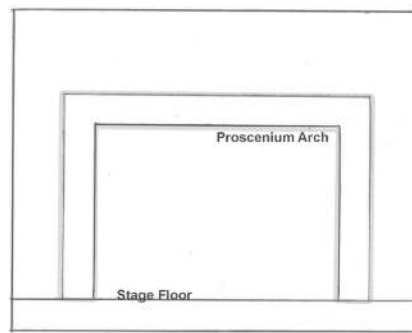


Figure 2.1.2: Proscenium theatre front elevation

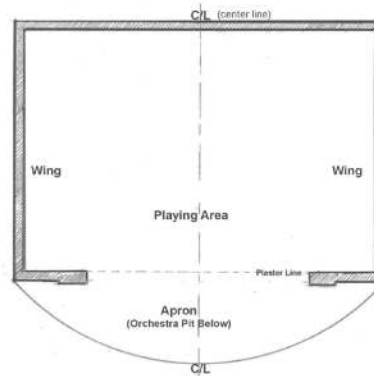


Figure 2.1.3: Ground plan

Thrust Theatre

Thrust theatre spaces were developed to decrease the distance between audiences and performers, thereby giving the drama a greater sense of intimacy. In a thrust theatre, the apron area has been thrust into the auditorium so the audience surrounds three sides of the playing area. The **upstage** wall remains for scenic representation and entrances and exits. Thrust theatre spaces allow the performers to be quite close to the audiences, but also cause the actors to be very aware of how they must move to be seen by all. In a thrust space, it is an interesting experience for an audience to be looking at other sections of audience as a background to the play. Designers working in these thrust or “three-quarter style” theatres must keep the playing area visible to all by using small or low level objects to transform the stage.

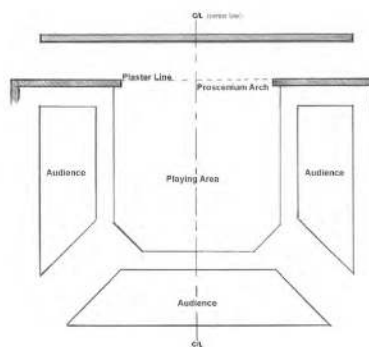


Figure 2.1.4: Thrust theatre plan view

Arena Theatre

The arena theatre is another format designed for greater intimacy between audiences and performers because it includes seating that completely surrounds the stage. Often circular stages with tiered audiences creating a bowl, these spaces can be scaled from relatively small to arenas seating thousands. Again, like in a thrust environment, acting on an arena stage, or “in the round,” requires special attention to “keeping open” so you are always engaging the entire audience surrounding you. The set design must keep from blocking the audience’s view, so elaborate scenery in this style auditorium is rare. Instead, designers often rely on small

furniture elements and floor coverings to establish scenic locations. You have probably been to an arena stage if you have been to any large sporting event or pop concert.

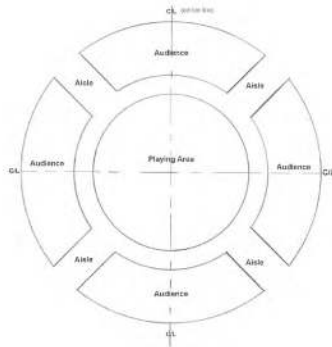


Figure 2.1.5: Arena theatre plan view

Black Box Theatre

The black box theatre is aptly named. These spaces are single rooms that house both the actors and audience. The black box is a flexible space; most have audience seating that is configurable so the room can be adapted for any production. Seating may be set up as “end stage” similar to a proscenium style, on two sides in an “L” configuration, on two opposing sides as a “traverse” layout, or in a three-quarter or arena configuration. Typically, a smaller scaled space, the black box often provides the closest connection between audience and performers. Scenic design for a black box space is largely dependent on the seating arrangement, but in general the intimacy of the space provides less opportunity to hide the “magic” behind the presentation.

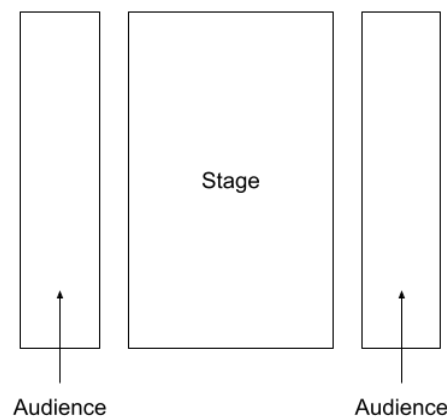


Figure 2.1.5: Traverse Stage Configuration

Site-Specific Theatre/Found Spaces

Site-specific or “found space” performances are held in a variety of locations. If you find a location that supports your story, such as performing in an historic ruin or on an ancient battlefield, you are doing site-specific work. The challenges for these locations may be the lack of traditional support spaces such as dressing rooms for performers, lack of technological resources, and the need to provide audience seating and accommodations. Many companies successfully produce outdoor seasons of classic plays such as Shakespeare in public parks, which could be considered site-specific events.

Found spaces tend to be theatre performance spaces adapted from a room’s former use. Warehouses, banks, storefronts, and churches are often converted into found spaces. But it is important to remember that for the location to be a true found space, it should help tell the story.

For Further Exploration Brockett, Oscar G., and Franklin J. Hildy. 2006. *History of the Theatre*, Foundation Edition. Boston: Pearson. *History of Theatre*. n.d. Accessed August 16, 2018. <http://www.historyworld.net/wrldhis/PlainTextHistories.asp?historyid=ab35>.

 Remix

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2.2: Navigating the Stage

As a theatre professional, understanding the stage, its equipment, and its architecture is crucial to the success of your productions. Whether you are a performer, a designer, a technician, or a member of the production team, knowing your way around the stage and being able to identify its various components is essential for ensuring smooth rehearsals and performances. In this chapter, we will explore the various parts of the modern stage. We will also discuss the various pieces of onstage technology, curtains, rigging and fly systems, and other basic automation tools that are used to move scenery and other elements in and out of view. By the end of this chapter, you should have a thorough understanding of the layout and components of a theatre stage and be able to navigate it with confidence.

Navigate through this picture of the Garvin Theatre at Santa Barbara City College. You will find all pieces of the theatre downstage of the proscenium detailed below.

The Stage

The stage is the main performance area in a theatre, located behind the proscenium arch (upstage) in a proscenium theatre. It is the space where the action of a play or performance takes place and is typically raised above the audience, allowing for visibility from all parts of the house. The stage is typically equipped with a variety of technical elements, such as lighting, sound, and projection equipment, as well as rigging and fly systems for moving scenery and other elements in and out of view. The stage is also equipped with various pieces of machinery, such as traps, revolves, and slip stages, which are used to create special effects and enable the stage to be transformed into different environments or settings.

Being able to navigate the stage is equally important. Thus, understanding **stage directions** is key for a successful performance. Stage directions are how we map the action that is taking place on stage and serve as a tool for actors, directors, and other members of the production team. There are five traditional stage directions, and they are all viewed from the perspective of the actor on stage, not the audience member.

- Upstage (toward the back of the stage)
- Downstage (toward the front of the stage)
- Stage Left (the left side of the stage as viewed by the actor)
- Stage Right (the right side of the stage as viewed by the actor)
- Center Stage (the center of the stage).

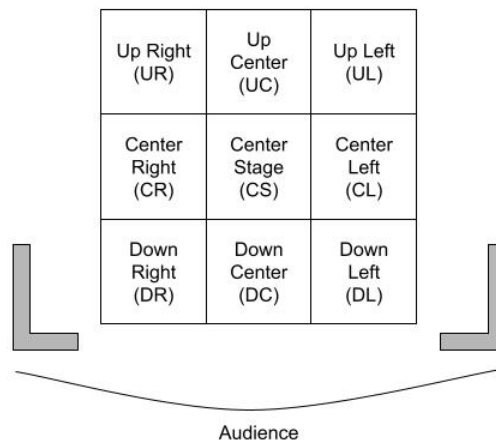


Figure 2.2.2: Stage Directions

Proscenium

The proscenium is the frame or arch that surrounds the stage in a proscenium theatre. It gets its roots from the skene and proscenium from the Greek and Roman theatres. It serves as the boundary between the stage and the audience and can be adorned with decorative elements such as molding, sculpture, or paint. The proscenium acts as a kind of "window frame" through which the audience views the performance, and its size and shape can have a significant impact on the overall look and feel of the stage. Some designers choose to install a "**false proscenium**", a proscenium constructed for one production to further control how the audience views the production.

Wings

The wings are the areas to the sides of the stage, located just beyond the proscenium. They are backstage areas for actors and other members of the production team, allowing them to enter and exit the stage without being seen by the audience. The wings also store scenery and other stage elements, provide space for actors to wait offstage or complete costume **quick changes**, and allow for the movement of actors and elements onto and off the stage. The wings are also used for the placement of technical equipment, such as some lighting and sound equipment, and for the operation of the automation and fly systems, which are used to move scenery and other elements in and out of view.

Apron

The apron is the area of the stage that extends forward from the proscenium. It is typically shallower in depth than the main stage and traditionally extends wider than the proscenium. The apron can also be used as a performance space without using the entire stage behind it.

Orchestra Pit

The orchestra pit is often located in the same area as the apron, or just downstage of it. The orchestra pit is a depression in the floor of the stage – or a portion of the apron that can lower – where musicians perform during a musical or opera. It is often raised or lowered as needed. Many orchestra pits extend deep under the stage to be able to fit large musical ensembles.

In some cases, the orchestra may be in a separate room or area of the theatre, rather than in the orchestra pit. This can be the case in larger theatres where the orchestra pit is not large enough to accommodate the full orchestra, or where the orchestra pit is not wanted for a particular production. In these cases, the orchestra may be in a separate room or area of the theatre, such as a balcony or an adjacent room or basement, and the music may be amplified to the stage and the auditorium through speakers. While this arrangement can have some advantages, such as allowing the orchestra to be larger or more flexible, it can also have some drawbacks, such as a loss of intimacy between the musicians and the performers, difficult communication between the performers and conductor, and a reduction in the overall acoustical qualities of the performance.

Auditorium

The auditorium is a critical element of theatre architecture, as it is the space where the audience views the performance. The auditorium is typically located below the stage and is divided into various seating areas, such as the orchestra, the mezzanine, and the balcony. The auditorium is typically designed to be comfortable and accommodating, with good **sight lines**, comfortable seating, and excellent acoustics.

Additionally, the "front of house" (FOH) is typically located in the back or center of the auditorium and is where the sound board and sound operator are situated. The FOH gets its name because it is located at the "front" of the house, or the main seating area of the theatre, as opposed to the "back" of the house, which refers to the stage and backstage areas. From the FOH, the sound operator can monitor and control the sound levels and balance of the performance, ensuring that the audience is able to hear the performance clearly and enjoy the best possible sound quality. The FOH is the central control point for the sound system in the theatre and is typically equipped with a mixing console and other equipment for controlling the sound.

Offstage

This specific area of the theatre is located outside of the main performance space, or "offstage" from the perspective of the audience. It includes the wings, the fly loft, the backstage area, and other spaces that are used for the preparation and operation of the performance but are not visible to the audience.

The Curtains

Most modern proscenium theatres are full of curtains, also known as stage drapes. Each one plays a role in the theatre, but most are used for masking the backstage areas or otherwise controlling the audience's view of the stage.

Grand Drape

The grand drape is the downstage-most curtain in a proscenium theatre, just behind the proscenium arch, and is typically used to block the audience's view of the stage before or after a performance. The Grand drape is typically made of heavy, ornately decorated fabric to fit into the style of the theatre architecture. Although there are many styles of grand drapes, most can both open in the middle, and fly up out of view. It is often used to create a sense of closure at the end of the performance – "...and, curtain."

Legs & Borders

Legs and borders (Tormentors and Teasers in England) are types of stage curtains that are used to mask the wings, overhead lights, and other offstage areas in a proscenium theatre. Legs are tall, narrow curtains that are hung on either side of the stage, upstage of the proscenium. They are typically made of a black, opaque fabric, like **Duvelyn**, and are used to mask the wings. Borders are like legs but are shorter and wider; they are hung above the stage blocking the audience's view of the lights and scenery suspended in the **fly gallery**. Many theatres use multiple sets of legs and borders in one theater depending on the depth of the stage to ensure the offstage areas are out of view.

Travelers

A traveler is another type of stage curtain that is used to mask the stage from the audience's view. Travelers are typically made of heavy, opaque fabric, and are used to create a change of scenery or to cover the stage during scene transitions. They cover either the width and height of the stage blocking the wall in the back of the theatre, or any scenery behind the traveler; they can also make the stage seem shallower if needed. Travelers have a split in the middle and are hung on a track above the stage. They can travel across the stage as they open and close horizontally, (thus, called "travelers") either manually or by means of a motorized system. There are typically two travelers in a theatre, one upstage ("back traveler") and one mid-stage ("mid traveler"), and they are used in combination with other curtains, such as legs and borders, to create a variety of stage configurations within the standard proscenium space.

Cyclorama

A cyclorama, also known as a 'cyc' (pr. sah-yk) in Greek, is a large, (often curved) curtain or wall that is used to create a seamless, wraparound background for a stage setting. A cyclorama is typically made of smooth white fabric and is hung at the back of the stage or on a separate support structure. It is used to create a variety of visual effects, such as a sky, a horizon, or an abstract background, and can be lit from the front or the back to create a variety of moods and atmospheres. Many theaters often conflate 'sky drops' and 'cycs', despite the two being distinct from one another. While a 'cyc' is a large, curved backdrop encircling the back of the stage, a sky drop is a single planar drop located far upstage with no curve. Still, it is important to know that most theatre practitioners use these terms interchangeably despite their differences.

Many designers use cyc and sky drops to create a sky or sunset. For example, by lighting the drop from the front with warm, orange and red tones, and by adding clouds or other atmospheric effects, a designer can create the illusion of a setting sun. In this way, a cyc or sky drop can be used to create a sense of time and place, and to enhance the overall visual impact of the performance.

Scrim

A scrim is a knit, translucent curtain, which often come in white and black varieties. It is typically made of a lightweight, sheer fabric, often in a shark's tooth knit pattern (see gallery below) and is hung on a pipe above the stage. One of the key features of a scrim is its translucency, while still providing some level of visual obstruction. This allows it to be used in several creative ways, such as creating the illusion of fog or mist, or allowing actors to appear and disappear on stage. When a scrim is lit from the front, the audience cannot see through it. However, when light is visible on the upstage side of the scrim, the curtain becomes transparent, and the audience can see the performers and scenery on the other side. Scrims can create a sense of depth and distance, establish mood and atmosphere, and even be used as a projection surface.

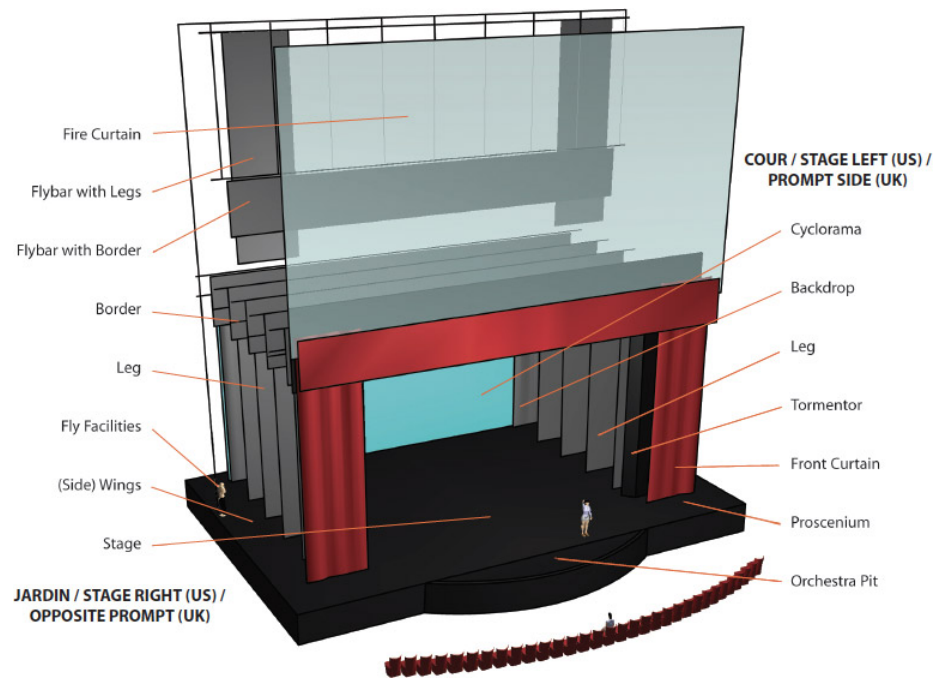
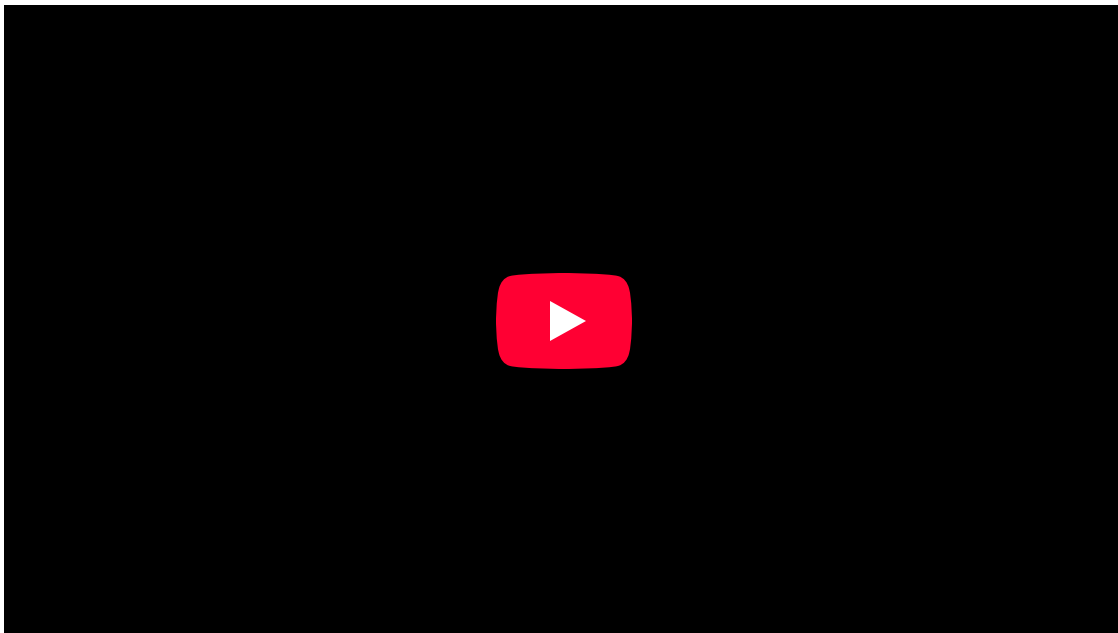


Figure 2.2.2: Stage Curtains, Image Credit [Show Tex](#)

Fly Systems

In most modern theatres, especially in a proscenium theatre, most (if not all) of the above drapery hang on battens. Battens are pipes that hang from line sets above the stage that make up both counterweight fly systems and automated fly systems. Fly systems are devices that are used to hoist drapes, scenery, and sometimes people over the stage. Most fly galleries are large enough to store a backdrop the size of the proscenium opening above the stage and out of view of the audience. When used well, designers can create magical and sometimes seamless transitions from scene to scene. See the video below to watch a scene transition in SBCC's production of *The Music Man* that uses fly systems and a trap lift to make for an engaging scene change.





Counterweight System

Of the two main types of fly systems, the counterweight system is the most basic and has been used for centuries. The counterweight system is – as its name suggests – a lineset with a batten attached to an equal amount of counterweight (iron bricks) on the offstage side. A stagehand pulls a rope that raises and lowers the counterweight. Much like a teeter-totter, when the weight goes down, the batten goes up, and vice-a-versa.

There are two main downsides to this system that are easily solved by the newer technology of the automated fly system.

1. Every time you need to add scenery to a batten, you also need to add weight. This can get very cumbersome, and sometimes dangerous, when you are adding heavy scenery to a batten because it can't be moved until both sides are balanced. Because of the heights of some scenery, this can make loading weight very difficult.
2. In order to move a lineset in or out, you need a stagehand to pull the rope. While that in itself is not a problem, it can get tricky to complete a scene transition where 10 linesets need to move simultaneously. In this scenario, you would need 10 stagehands working at the same time, which can really affect a production's budget.

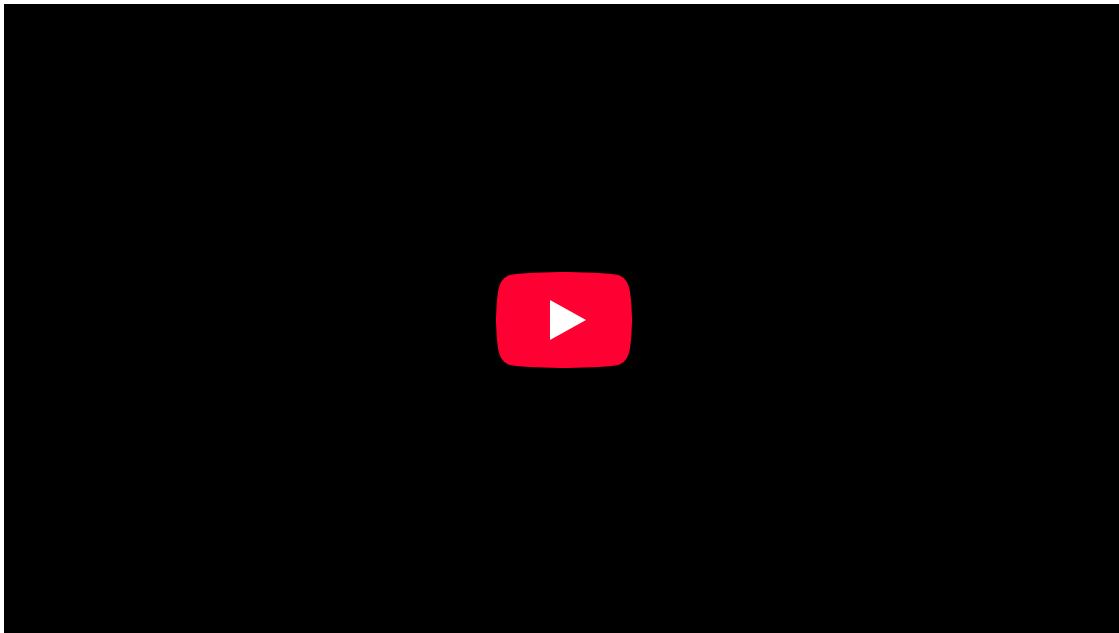
Motorized Flying Systems

Like the counterweight system, motorized flying systems generally control battens that run the width of the stage (although they are very versatile and can lift a single or multiple points across the stage). Early motorized systems were simply a motor attached to the lift lines or **head-blocks** of an existing counterweight system, thus making a set moveable without the need for an additional stagehand. Sometimes these early systems made it so weight did not need to be added when changing scenery.

In contemporary construction and remodels, however, most theatres install packaged-hoist systems. A packaged-hoist system is a **motorized winch** attached to a **cable drum** that has enough wire rope to lift a single batten. A theatre can have anywhere from one, to hundreds of automated linesets. These can be connected to a central computer, which knows where every batten is in the theatre at any time and can coordinate very complex scene changes at the press of a button. No longer do theatres need to reweight counterweights when hanging scenery or coordinate multiple stagehands for complex fly cues.

Automated linesets do come with their own downside, which in some cases could outweigh their benefits. The chief weakness of these systems is that they run on computers. If the computer is not working for any reason, the show stops. No scenery (or performers) can fly in or out if any part of the system fails, or worse, shows the notorious 'blue screen of death.'

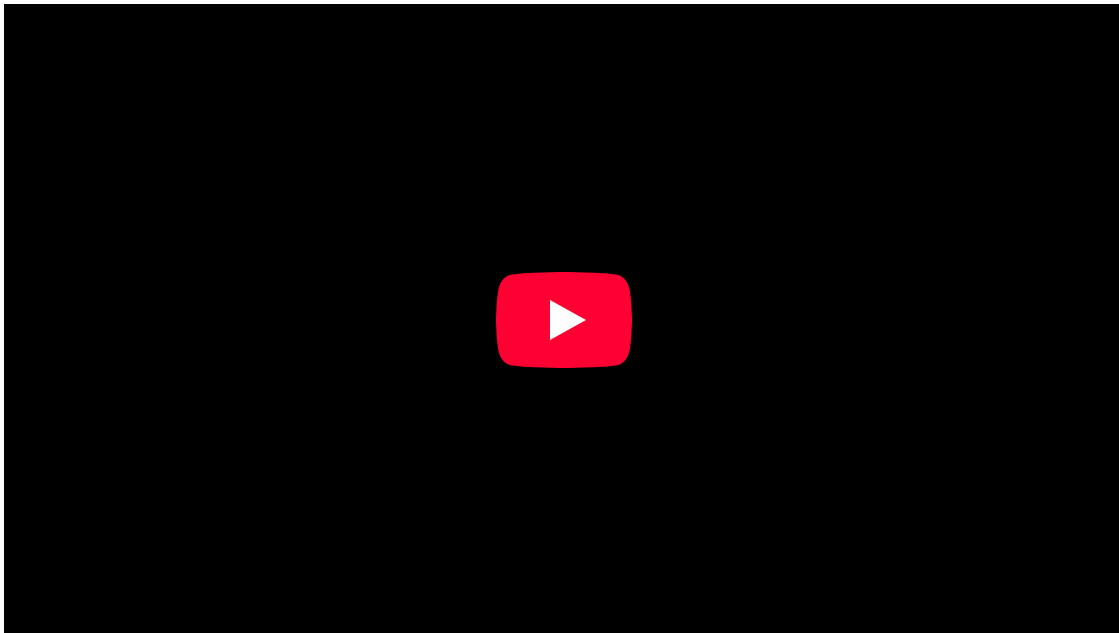
The video below gives you a backstage view of **performer flying** at The Theatre Group at SBCC's production of David Lindsay-Abaire's *Ripcord*. In the play, the characters have a bet that they can scare each other, so they go tandem skydiving. The director wanted to wow the audience with some spectacle to engage them in this 'scary' act to further the story. A motorized lineset was the perfect solution to this challenge. *



*Performer flying should only be created and performed by qualified and trained personnel, with proper ANSI-rated equipment and a comprehensive risk analysis. If you are wondering whether you are a qualified person... you probably are not.

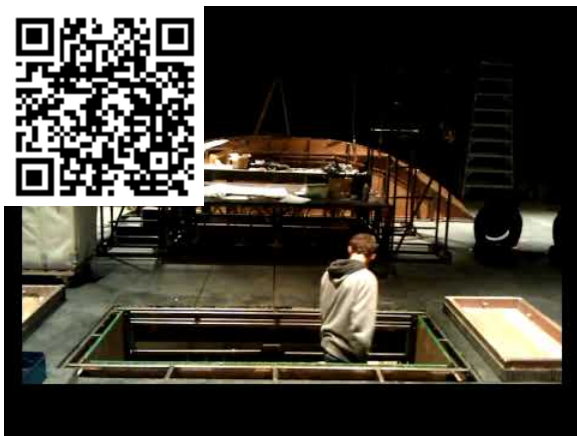
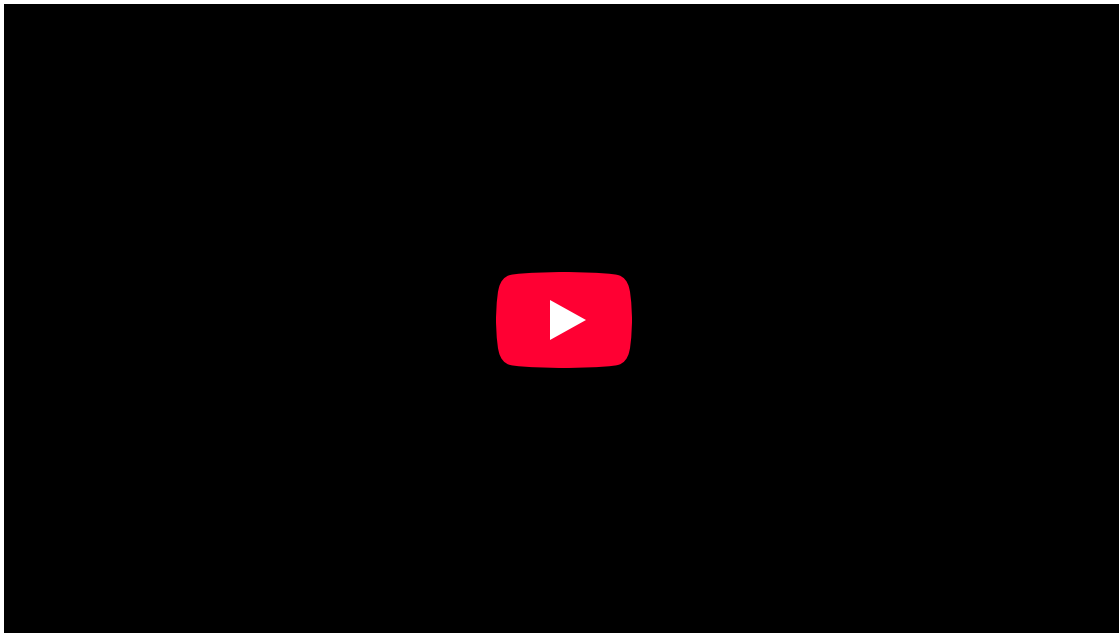
Stage Equipment

Many theatres have built-in stage equipment to facilitate simple and awe-inspiring scene changes and make the theatre more versatile in the events it can accommodate. Most of what we use today date back to the Japanese Kabuki theatre of the 1600's, but some date back even further to the Greek amphitheaters in 550 BCE. We will look at three such systems: traps, revolves, and slip stages (wagons). Some theatres even have all three devices built into one synchronized stage, like the Munich Opera House or London's National Theatre.



Traps

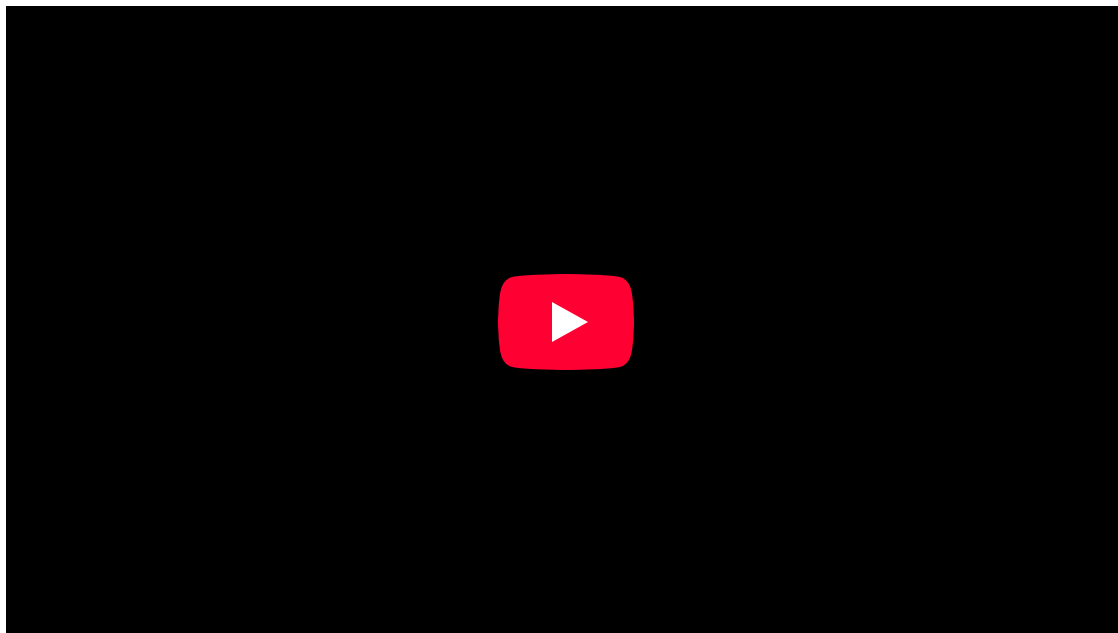
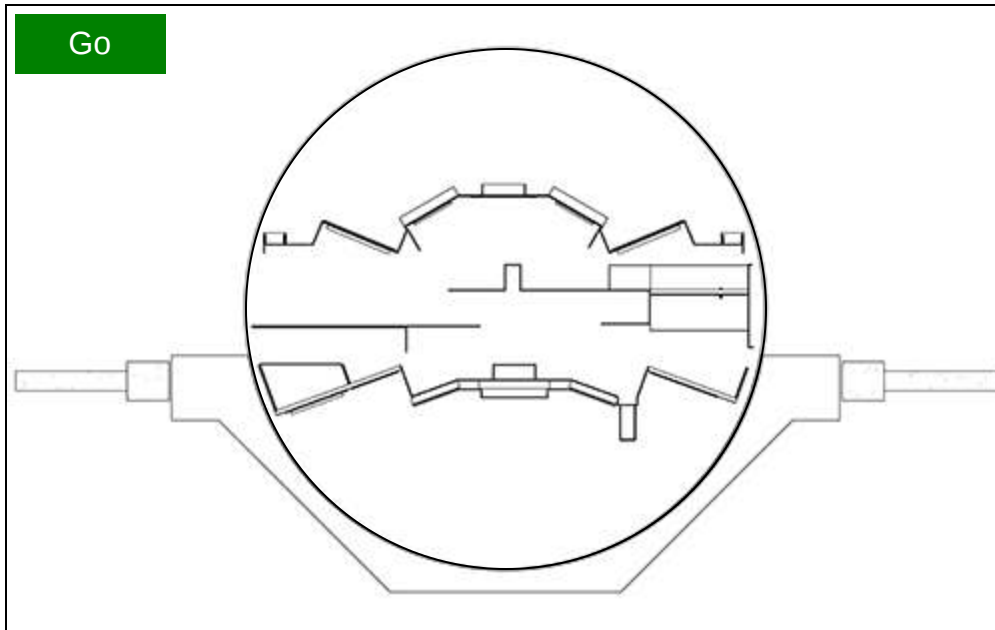
A trap, in its simplest form, is a hole in the stage that can be covered with a flooring panel when not in use. They allow people or scenery to move from below the stage-to-stage level. Traps can also be used in more creative ways, such as to create the illusion of actors rising from or disappearing into the stage – think the Wicked Witch melting in *The Wizard of Oz* – or to allow for the rapid and dramatic transformation of stage settings. Traps can also be fitted with elevators or other lifting mechanisms to allow for the smooth and seamless movement of scenery or other stage elements. Watch the video below of a custom fabricated **trap lift** we created for the Theatre Group at Santa Barbara City College.



Revolve

A revolve is a circular platform that rotates on a central axis. Some theatres have them built-in to their architecture, but it is more common to use one that is custom built for a specific performance. They allow for the rapid and seamless transformation of stage settings, or for the movement of actors or other stage elements. Often, two or three sets are built on one revolve, and as it spins, it can easily display a new scene very quickly and magically. See the video and interactive game below of a revolve stage I designed for The Theatre Group at SBCC's production of *Harvey*, by Mary Chase.

Press the "Go" button below to rotate the stage



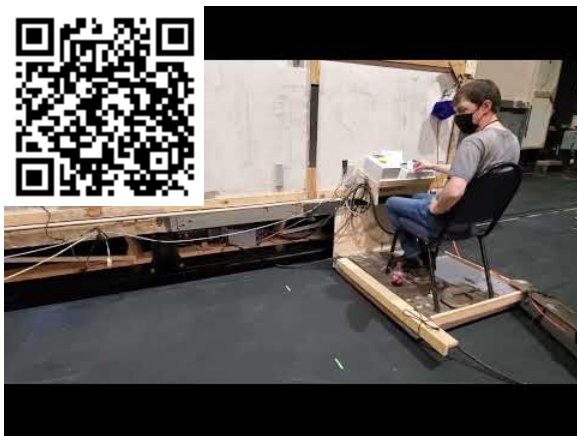
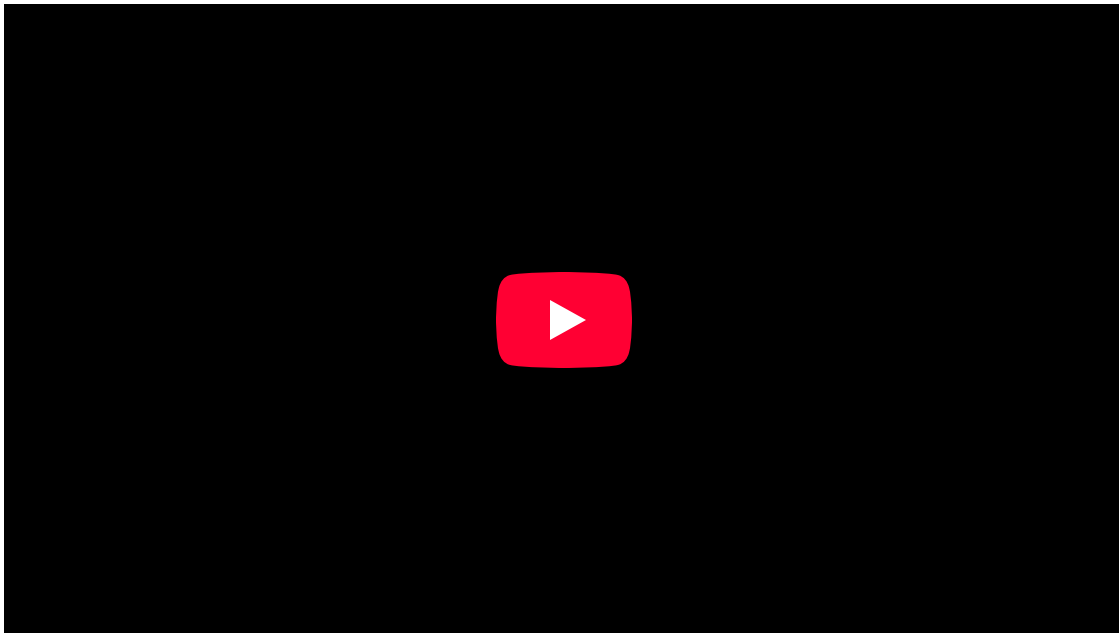


Slip Stage

A slip stage is a platform on wheels (or a built-in track in a theatre) that can roll across the stage with the use of motors, appearing to move magically. Slip stage platforms usually carry actors or scenery to aid in scene transitions. It is most often used to create multiple performance areas on a single stage, to transform stage settings quickly, and/or to move large scenic elements or performers with ease. At The Theatre Group At SBCC, we used a slip stage to automate the movement of a train in Ken Ludwig's adaptation of Agatha Christie's play *Murder on the Orient Express*. With the press of a button, the entire train could 'magically' slide from stage right to stage left and back again, as though the audience was watching a real train roll across the stage. See the video and interactive game below of the slip stage for *Murder on the Orient Express*.

Use the buttons to move the train across the stage





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3: Equipment Through History

In efforts to keep their jobs, countless history teachers live by the words of George Santayana who is quoted saying, “Those who do not remember the past are condemned to repeat it.” While it may seem like a trope, it is indeed important to keep in mind. But perhaps an even more important reason to study history is so that we can learn from it. How did our ancestors solve problems without computers? Is there a mechanical way to change scenes without a digital projector? Why do governments censor artists? History has answers to all these questions and more. It all starts with a good story.

8,000 BCE - Storytelling

We are all storytellers – and therefore actors in our own stories. Too often, our theatre industry separates itself into partisan categories that create two distinct groups, technicians and actors. When, in reality, we are all actors, and indeed all storytellers. You surely have embellished a story to a friend or lowered your voice to imitate the angry person at the store. That is acting, that is storytelling. So, it is fitting to start our review of theatre equipment and architecture at the very beginning, the telling of stories around the fire. As we learned in Chapter 1, the purpose of all theatre is quite simple: to tell a story.

It can be argued that theatre began in the very moment that humans began to tell stories to each other. We wanted to share our life experiences, struggles, and accomplishments. First, we had rituals. Bali had the *Barong* (Trance Dance) where farmers dressed in masks to act out the battle between good and evil. Mexico’s *Día de Los Muertos* is a ritual, as is *Carnival* and one can argue even the ubiquitous American Football Game. At some point in history, millennia ago, ritual transitioned into what we call theatre when storytelling began as a rehearsed tool used primarily to entertain an audience. Every culture cites a different time when that transition took place, in the Mayan culture they had professional entertainers (the *talquetzque*), the Chinese had professional Monk performers.



Figure 3.1: A Woman at Carnival

There are four basic elements required to create theatre. This was just as true millennia ago as it is today:

1. An Idea
2. A Space
3. A Performer
4. An Audience (with willingness to suspend disbelief)

✓ Key Tech

Venue: Any place people can gather

2675 - 332 BCE – Egyptian Theatre

Over 4,000 years ago, the Egyptians created the first theatre that we have in written record. Theatre was a ceremonious ritual often used to conjure gods and resurrect the dead, regularly performed at festival times. The Egyptian coronation Festival Play is a commonly cited example where citizens celebrated annually the coronation of the pharaoh. Theatre grew from its roots at the fire and was performed in public areas, often at the steps of a temple to a large audience.

✓ Key Tech

Venue: Public structures and temples

Greek (550 – 220BCE)

The Greeks of our distant history gave us a rich theatre foundation on which we built our modern theatre equipment and architecture. The Greeks were the first to use scenery and architecture to aid in storytelling. Most Greek theatres--which showed work from today's "classic" playwrights Sophocles, Euripides, and Aristophanes--were outdoor stages, often representing modern **amphitheaters** and **arena stages**. Greek amphitheaters were composed of a steeply **raked** seating area for the audience (the 'auditorium' or *theatron*) with a central performing area (the *orchestra*) in front of all the seats. Immediately behind the orchestra stage was the Greek's chief stage invention, the *Skene*, a long wall with several doors or arches through which actors made their entrances.



Figure 3.2: A Greek amphitheater Skene by [ER's Eyes - Our planet is beautiful](#)

To aid in the creation of space, the Greeks used many novel theatre devices. *Periaktoi*, were three-sided scenic columns on a central pivot that could be rotated to display three unique scenes. If a play required a dead body to be shown to the audience – as many did because Greek theatre traditions dictated that no violence be shown onstage – the *Eccyclema* (aka. Death Wagon) was used to roll people or scenery on stage. Another fascinating technical device was the *mechane* (*machina* in Latin). This led to the expression "Deus ex Machina," or God descending from a machine during the play. When a play called for a God to descend from the heavens or rise from earth, the Greeks employed this crane-like device to raise or lower actors and scenery from the stage up and over the *skene*.

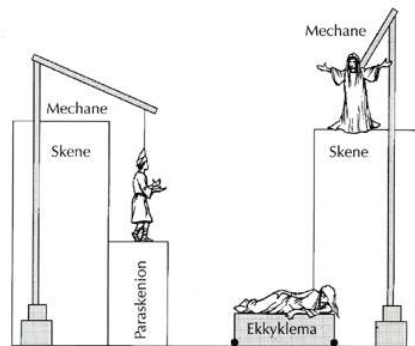


Figure 3.3: A drawing of Greek stage machinery. by [Lauracorominas](#) via Wikimedia Commons

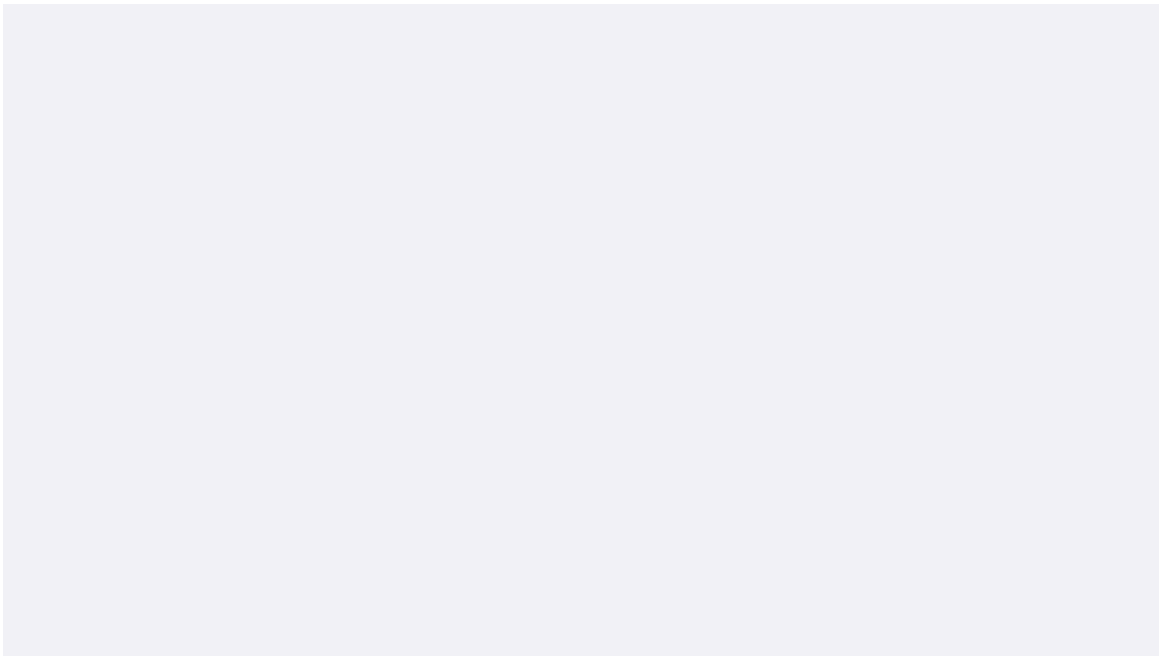
✓ Key Tech

Venue: Amphitheaters and arenas

New Technology: Skene, Periaktoi, Eccyclema, and Machnia

Roman (365BCE – 568CE)

With the fall of the Greek empire, Rome's art and culture thrived. The new superpower of the region, Romans drew from Greece's theatrical traditions to create new spectacles of space and technology. In the year 55BCE, Rome built the world's first permanent theatre dedicated to theatre arts. Under Roman design, amphitheater auditoriums grew into larger, steeper *cavas*, and the *skene* expanded into the sometimes elaborately decorated three-story *scaenae frons*.



3.4

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These events show the power of theatre and story, as theatre was often more than just entertainment, it could be transformative or even revolutionary.

✓ Key Tech

Venue: Amphitheaters and arenas

New Technology: Scaenae frons, Coliseum, Elevators, and Wagons

Medieval (400 – 1500)

With the fall of Rome, theatre – as Roman's knew it – was effectively dead. Some traditions were kept alive by traveling performers who would journey from town to town, laying the groundwork for many medieval theatre practices.

Luckily, the same Church that banned all spectacle at the end of the Roman empire, can be credited with its revival. The ecclesiastical leadership found value in the storytelling to the masses that theatre delivered. Within Europe in the tenth century, clerics began to create staged scenes in the church. Eventually those scenes grew too big for the usual small-town church and sometime in the thirteenth century, they took their shows on the road – as they say. Acting companies funded by the church mounted platforms on top of wagons to create one of the first mobile stages. Known as **Pageant Wagons** (or the immobile *Booth Stages*), these ambulatory stages were pulled from town to town where the acting company could produce the same liturgical scenes that were once in the church, but to a much larger audience. The scenery was an oddly simplified version of the Greek *skene*, often being a small house known as a *mansion*, always the same and not changed from play to play – although one stage could have multiple *mansions*, just as the *skene* had multiple doors.

Another Medieval theatre tradition was the festival **rounds**. Produced every year, skilled craftspeople worked on the many scenes of the church (hell, the sermon on the mount, heaven, etc.). An arena-like stage was created with unique locations for each story. Audience members could traverse through the festival and experience every scene. We know there was complex scenery at this time as we have written record of the “*secrets*” artists employed, such as flying devices, **pyrotechnics**, and moving scenery. In one account, “One French Hellmouth was so elaborate that it required 17 men to operate its various pulleys, winches, and bellows.”^[1]

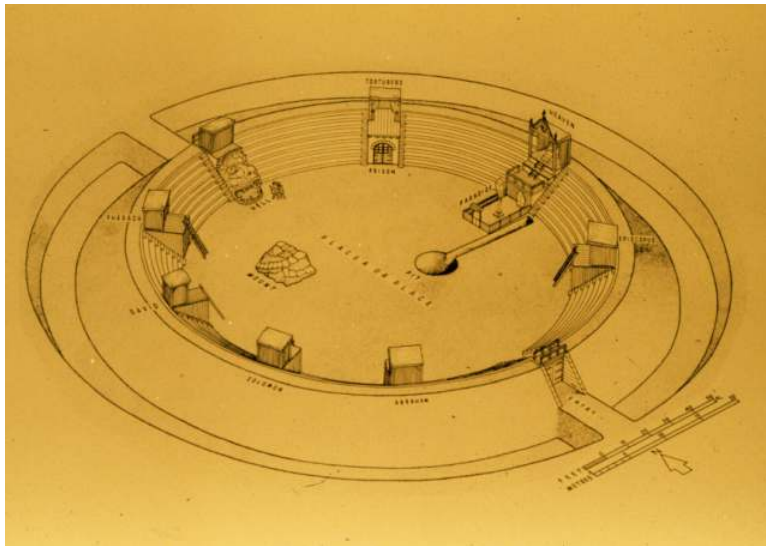


Figure 3.5: An artist's sketch of The Perran Round Medieval Amphitheater by Theatre and Playhouse via the [HekmanDigitalArchive](#)

✓ Key Tech

Venue: Churches, rounds, and pageant wagons

New Technology: Secrets, mansions, pyrotechnics

Renaissance (1500 – 1675)

To the good fortune of many in Medieval Europe, art improved and theatre succeeded as a central part of modern culture, giving birth to the Renaissance. In 1576, the first public theatre was built in England, laying the groundwork for some of the most famous theatres of our time. William Shakespeare's Globe theatre followed shortly after, opening in 1599. It was a venue that created space for citizens of all walks of life and financial means to enjoy theatre. The Globe Theatre is the most replicated theatre in the world, with over 24 replicas in operation today. The *skene's* influence is still present as architects created playhouses with elaborate permanent backdrops. At the *Teatro Olimpico* in Italy, the hallways of the skene were constructed with a **forced perspective**, a design style that creates the visual illusion that a hallway continues farther than it does in actuality – a sort of visual representation of today's "fun houses". In many renaissance theatres, the stages were slanted towards the audience to give them a better view, a technique known as the **raked stage**.



Figure 3.6: forced perspective at the Teatro Olimpico by [Vincenzo Scamozzi](#)

Even though little scenery was known to be constructed for the renaissance stage, artists did create **backdrops** and several **props** were understood to be used. Because some of the theatres were fully indoors, the renaissance gave birth to the first lighting for the stage in the way of candlelight. While this lighting was a great resource for designers, it also posed a great threat to the audience and performers. With hundreds of live flames burning throughout the evening, it was only a matter of time before the theatre burned down. Shakespeare's own Globe Theatre burned down in 1613 due to a theatrical cannon misfire.

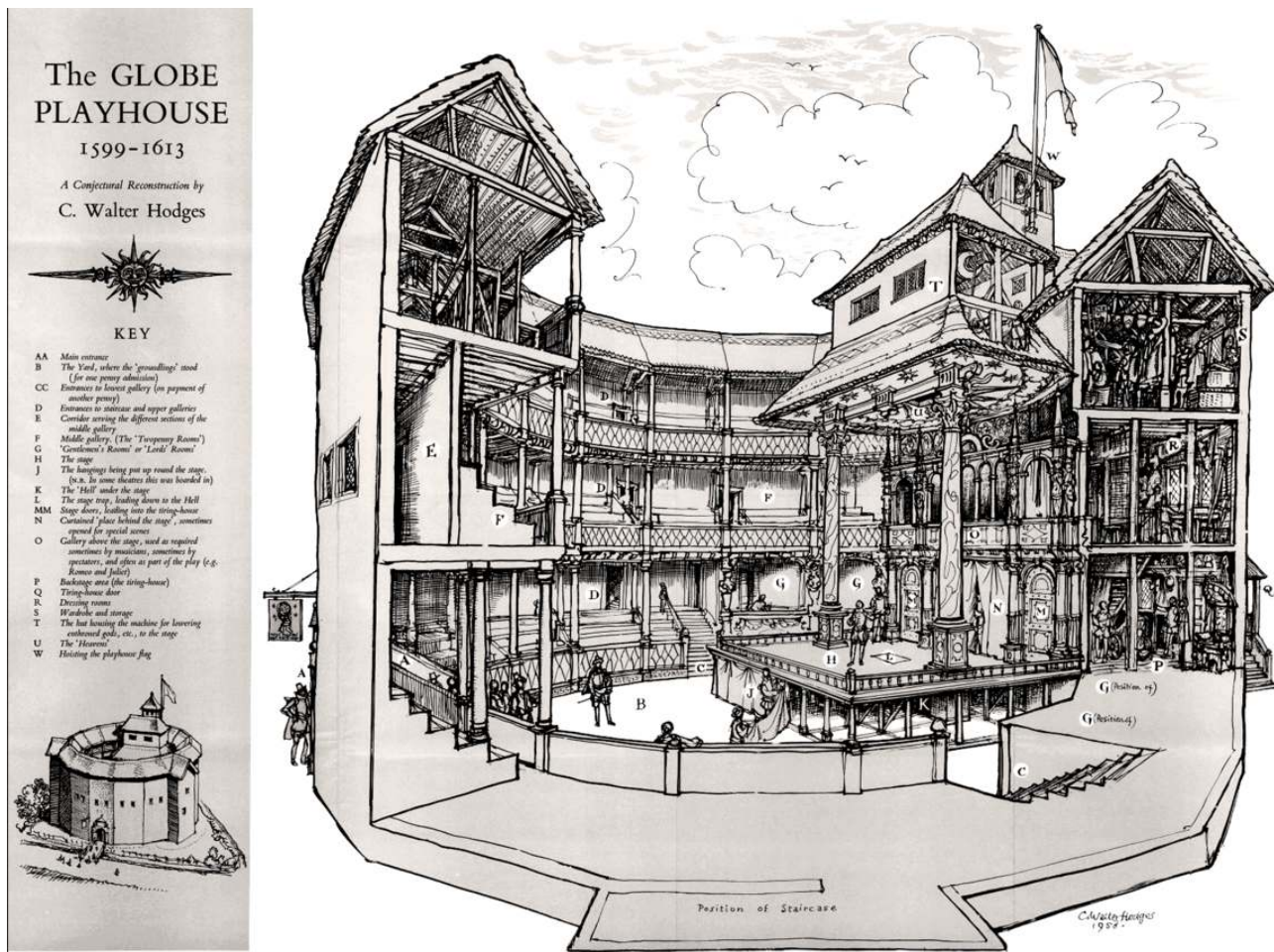


Figure 3.7: [Reconstruction of the first The Globe, 1599–1613](#) By C. Walter Hodges, 1958 /Folger Shakespeare Library. License: [Fallen in the open \(Public domain\)](#)

✓ Key Tech

Venue: Permanent Theatres, Globe Theatre

New Technology: Candlelight, show-specific backdrops, forced perspective, raked stages

Restoration+ (1660 – 1700)

At the end of the Renaissance, public theatres closed their door again. This time due to a ban from the Puritans in 1642 in who recently seized power over England and reigned for 18 years. With the fall of the Puritans, King Charles II reopened the public theatres to rein in a fruitful 40 years of restorative theatrical innovation.

Theatre innovated in other parts of Europe and Russia over this time and those influences spread over Europe and England. The principal theatre at the time is the proscenium theatre. Now designers have offstage space, in the [wings](#) and behind the scenery. Set designers were still creating backdrops and other decorative scenery, but most of it was purely visual – as opposed to our more modern standards of building entire working houses on stage. Nevertheless, the stage was a visual treat, now framed with [borders](#) and [legs](#) to limit the audience's view of the offstage area.

✓ Key Tech

Venue: Permanent Proscenium Theatres

New Technology: Wings, borders, legs

Japan and Kabuki Theatre (1607 - 1867)

Meanwhile, to the east of Europe, Japan was expanding its own theatrical spectacle. At the time, the traditional theatre of Japan, the *Noh* (*Nō*) Theatre, had strong roots dating as far back as 1350. As Japan's desire for an avant-garde theatre with more spectacle grew, *kabuki* emerged. Often a 12-hour-long event full of dance and music, audiences could come and go as they pleased, and the actors often entered and exited through the audience area further involving the audience in the event.

Kabuki theatre designers crafted many theatre machines and devices that we still use today. Most *Kabuki* stages had multiple [elevator traps](#), [revolving stages](#) (even concentric revolving stages), a western-style proscenium, and [flying effects](#) known as *chunori*. Japanese theatres were very advanced at the time, often hosting “water plays” (*mizumono*) which had their own special water effects (*honmizu*) throughout. But perhaps one of the biggest theatrical devices that *Kabuki* theatre is known for today is the *Kabuki Drop* (originally *Furiososhi* (shake)). Japanese artisans and engineers invented the *Kabuki Drop* to facilitate quick set changes. It is a device used to quickly drop a fabric backdrop from its hanging position in the theatre. A simple bamboo pole with small prongs on it pointing up would hold a curtain in the air. At the right moment, stagehands would pull a rope, rotating the pole and pointing the prongs down, thus quickly dropping the curtain.



Figure 3.8: The side view of a bamboo Kabuki Drop by [Magic Kabuki Drop](#)

✓ Key Tech

Venue: Permanent Proscenium Theatres

New Technology: elevator traps, revolving stages, flying effects, water effects, Kabuki Drop

The Industrial Revolution+ (1760 – 1900)

Leading into the industrial Revolution, American theatre was just getting started. The first theatre in America was built in Williamsburg, Virginia in 1716, providing a permanent space for theatre in the new colonies. Yet somehow, we see history repeating itself again. In the beginning of the industrial revolution, after America declared their independence, all stage performances were banned in 1774 for over ten years – assumedly, to control public opinion. Theatre clearly continued to have power over thought and story.

Nevertheless, over the brief 80 years that were the industrial revolution, theatre saw some of its biggest technical growth. Theatre technology usually follows the technology of the time; the Industrial Revolution was no different as it was ripe with technological advancement. In 1792, theatrical lighting got another important lighting upgrade with the advent of **Gas Lighting**. Now, theatre technicians could change the intensity of the light on stage. We saw partial blackouts and the ability to focus the audience's attention with light. Designers experimented with colored glass and liquids in front of the flame to change the color of the gaslight to further effect the mood of the stories on stage.

Not to be outdone, less than 100 years after the gas light, Thomas Edison invented the light bulb which quickly spread to theatres all over the world, providing electric light to millions. The first theatre was lit with electricity in 1881 and all others quickly followed or were left behind. Theatres now had complete **blackouts**, granular **intensity changes**, and (perhaps more importantly) fewer fires.

✓ Key Tech

Venue: Permanent Proscenium Theatres

New Technology: Gas Lighting, Electric Lighting, blackouts, intensity changes, colored lights

The 20th Century

Much of what we know of modern theatre took its hold in the twentieth century. Playwrights began writing plays of realism, an art that more deeply reflected life, and stagecraft had to follow in this storytelling practice. Splintering from other twentieth century theatre movements, artist began to experiment with “**found spaces**”, further challenging the lines of the actor/audience relationship. Perhaps from this movement grew the desire for more **black boxes**, **arena**, and **thrust stages** to better involve the audience’s participation in the story. Artists everywhere were implementing every technology available to better tell their stories. The twentieth century even saw the first theatrical degree program at a university.

It is hard to imagine a production today without the use of recorded music or sound effects, but its introduction to theatre is surprisingly recent. While we had sound in theatre since the advent of live music millennia ago, it was not until the 1930s that **audio playback** was first used on stage with the arrival of record players and amplified speakers. Throughout the twentieth century, sound technology advanced from record players to different versions of cassette tapes. This form of manual analogue sound playback was used regularly, all the way up until the 1980s with the invention of computers capable of digital playback.



Figure 3.9: A record Player, Photo by [Jace & Afsoon](#) on [Unsplash](#)

Photo by [Jace & Afsoon](#) on [Unsplash](#)

Also, with the invention of the computer, lighting systems began to see an upgrade. Now designers were able to store preset scenes on a digital computer, switching from scene to scene with the press of a button. With this new control, companies began to create **moving lights** that could respond to the commands of a computer, move to predefined locations, and change colors. At the time, this seemed like pure magic, opening endless possibilities for lighting designers.

✓ Key Tech

Venue: Venue: Permanent Theatres (Arena, trust, blackbox, and proscenium), found spaces

New Technology: Computer Control, electronic sound playback, digital computers, moving lights

The 21st Century

Technology is advancing quickly. So far, Moore’s law has been holding true. Moore hypothesized that the number of transistors in an integrated circuit will double about every two years. Simply speaking, digital storage and computer capacity is growing at an exponential rate. At the beginning of the twenty-first century, lighting systems could hold around 1.44MB of data, twenty years later that ever-growing number exceeds 71,000% of the size it once was. With this advance in technology, technicians have created state-of-the art tools used in theatre storytelling.

Entire shows can be designed virtually in full 3D with every detail expertly rendered, including scenery, lighting, sound, and video. Before a single paint can is opened, artists can ensure everything fits together and that all colors match a director’s vision. This information can be transferred among computers limiting the need for many human operators. Some productions even run on a **word-clock**, sending time-based commands to every theatre system (lights, sound, video, automation), automatically triggering each system without the need for human input.

For better or worse, the COVID-19 pandemic of 2020/2021, saw a shift of venue. People were unable to be together in the same room as audience and performer are accustomed to. So, a quick shift to a digital venue took place, the dreaded “Zoom Room” (or any other number of video chat platforms). Actors were able to perform their plays to a virtual audience, many hailing from all over the world simultaneously. Of course, when it became safe to return in person again, most artists quickly dismissed the Zoom Room as a venue, mainly because it lacked intimacy and produced a forced relationship between the actor and the audience. But who knows, sometime in this century we may see video chat technology advance to a more palatable level, leaving the traditional theatre venues behind.



Figure 3.10: “Acting in a play on a zoom.us computer screen.” – Created by Dall-E AI

The early twenty-first century saw the adoption of computer-controlled **digital video projectors** capable of painting the set walls with full-color moving video. Many theatre companies are embracing this technology, reducing their need for multiple backdrops or scene changes. We are even beginning to see **holographic projection** take the stage. With the invention of **artificial intelligence (AI)** and **deep learning** algorithms, artists can create holographic projections of anything, even long-deceased actors and musicians. Now we even have applications like OpenAI’s Dall-E that can generate any image with a simple word prompt.

The future of the twenty-first century is exciting, and a little scary. Where technology will take our art form is yet to be seen, but if history has anything to tell us, it will remain powerful, transformative, and state-of-the-art.



Figure 3.11: “The hologram of an actors in a play on a theater stage in an auditorium, 3D render.” – Created by Dall-E AI

✓ Key Tech

Venue: Permanent Theatres, digital video rooms

New Technology: Digitized automation, Holograms, Artificial intelligence (AI)

[1] Greenwald, Mike, et al. *The Longman Anthology of Drama and Theater: A Global Perspective*. Longman, 2004. p. 413

 For Further Exploration

Greenwald, Mike, et al. *The Longman Anthology of Drama and Theater: A Global Perspective*. Longman, 2004. p. 413

Ogawa, Toshiro. *Theatre Engineering and Stage Machinery*. Revised 2010. Entertainment Technology Press, 2010.

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CHAPTER OVERVIEW

4: Drafting

4.1: The Language of Drafting

4.1.1: The Language of Lines

4.1.2: Visualization

4.1.3: Technical Sketching

4.1.4: Dimensioning

4.1.5: Sectional Views

4.2: Mechanical Drafting

4.2.1: Drafting Tools and Materials

4.2.1.1: Tools

4.2.1.2: Computer drafting printing

4.2.2: Use scale rulers to determine actual dimensions from drawings

4.2.2.1: Prelude to Scales

4.2.2.2: Using an Architects Scale Ruler

4.2.3: Interpreting scale drawings

4.2.3.1: Basic layout of a drawing

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4.1: The Language of Drafting

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4.1.1: The Language of Lines

You have heard the saying, “A picture is worth a thousand words”. This statement is particularly true in regards to technical drawings.

It would be almost impossible for an engineer, designer, or architect to describe in words the shape, size, and relationship of a complex object. Therefore, drawings have become the universal language used by engineers, designers, technicians, as well as craftsmen, to communicate the Information necessary to build, assemble and service the products of industry.

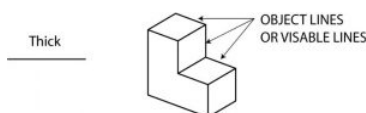
It is Important to remember, as you study Print Reading, that you are learning to communicate with the graphic language used by Industry: Lines are part of that language.

Since technical drawings are made of lines, it is logical that the first step in learning to “read” a drawing is to learn the meaning of each kind of line. Generally, there are 11 basic types of lines. Each kind of line has a definite form and “weight”. Weight refers to line thickness or width. When combined in a drawing, lines provide part of the Information needed to understand the print.

Being able to interpret a blueprint and accurately build objects is a needed skill to become successful in all trade crafts. It is a skill, like many others you will learn, and it will take time and practice to fully understand and become proficient.

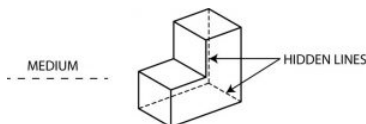
Object Line

A **visible line**, or **object line** is a thick continuous line, used to outline the visible edges or contours of an object.



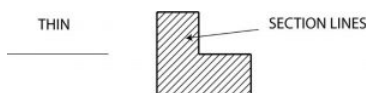
Hidden Line

A **hidden line**, also known as a **hidden object line** is a medium weight line, made of short dashes about 1/8” long with 1/16” gaps, to show edges, surfaces and corners which cannot be seen. Sometimes they are used to make a drawing easier to understand. Often they are omitted in an isometric view.



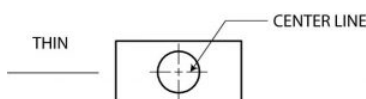
Section Line

Section lines are used to show the cut surfaces of an object in section views. They are fine, dark lines. Various types of section lines may indicate the type of material cut by the cutting plane line.



Center Line

Center lines are used to indicate the centers of holes, arcs, and symmetrical objects. They are very thin (size), long-short-long kinds of lines.



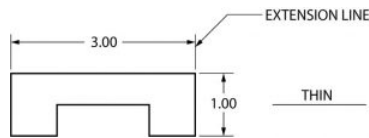
Dimension Line

Dimension lines are thin and are used to show the actual size of an object. There are arrowheads at both end that terminate at the extension lines.



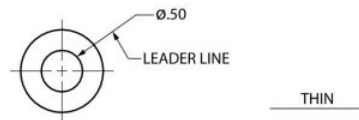
Extension Line

Extension lines are also thin lines, showing the limits of dimensions. Dimension line arrowheads touch extension lines.



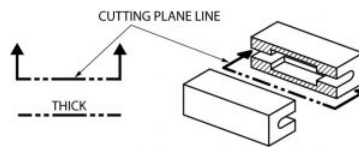
Leader Line

Leaders are more thin lines used to point to an area of a drawing requiring a note for explanation. They are preferably drawn at a 45° angles.



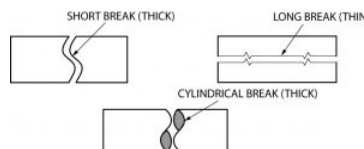
Cutting Plane Line

A cutting plane line (very heavy) helps to show the internal shape at a part or assembly by slicing through the object.



Break Line

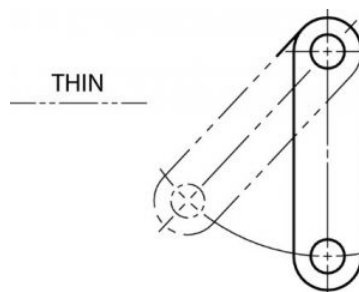
There are three kinds of break lines used in drawings. They are used to remove, or 'break out' part of a drawing for clarity, and also to shorten objects which have the same shape throughout their length and may be too long to place on the drawing.



Short and long break lines are used for flat surfaces. Cylindrical are used on rods, dowels, etc.

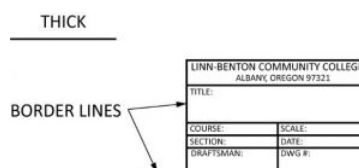
Phantom Line

Phantom lines are long-short-short-long lines most often used to show the travel or movement of an object or a part in alternate positions. It can also be used to show adjacent objects or features.



Border Line

Borderlines are very thick, continuous lines used to show the boundary of the drawing or to separate different objects drawn on one sheet. They are also used to separate the title block from the rest of the drawing.



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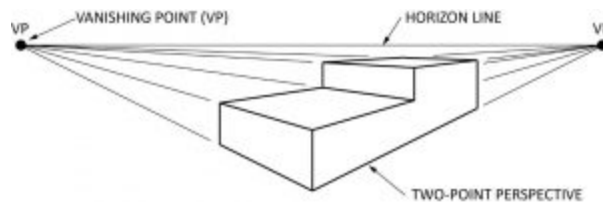
4.1.2: Visualization

Now that you have learned about the kinds of lines found on prints, the next step is to develop your visualization abilities. The ability to "see" technical drawings; that is to "think in three dimensions," is one of the most important part of this course. Since most engineering and architectural prints utilize some form of orthographic projection (multi-view drawing), that type of drawing will be emphasized.

Before going into a study of orthographic projection, you should be able to recognize several other types of drawings. They are; 1. Perspective drawing, 2. Oblique drawing, and 3. Isometric drawing. As a group, they are called "pictorial drawings". They are found on prints and are easy to visualize, so let's look at their differences.

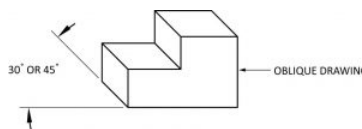
Perspective

Perspective is the most realistic form of drawing. Artists use one-point perspective, two-point (shown here), and three point to create visual depth. Perspectives are used by architects and for industrial pictorials of plan layouts, machinery, and other subjects where realism is required. Objects drawn in perspective grow smaller as they recede into the horizon.



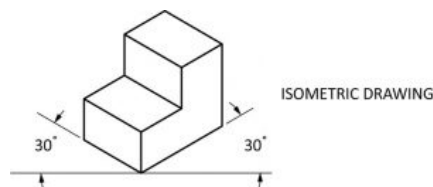
Oblique

Oblique drawings are drawn with one plane (front) of the object parallel to the drawing surface. The side, or other visible part of the object is generally drawn at 30° or 45° . Note that only the side is on an angle. Many times these types of drawing are not drawn to scale. The receding lines are drawn at 45° or 30° and will be drawn at a different scale as the vertical and horizontal lines. This make the drawing seem "out of shape". This type of drawing is not used very often in industry.



Isometric

Isometric drawings have less distortion than oblique drawings, and are used more frequently by industry for that reason. An isometric drawing has both visible surfaces drawn at 30° . These are the most used type of drawings in the piping industry and take a good deal of practice to fully understand how to draw. They best represent what is being built and what it will look like from the different sides with one drawing.

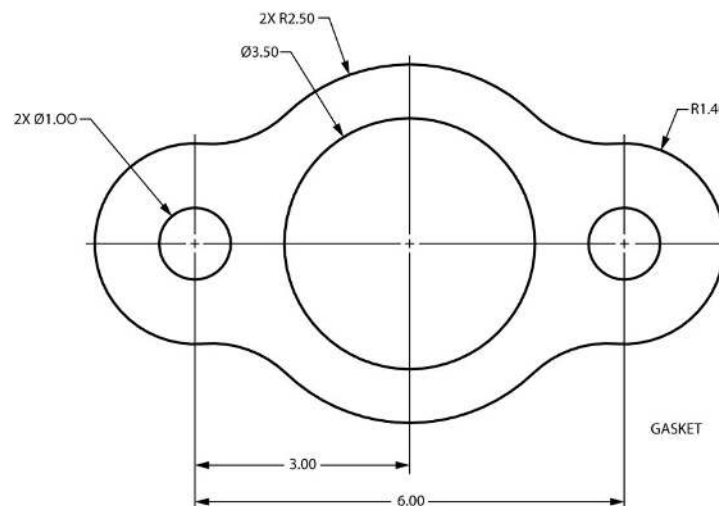


Single View

A single view of an object is sometimes all that is needed for a complete visual explanation. When dimensions, material, and other information is Included, an object requiring only a single view is easy to understand.

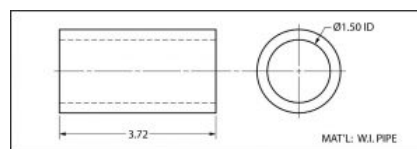
Most one-view drawings are of flat objects, made from materials such as sheet metal and gasket stock. Spherical objects, such as a cannonball, would require only one view and a note indicating the material and diameter of the sphere.

The object shown in the one-view drawing below could be made of any appropriate material that might be specified. In appearance, it is much like the gasket used as part of the cooling system on many cars. All that would need to be noted is the material type and thickness required.



Two View

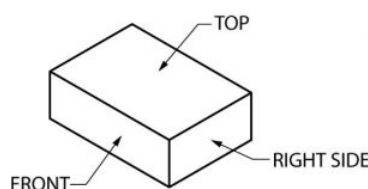
Sometimes “two-view” drawings are used on prints. Two views may be all that is needed to show the shape of an object. Objects that are cylindrical, such as a length of pipe, are usually shown on a print with two views. In such a case, two views is sufficient to explain the shape. Notice in the two-view drawing shown below that the length of the pipe is shown in one view, while the diameter is called out in the other. Without the view on the right, what might this shape be mistaken for? Square tube, channel...



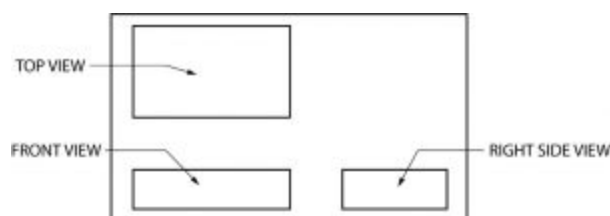
Orthographic Projection

Orthographic projection is a name given to drawings that usually have three views. Often, the three views selected are the top, front, and right side. It is possible, of course, to select other views such as the left side or bottom. Generally, though, it's the top, front and right side that are traditionally seen by the person reading prints.

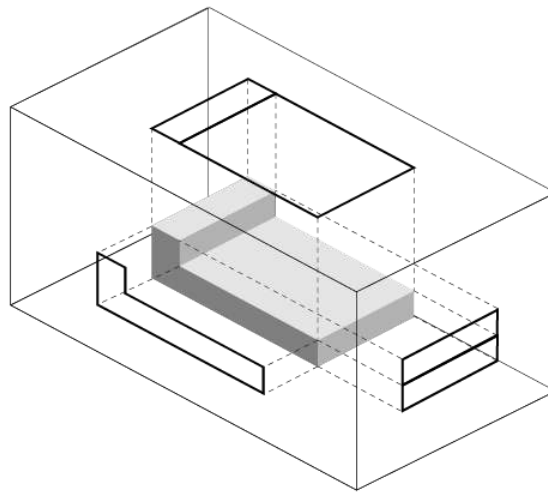
Since most prints make use of the orthographic projection system, and because the top, front, right side views are most often used, it is important that you have their order, or arrangement on the print fixed in your mind. To help you understand this system, think of a chalkboard eraser, a short length of 2" x 4" lumber, or a common brick. It looks like this:



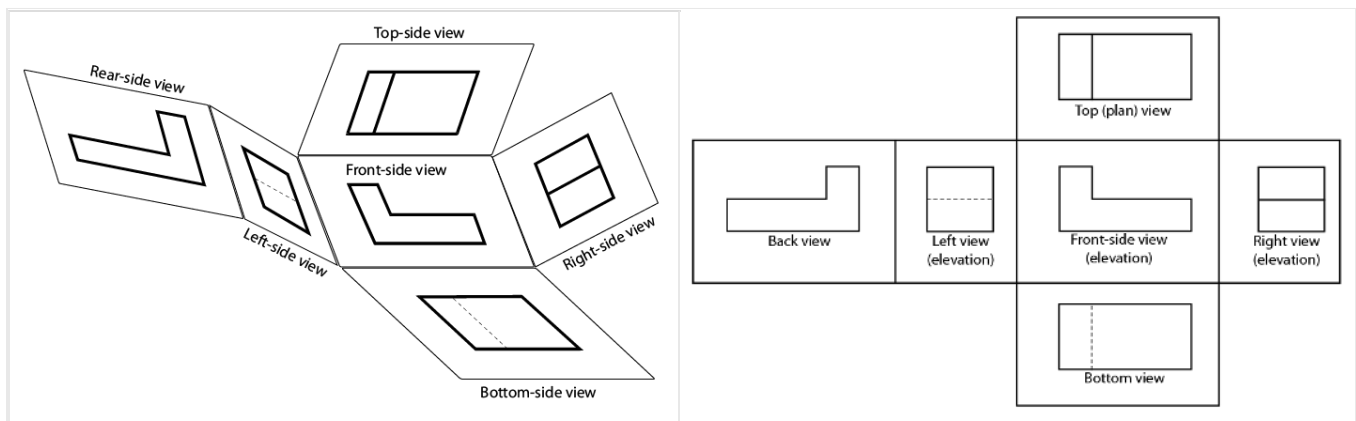
When seen on a print, using orthographic projection, it would appear like this.



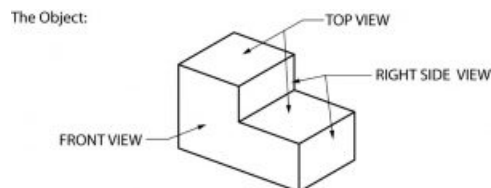
It is often easiest to visualize orthographic projection with the "glass box" method. Imagine that your object is placed within a glass box with six sides. Look at the object from each of the six sides and project onto the glass panes only the objects that you can see from that plane in vision. This is an example of how we can visualize that glass box.



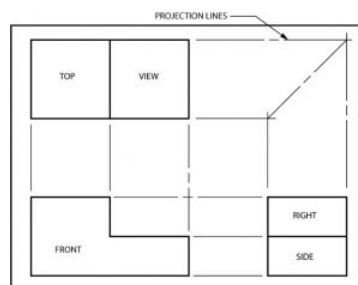
Now, slowly peel that glass box open and you will have 2-dimensional drawings of each orthographic view of your object (top, front, left, right, back, and bottom). Notice that the "elevations" include hidden lines.



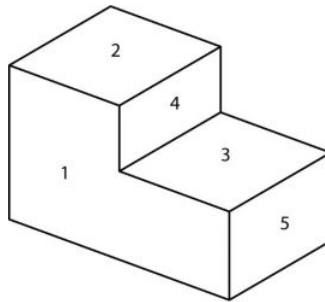
This system of orthographic projection may be difficult to understand or visualize at first, but you will grasp it with some practice. Here's a basic example of how it works, using a simple object.



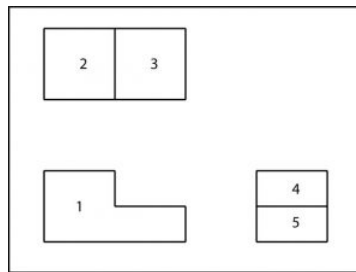
Orthographic projection does not show depth, so the object shown above will appear flat. With practice, however, you will learn to scan the three views and "read" depth into them. Remember that the location of the top, front and right side views does not change. The projection lines between the orthographic views below show the height, width, and depth relationship that exists between each view and the other two views.



In case you did not understand the three-view on the last page, let's take another look at the same thing. This time numbers will be used for identification for the surfaces.



Using orthographic projection, the object with the surfaces numbered appears like this:



Notice that the front view (1) is the key to the drawing, because it most clearly shows the shape of the object. It tells you the object is "L" shaped from the front. The other two views don't tell you much by themselves. By looking at surface 1, however, you can see that 2 is taller than 3. Therefore, in "reading" the surfaces, 2 should appear to be closer to you than 3. Now look at 4 and 5. Which surface is projected closest to you?

Answer: Surface 5 (rotate and place at bottom of layout)

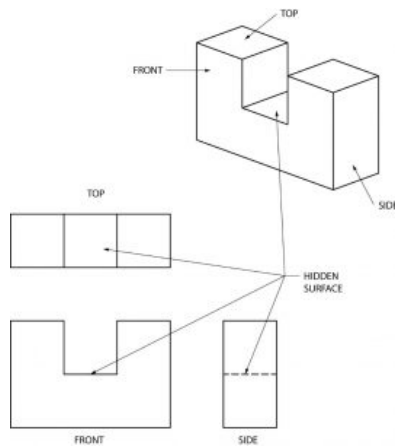
You may be wondering at this point why something like orthographic projection is used on prints when isometric or oblique drawings are so much easier to visualize. The answer is that both of those types of pictorials are used for relatively uncomplicated drawings. When an object is complex, however, neither can equal the orthographic system for clear presentation of dimensions, notes, and configuration details.

Hidden Surfaces

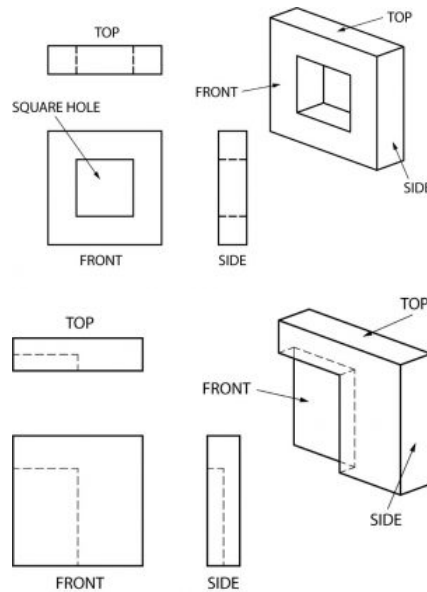
Another advantage of orthographic projection is that it allows the person reading the print to have the ability to see the inside, or surfaces of an object which normally could not be seen.

With complicated objects this can become very useful.

In the drawing below, the hidden line in the right side view represents the entire surface of the flat area between the two higher sides.



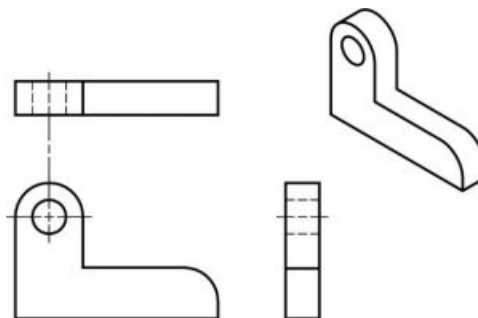
In this example, the hidden lines result from a square hole through the middle of the object.



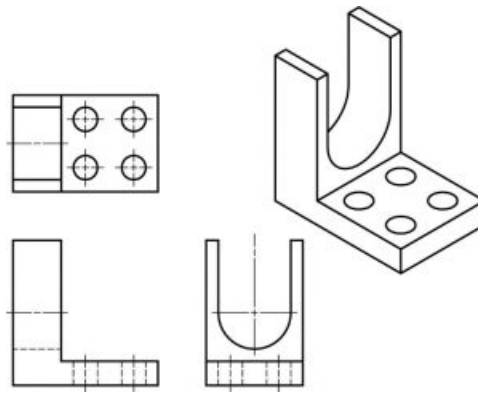
The hidden lines in this example are there because a part of one corner of the front surface was cut away, or “recessed.”

Curved Surfaces

Curved surfaces are perhaps tricky to “see” until you remember that the curve is only shown in one view. You must put the curve in the other views yourself, through visualization. Try to think that when there is a sharp change of direction like at a corner, then that will produce a line visible in another view. When the change of direction is smooth like a curve, no line will be seen.



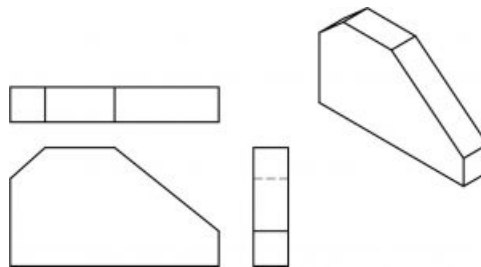
Here’s another example of curved surfaces:



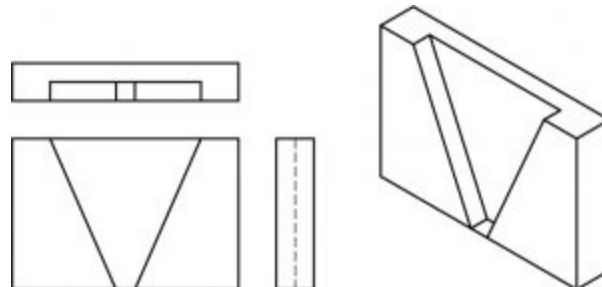
Inclined Surfaces

Inclined surfaces are those which are at an angle, or slanted. In other words, they are surfaces which are neither horizontal nor vertical. In viewing orthographic drawings you need to be alert to angles and inclined surfaces, for they are often found on the prints you will be reading later.

Notice the hidden line in the right view created by the inclined surface on this object:



Here is an object with two inclined surfaces.



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4.1.3: Technical Sketching

- Many times out in the field you are working on sketches drawn on anything from napkins, cardboard, wood scrapes or any flat surface. Don't get me wrong, you will work projects with professionally produced drawings but sometimes you have to work with what you have.

Being able to make technical sketches doesn't mean you need to be an artist; and sketching isn't difficult if you follow a few simple rules. You may be a little slow at first, but with some practice you will be able to turn out reasonably good sketches without too much effort.

You are not going to be judged as a professional draftsman or architect but you need to be able to describe, with lines what you are needing built, repaired or modified. This takes practice and is a very important skill to develop.

Sketching Techniques

All you need to start is a pencil and some paper. A soft pencil works best for most people, so try a #2 or an F. Keep the pencil sharp, but not too sharp: hold it with a grip firm enough for control, but not so tight that your arm isn't relaxed. Don't draw heavily at first. That way it is easier to erase without smudging. Darken the sketch when it begins to shape up the way you want it.

It's generally best to begin sketching with plain paper, although some people like to use grid paper. On the job, you may find yourself sketching on the back of a work order or piece of packing crate. In any case, it's learning to sketch quickly and effectively that's important.

Lettering

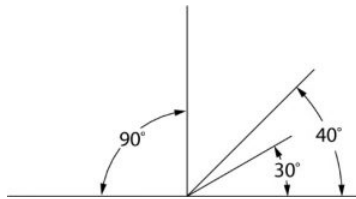
Look at the lettering below. If your printing is similar, and is easily readable, great! Some of the work ahead (and tests) require good lettering. When drafting, we only use upper-case letters, known as Single Stroke Gothic.

Remember, the most important requirement of good lettering is legibility. There is no use making a drawing if the person looking at drawing cannot read your writing. Use the guide below when lettering any drafting assignment.

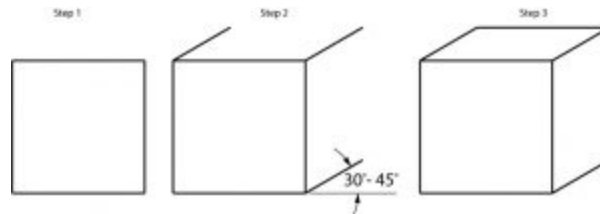
A	N
B	O
C	P
D	Q
E	R
F	S
G	T
H	U
I	V
J	W
K	X
L	Y
M	Z

Oblique Sketching

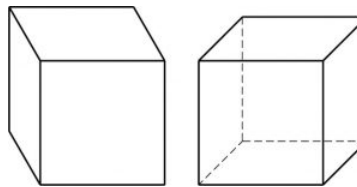
Oblique sketches are a type of pictorial having one plane parallel to the drawing surface, and the visible side sketched at an angle. Usually, that angle works best at 30° to 45° , or somewhat in between. Beginners often have trouble keeping the 30° or 45° lines as the same angle. If that happens, your sketch will look distorted.



Here's how to sketch an oblique cube in three steps:



Possibly you might want to show the left side of the cube, or perhaps draw the hidden lines, as at the right;



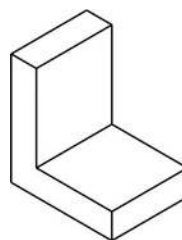
Isometric Sketching

Isometric sketches, unlike oblique, must maintain an angle very close to 30° .

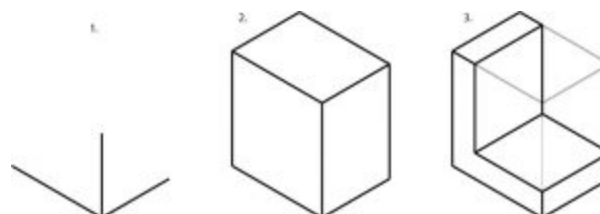
Therefore, to get the “feel” of an isometric.



Sketching in isometric can be done in different ways. Generally, it's recommended that you start with the bottom of the object and “box it in”, thereby enclosing it within a rectangular framework. For example, if we were to take a simple object like this,



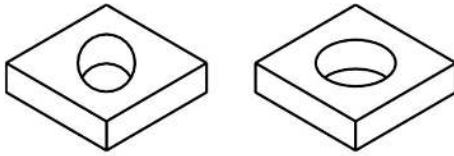
The steps needed to sketch it in isometric would be;



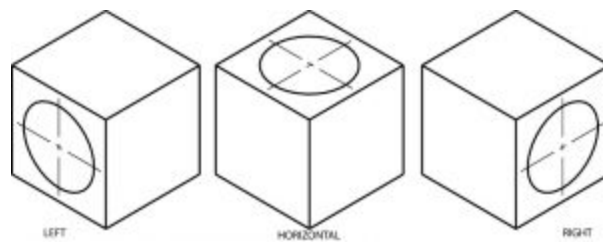
The unnecessary lines are then removed, leaving the object. Once you gain some practice at this, it will be possible for you to make an ISO drawing without the “guide” lines. It is important to use them early on the help train your brain.

To the beginner, building a “frame” before sketching the object often seems unnecessary. That may be true with simple objects. However, when things become more complex, a frame gives you a means of developing the various parts in an organized way. Without such guidelines you can easily “lose” your sketch.

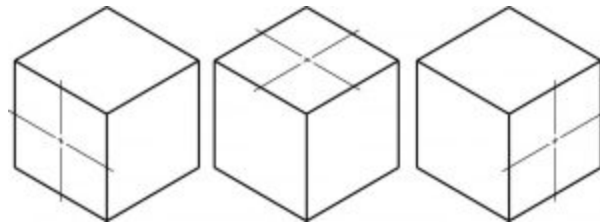
Circles and arcs, when sketched in isometric, become elliptical in shape. If a circle is used, it will appear distorted, as in this example:



In sketching isometric circles and arcs, there are three positions in which they are normally sketched, depending upon the surface where the circular feature is located. Those surfaces, or picture planes are:



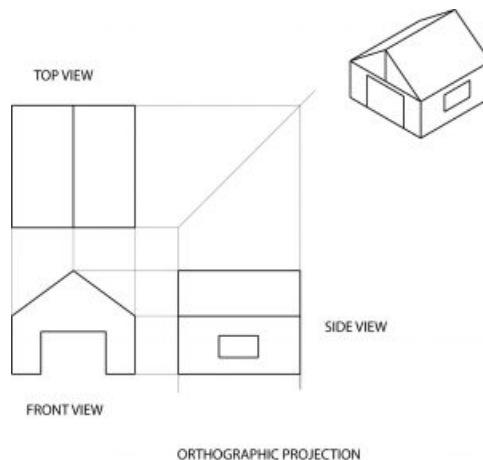
On the cube shapes below sketch ellipses as on the examples above.



Orthographic Sketching

Of all the methods of making drawings, orthographic projection is the most commonly used by draftsperson. Although the other methods serve their purposes, they cannot always show the parts of an object as well as orthographic representation.

Orthographic projection is a system of projecting from view to view to graphically describe the object. As a way of reviewing, study the views of the small garage in this drawing. Notice the location and relationship of each view to the other views.



The important thing to remember in orthographic sketching is the alignment of views. The top view is projected directly above the front view. The front and side view also line up with each other. The height, width, and length of the object must remain the same from view to view. There should be enough distance between the views to prevent crowding; and to leave room for dimensions.

“On-THE-SPOT” Sketching

Now that you have learned the three different methods of sketching, it is time to make sketches you can place in front of you and touch, rather than sketching from drawings on paper.

Sketching “ON-THE-SPOT” is a standard industry practice. A piece of machinery needs to be changed, a support needs to be added, or pictorial information in some way requires a sketch.

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4.1.4: Dimensioning

If a drawing is to be complete, so that the object represented by the drawing can be made as intended by the designer, it must tell two complete stories. It tells this with **views**, which describe the shape of the object, and with **dimensions and notes**, which gives sizes and other information needed to make the object.

Therefore, your next step is to learn the basics of dimensioning. In that way you will understand not only how to interpret a drawing to get the information you need, but also how to dimension your sketches so that they can be used to communicate size information to others.

When deciding how and when to use dimensions, three principles must be followed:

1. Do not leave any size, shape, or material in doubt.
2. To avoid confusion and the possibility of error, no dimension should be repeated twice on any sketch or drawing.
3. Dimensions and notations must be placed on the sketch where they can be clearly and easily read.

Numerals

It may seem a bit basic, but a few exercises with the shapes of numbers comes before dimensioning. The reason for such review is simply that incorrectly or carelessly made numbers on a drawing or sketch can easily be misinterpreted by someone on the job. That can be costly.

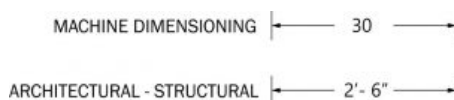
Therefore, the study of numbers forms is justified.

The number forms presented here have been determined to be the most legible, and are used by industry nationwide. The United States standardized 1/8" vertical numbers are correctly formed as follows:

1 2 3 4 5 6 7 8 9 0
 1/2 1/4 3/4 7/8 1 1/16 4 3/4"
 10'-6 3/4" 20'-7 5/16"

Dimension Lines

The dimension line is a fine, dark, solid line with arrowheads on each end. It indicates direction and extent of a dimension. In machine sketches and drawings, in which fractions and decimals are used for dimensions, the dimension line is usually broken near the middle to provide open space for the dimension numerals. In architectural and structural sketches and drawings, the numerals are usually above an unbroken dimension line.

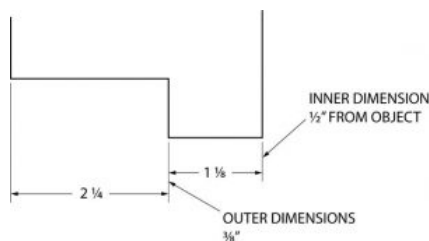


In either case, the dimension line which is closest to the object should be placed approximately

1/2" away. The other dimensions beyond the first dimension (if any) should be approximately 3/8" apart. You do not necessarily have to remember this, but you should remember not to crowd your dimension lines and to keep them a uniform distance apart.

The most important thing is that the drawing needs to be "clean" and dimensions need to be located in a space where they cannot be confused with a surface they are not intended to be used for.

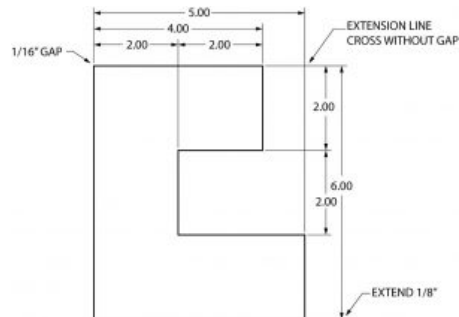
Here is how dimension lines should be sketched:



Be sure that it is clear how dimensions are called out. When calling out dimensions that are over 12", make sure ALL of dimensions are called out in total inches or feet inches throughout the entire drawing. Either 4'-5" or 53", they both mean the same thing but if there is a mix of dimensioning it can become easy to look at 4'-8" and see 48".

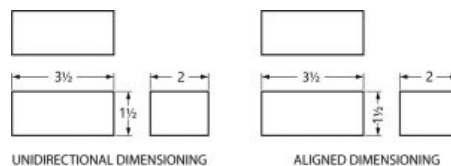
Extension Lines

Extension lines on a drawing are fine, dark, solid lines that extend outward from a point on a drawing to which a dimension refers. Usually, the dimension line meets the extension line at right angles. There should be a gap of about $1/16"$ where the extension line would meet the outline of the object, and the extension line should go beyond the outermost arrowhead approximately $1/8"$. Also, there should be not gaps where extension lines cross. Notice in this example the larger dimensions are correctly placed outside, or beyond the shorter dimensions, and that the dimensions are preferably not drawn on the object itself. Sometimes, however, it is necessary to dimension on the object.

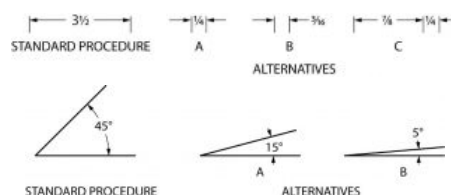


It is important to remember to place dimensions on the views, in a two or three view drawing, where they will be the most easily understood. Avoid dimensioning to a hidden line and avoid the duplication of dimensions. Use common sense; keep dimensions as clear and simple as possible. Remember, the person reading your drawing needs to clearly understand, beyond question, how to proceed. Otherwise, costly time and material will be wasted.

There are two basic methods of placing dimensions on a sketch. They may be placed so they read from the bottom of the sketch (unidirectional dimensions) or from the bottom and right side (aligned dimensions). The unidirectional system is usually best, because it is more easily read by workmen.



When dimensions will not fit in a space in the usual way, other methods are used to dimension clearly, when those crowded conditions exist.



Arrowheads

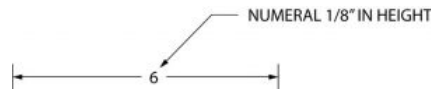
Arrowheads are placed at each end of dimension lines, on leader lines, etc. Correctly made, arrows are about $1/8"$ to $3/16"$ in length, and are about three times as long as they are wide. Usually they have a slight barb, much like a fishhook.

To make your drawing look clean, use the same style throughout your drawing or sketch.

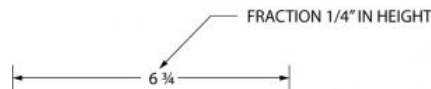


Dimension numerals

Numerals used to dimension an object are normally about $\frac{1}{8}$ " in height.



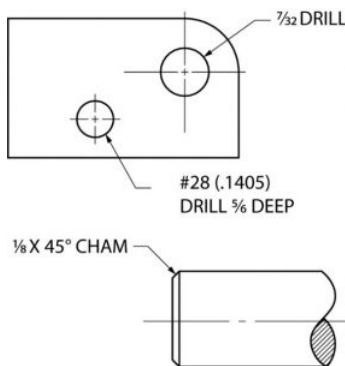
When a dimension includes a fraction, the fraction is approximately $\frac{1}{4}$ " in height, making the fractional numbers slightly smaller to allow for space above and below the fractional line.



Again, it is particularly important that the numbers and fractions you may put on a sketch or drawing be legible. Sloppy numbers can cause expensive mistakes.

Notes

Notes are used on drawings to provide supplementary information. They should be brief and carefully worded to avoid being misinterpreted, and located on the sketch in an uncrowded area. The leader lines going to the note should be kept short. Notes are usually added after a sketch has been dimensioned to avoid interference with dimensions.

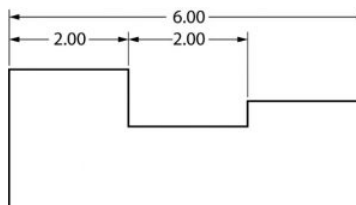


Orthographic Dimensioning

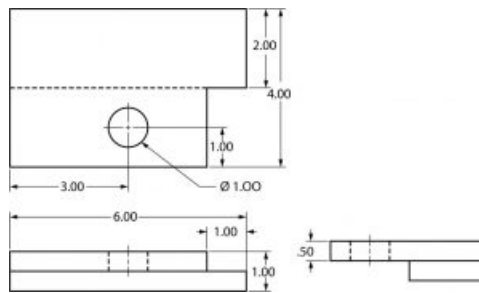
When you look at the dovetailed object several pages back, it is easy to see that an isometric sketch can quickly become cluttered with dimensions. Because of this, more complicated sketches and drawings are dimensional in orthographic. This method provides the best way to dimension clearly and in detail.

Here are seven general rules to follow when dimensioning.

- Show enough dimensions so that the intended sizes can be determined without having a workman calculate or assume any distances.
- State each dimension clearly, so it is understood in only one way.
- Show dimensions between points, lines or surfaces which have a necessary relationship to each other or which control the location of other components or mating parts.
- Select or arrange dimensions to avoid accumulations of dimensions that may cause unsatisfactory mating of parts. (In other words, provide for a buildup of tolerances, as in the example below.



- Show each dimension only once. (Do not duplicate dimensions).
- Where possible, dimension each feature in the view where it appears most clearly, and where its true shape appears.
- Whenever possible, specify dimensions to make use of readily available materials, parts and tools.



Notice the dimensions are correctly placed between the views, rather than around the outside edges of the drawing.

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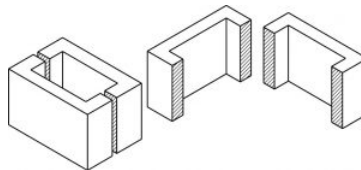
4.1.5: Sectional Views

You have learned that when making a multiview sketch, hidden edges and surfaces are usually shown with hidden (dash) lines.

When an object becomes more complex, as in the case of an automobile engine block, a clearer presentation of the interior can be made by sketching the object as it would look if it were cut apart. In that way, the many hidden lines on the sketch are eliminated.

The process of sketching the internal configuration of an object by showing it cut apart is known as sectioning. Sectioning is used frequently on a wide variety of Industrial drawings.

In this example, blocks A and B result after the block in figure 1 has been “Sectioned”. When you cut an apple in half you have sectioned it. Just as an apple can be sectioned any way you choose, so can an object in a sectional view of a drawing or sketch.

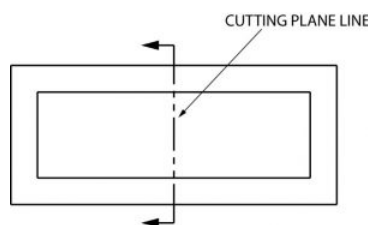


Cutting Plane

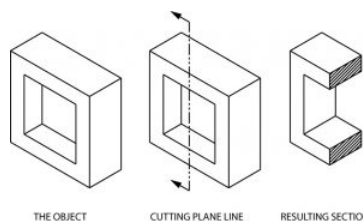
A surface cut by the saw in the drawing above is a cutting plane. Actually, it is an imaginary cutting plane taken through the object, since the object is imagined as being cut through at a desired location.

Cutting Plane Line

A cutting plane is represented on a drawing by a cutting plane line. This is a heavy long-short-short-long kind of line terminated with arrows. The arrows in show the direction of view.



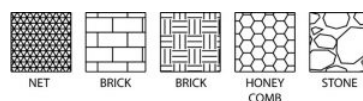
Once again, here is an graphic example of a cutting plane line and the section that develops from it.



Section Lining

The lines in the figure above, which look like saw marks, are called section lining. They are found on most sectional views, and indicate the surface which has been exposed by the cutting plane. Notice that the square hole in the object has no section lining, since it was not changed by sectioning.

Different kinds of section lining is used to identify different materials. When an object is made of a combination of materials, a variety of section lining symbols makes materials identification easier. Here are a few examples:

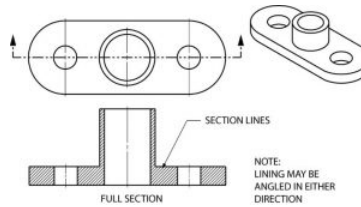


Section lines are very light. When sketching an object or part that requires a sectional view, they are drawn by eye at an angle of approximately 45 degrees, and are spaced about 1/8" apart. Since they are used to set off a section, they must be drawn with care.

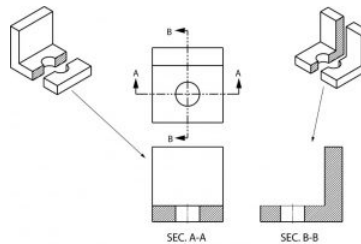
It is best to use the symbol for the material being shown as a section on a sketch. If that symbol is not known, you may use the general purpose symbol, which is also the symbol for cast iron.

Full Sections

When a cutting plane line passes entirely through an object, the resulting section is called a full section Fig. 7 illustrates a full section.

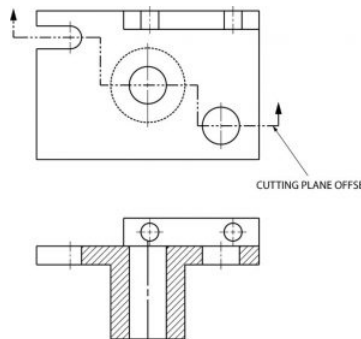


It is possible to section an object whenever a closer look intentionally is desired. Here is an object sectioned from two different directions.



Offset Sections

An offset section is a means of including in a single section several features of an object that are not in a straight line. To do this, the cutting plane line is bent, or “OFFSET” to pass through the features of the part.



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4.2: Mechanical Drafting

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SECTION OVERVIEW

4.2.1: Drafting Tools and Materials

Traditionally, drafters sat at drafting boards and used pencils, pens, compasses, protractors, triangles, and other drafting devices to prepare a drawing manually. Today, however, most professional drafters use computer-aided drafting (CAD) systems to prepare drawings. Although drafters use CAD extensively, it is only a tool. Drafters and tradespersons still need knowledge of traditional drafting tools and techniques.

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4.2.1.1: Tools

Drafting tools are needed to lay out the different shapes and lines used to create drawings and sketches. Basic knowledge of the available tools and how to use them will assist you in your drawing.

Drafting board or table

The drafting board is an essential tool. Paper will be attached and kept straight and still, so the surface of the drafting board must be smooth and true, with no warps or twists. The surfaces of most drafting boards are covered with vinyl because it is smooth and even.

The drafting board or table should have two parallel outside working edges made of either hardwood or steel.

Most drafting table tops can be set at different heights from the floor and at any angle from vertical to horizontal. Other drafting tables may not have the same adjustments and may be limited to being raised only from horizontal to a low slope.

To reduce back strain, use an adjustable drafting stool when working at a drafting table. Tables or boards should be a minimum of 1.2 m (4') in width and 0.9 m (3') in height.

T-square

The fixed head T-square is used for most work. It should be made of durable materials and have a transparent edge on the blade. To do accurate work, the blade must be perfectly square and straight, which should be checked regularly.

The T-square is used to draw horizontal lines and align other drawing instruments. If you are right-handed, you hold it tight against the left edge of the drawing board and move it up and down as required. When you make close adjustments, your fingers should be on top of the square, and you should use your thumb to control the T-square's movement, Figure 4.2.1.1.1



Figure 4.2.1.1.1 A person using a T-square

When drawing horizontal lines, incline your pencil in the direction you are drawing the line. Hold the pencil point as close as possible to the blade. Roll the pencil between your fingers to prevent the point from becoming flat on one side.

Triangle

A triangle (set-square) is made of clear plastic. Some triangles have rabbeted edges (Figure 4.2.1.1.2) so that when you draw lines, the corner of the edge is set away from the paper to help prevent smudges and ink blotches.

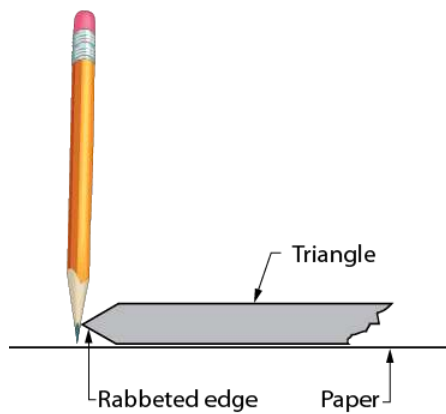


Figure 4.2.1.1.2 Hold a pencil vertical against the rabbeted edge

Triangles are available in 45° - 90° - 45° or 30° - 60° - 90° combinations. For most work, triangles should be about 200 mm to 250 mm (8" to 10") long. Triangles should be stored flat to prevent warping and not stored underneath other objects to prevent any pressure from causing them to deform.

Check a triangle for accuracy by drawing a perpendicular line, then reversing the triangle and drawing another perpendicular line (Figure 3).

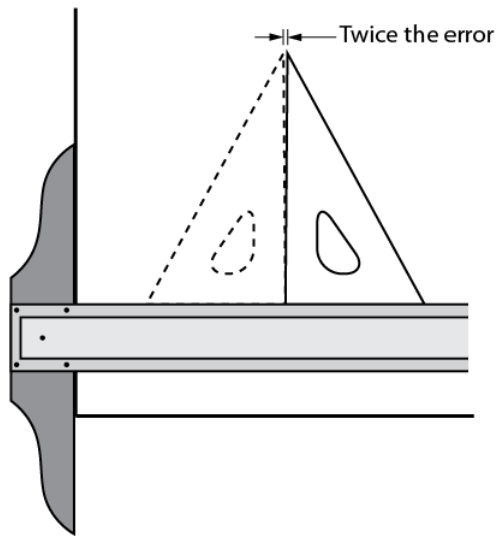


Figure 4.2.1.1.3 Testing a triangle

Triangles are used to draw vertical lines and other lines at set angles. Rest the triangle on the T-square blade and slide it along the blade to the desired location. Draw the full length of the vertical line in one pass if possible. Hold the blades of the T-square and the triangle together to prevent movement when you are drawing, and hold the pencil point as close as possible to the triangle. You can also draw 15° and 75° angles by using both a 45° - 90° - 45° and a 30° - 60° - 90° in combination. Figure 4.2.1.1.4 shows how triangles are placed to draw angles that are every multiple of 15° .

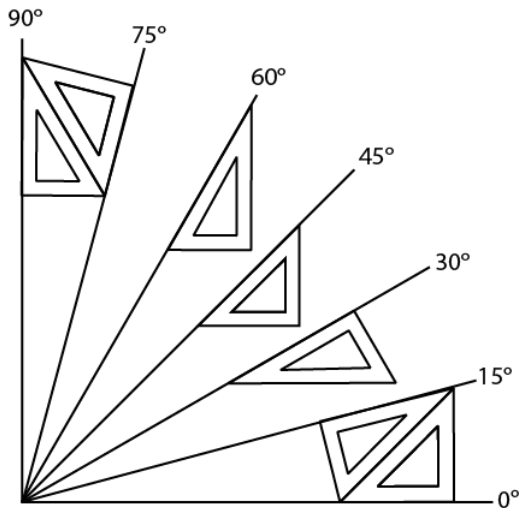


Figure 4.2.1.1.4 How to create the most common angles with triangles

Protractor

A protractor, Figure 4.2.1.1.5 is an instrument used to measure angles. It is typically made of transparent plastic or glass. Protractors can be used for checking and transferring angles to and from a drawing sheet.

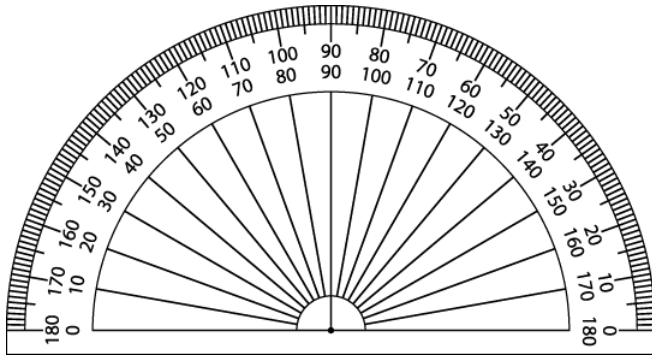


Figure 4.2.1.1.5 Protractor

Drafting machine

A drafting machine (Figure 4.2.1.1.6) is a device that is mounted to the drawing board. The drafting machine replaces the T-square and triangles, as it has rulers with angles that can be precisely adjusted with a controlling mechanism. A drafting machine allows easy drawing of parallel lines over the paper. The adjustable angle between the rulers allows the lines to be drawn at various accurate angles. The rulers are replaceable and can be replaced with scale rulers. Rulers may also be used as a support for separate special rulers and letter templates.



Figure 4.2.1.1.6 Drafting machine

Drawing pencils

Both wood and mechanical pencils are used for drafting (Figure 4.2.1.1.7). Manufacturers grade drawing pencils using numbers and letters. These range from 6B (very soft and black) to 9H (the hardest). From 6B, the pencils progress through 5B, 4B, 3B, 2B, B, and HB, and then to F, the medium grade. After that, they move to the harder graphite: H, 2H, 3H, 4H, 5H, 6H, 7H, 8H, and finally 9H. The softer grades are used for sketching and rendering drawings. The harder grades are used for instrument drawings. Mechanical pencils do not require sharpening and are made to hold leads (they are actually made of graphite) that are bought separately. Thin-lead mechanical pencils, with leads as small as 0.5 mm, are available in different grades of lead. Most draftspersons use four or five different mechanical pencils with a different lead in each. The pencils come in different colors, so it is easy to track which lead is in each.



Figure 4.2.1.1.7 Wood and mechanical pencils

Erasers and erasing shields

The best eraser to use on drawings is either a soft pink eraser with beveled ends or a white plastic eraser. Electric rotary erasers are also available. They permit easy erasure of small errors without erasing adjacent lines. A metal erasing shield helps to confine erasures to the desired area. Erasing shields are made from very thin stainless steel and have holes of various shapes to accommodate the sections to be erased. Figure 4.2.1.1.8 shows two erasers and an erasing shield.



Figure 4.2.1.1.8 Erasers and erasing shields

Templates

Templates (Figure 4.2.1.1.9) are available for many different trades. Templates incorporate cut-outs of symbols and fixtures commonly used in that trade. These cut-outs make it easy to trace shapes onto drawing paper.

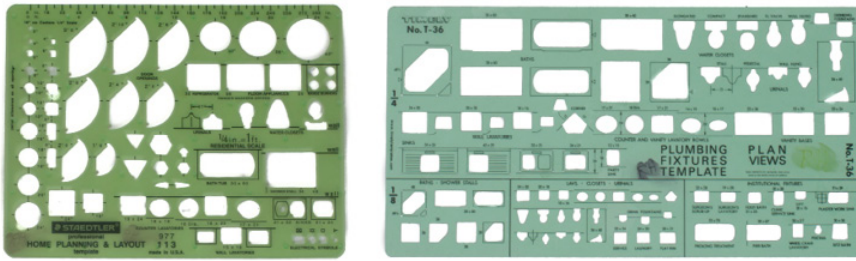


Figure 4.2.1.1.9 Templates

French curves and splines

A French curve (4.2.1.1.10) is a plastic template designed to help you draw curves. The French curve contains many different curves, but each is represented over a very short distance only. One radius of the curve blends into another radius. It takes a lot of practice to use French curves effectively.



Figure 4.2.1.1.10 French Curve

A spline or flexible curve (Figure 11) can be used instead of a French curve to draw most curves. A spline is a plastic or rubber rod that is reinforced with metal. To use a spline, bend it to the shape of the curve you need. The design of the spline lets you hold a pencil against an edge and draw an accurate line without smudging. A spline cannot be used to draw curves with a very short radius because the spline will not bend tightly.



Figure 4.2.1.1.11 Spline

Compass

A compass can be used for drawing circles, bisecting lines, or dividing angles. For very large circles, you can use a beam compass. The four types of compasses are shown in Figure 4.2.1.1.12— Figure 4.2.1.1.14 Most compasses can be fitted with leads, pens, or points.



Figure 4.2.1.1.12 Friction Compass



via source)

Figure 4.2.1.1.1 Copy and Paste Caption here. (Copyright; author



Figure 4.2.1.1.13 Wing Compass



Figure 4.2.1.1.14 Beam Compass

When using the compass, tilt it in the direction of the line, as shown in Figure 13

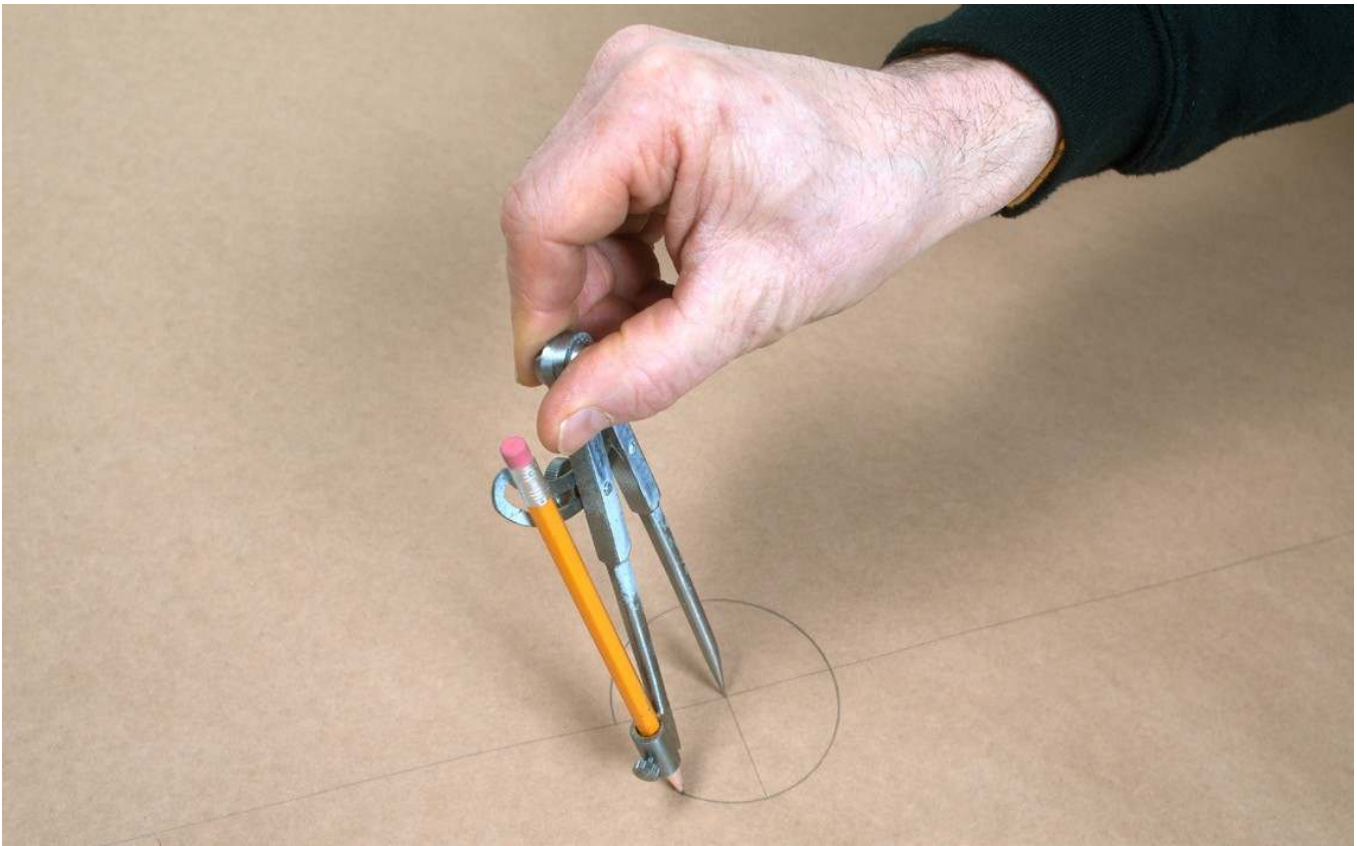


Figure 4.2.1.1.15 Drawing a circle with a compass

Dividers

Dividers (Figure 4.2.1.1.10) are used for transferring dimensions from a drawing to a measuring device such as a ruler or scale. They are also used when scribing directly on material like metal.

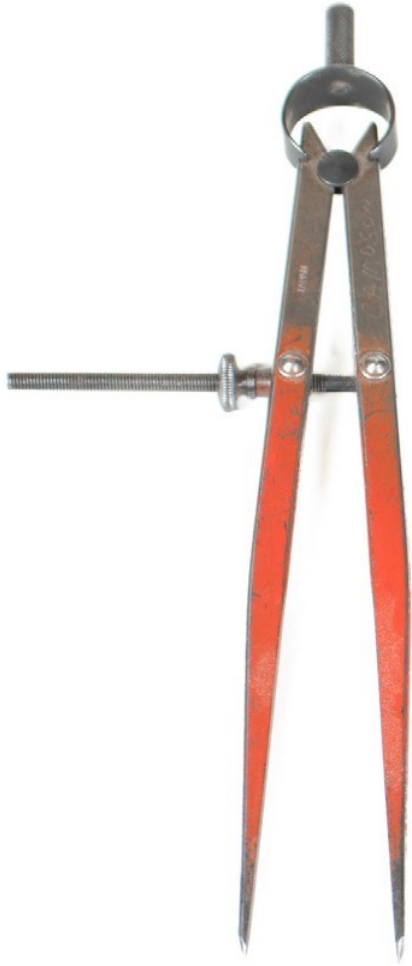


Figure 4.2.1.1.16 Dividers

Dusting cloth or brush

It is essential to keep your drawings and drafting surface clean. When equipment gets dirty from the lead pencils, you should clean it regularly so that it does not smudge your drawings. Any soft, clean cloth is suitable. You may want to wash your board occasionally with a spray cleaner.

Use a brush like the one in Figure 4.2.1.1.17 to clean your table before placing paper down and sweep away any debris as you draw. If you use your hand to brush, you could leave marks on the paper. After sharpening a pencil, wipe off any dust clinging to the pencil's point to prevent smudging.



Figure 4.2.1.1.17 Dusting Brush

Scale rulers

Scale rulers let you draw diagrams at a reduced scale. They also let you obtain dimensions from a scaled drawing. Scale rulers come in various types to meet the requirements of many kinds of work. Most scale rulers have three edges and six different scales. The scales are read from either end of the rule. A typical combination of metric scales is 1:20, 1:50, 1:100, 1:25, 1:75, and 1:125.

Because of the decimal basis of metric measurements, metric scale rulers are both applicable and easy to use at any scale. Figure 4.2.1.1.18 shows the two scales from both ends of the same side.

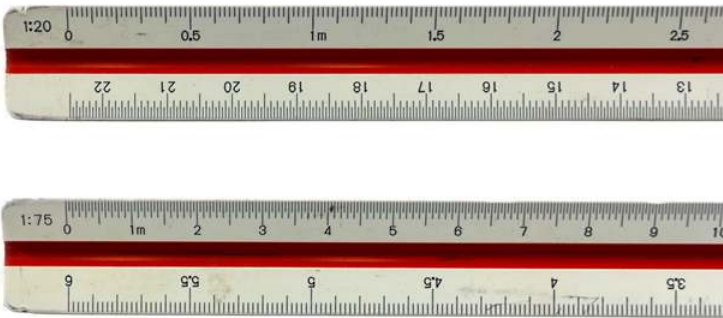


Figure 4.2.1.1.18 Metric scale ruler

Imperial scale rulers may be an architect's ruler, a mechanical engineer's ruler, or a civil engineer's ruler (Figure 17). The architect's scale ruler is the most common and is in inches and fractions of inches. A mechanical engineer's scale ruler comes in inches and decimals of inches. A civil engineer's scale ruler comes in feet and decimals of feet.

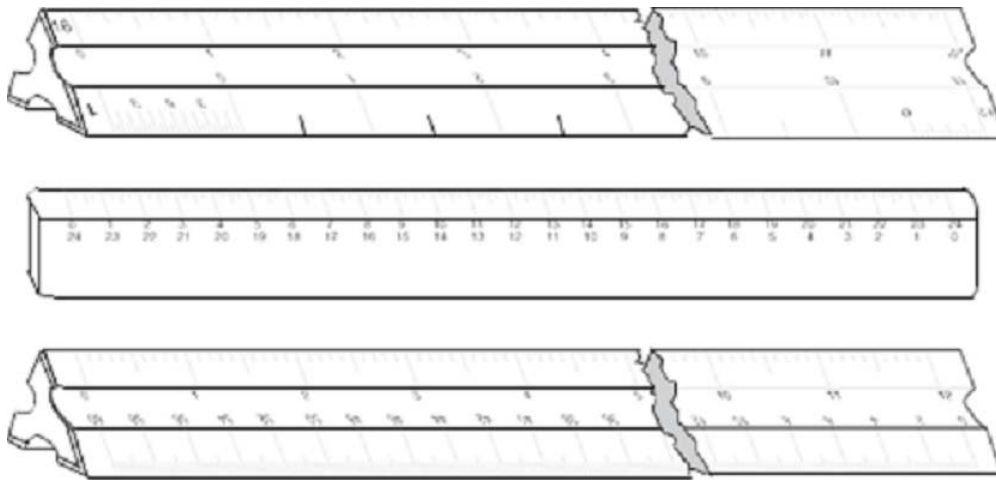


Figure 4.2.1.1.19 Imperial Scale

Rulers

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4.2.1.2: Computer drafting printing

Computer drafting programs are used effectively for all manner of drafting and have virtually replaced manual drafting. Small size computer-generated drawings can be printed on normal computer printers. However, larger drawings require a plotter. Older plotters used pencils, pens, or felt pens, but the new plotters are laser-based or jet printers and are capable of multiple colors. They are made to print all the sizes of drawings. Plotters also print well on vellum and some other non-paper media. We will cover CAD drafting later in this chapter.

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SECTION OVERVIEW

4.2.2: Use scale rulers to determine actual dimensions from drawings

4.2.2.1: Prelude to Scales

4.2.2.2: Using an Architects Scale Ruler

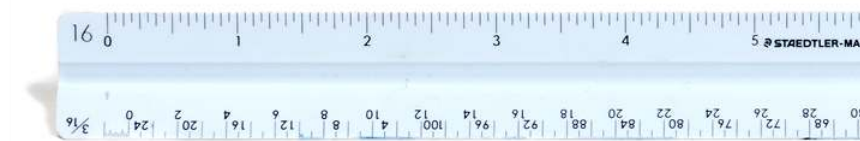
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4.2.2.1: Prelude to Scales

Use scale rulers to determine actual dimensions from drawings

Scale drawings are accurate and convenient visual representations made and used by engineers, architects, and people in the construction trades. The accuracy is achieved because the drawing is proportional to the real thing. The convenience comes from the size of the drawing. It is large enough to provide the desired detail but small enough to be handy.

The flexibility to draw proportionally in different sizes is provided by scales. For the purposes of representation, we will only be concerned with reduction scales. Reduction scales make the drawing smaller than the object. The kinds of rulers we will be discussing for making scaled drawings are the architect's scale shown in Figure 1.



Architect's scale ruler

Architect's scale rulers

The scale of the drawing is always written on the drawing, unless the drawing is not drawn to scale. In the latter case, this will be indicated by the "not to scale" abbreviation (NTS). The scale is the ratio of the size of the drawing to the object. For drawings smaller than the object, the ratio is that of a smaller distance to a larger one.

The architect's scales use ratios of inches to a foot. One of the most common architect's scale used is 1/4 inch to the foot, written on drawings as:

Scale 1/4" = 1'-0"

This means that a line 1/4" long on the drawing represents an object that is one foot long in real life. At the same scale, a line 1 1/2" long represents an object 6' long, because 1 1/2" contains 6 quarter-inches.

Figure 2 lists the scale ratios used for building plans and construction drawings in both metric and the approximate equivalent architectural scale ratios.

Type of Drawing	Imperial Equivalents and Ratios		Use
Sketch plans	1/16" = 1'-0"	1:192	- To show the overall design of the building - To indicate the juxtaposition of the rooms and locate the positions of piping systems and components
Ground Plans	1/8" = 1'-0"	1:96	
Design Drawings	1/4" = 1'-0"	1:48	
Construction details	1/2" = 1'-0"	1:24	To show the detail of system components and assemblies
	1" = 1'-0"	1:12	
	3" = 1'-0"	1:4	
	Full size	1:1	

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4.2.2.2: Using an Architects Scale Ruler

Architect's (imperial) scales

Traditional architectural measurements of length are written very precisely in feet and inches using the appropriate symbols for feet and inches separated by a dash (e.g., 4'-3 1/2" and 7'-0"). This is the way that all imperial measurements are written on construction drawings. In the United States, we use imperial measurements of feet and inches, not the ubiquitous metric system of meters used across the world.

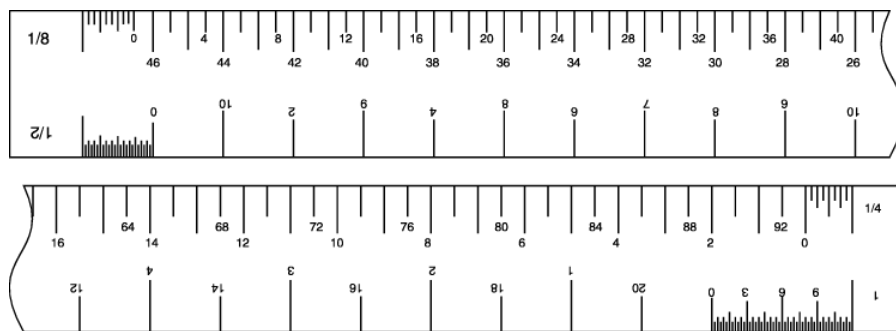
Listed below are the scales found on the architect's triangular scale ruler.

1. 3/32" = 1'-0"
2. 3/16" = 1'-0"
3. 1/8" = 1'-0"
4. 1/4" = 1'-0"
5. 3/4" = 1'-0"
6. 3/8" = 1'-0"
7. 1" = 1'-0"
8. 1/2" = 1'-0"
9. 1 1/2" = 1'-0"
10. 3" = 1'-0"
11. 1" = 1" (full size—use the scale Labeled 16)

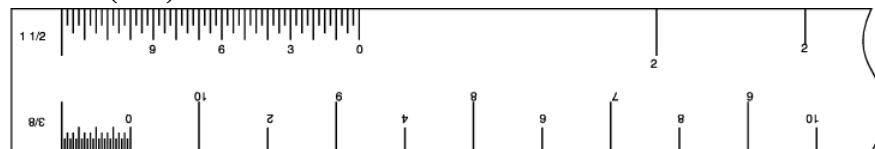
Figure 3 shows one face of an architect's imperial triangular scale ruler. There are two edges on each face and each edge contains two scales that run in opposite directions. At each end of an edge, a number or fraction indicates the distance in inches that represents one foot. The top edge is in eighths of an inch from left to right, and in quarters of an inch from right to left. Note that the 1/8" scale from 0 to the right end represents 95 feet, and the 1/4" scale from 0 to the left end represents 47 feet. Whenever using a scale ruler, always begin your measurement at "0" and slowly slide the ruler over until you have the end of the line you are measuring in alignment with an even foot measurement.

Inches

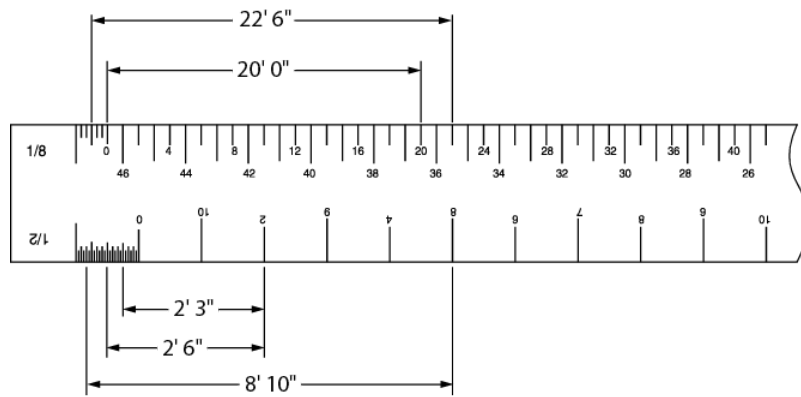
The small lines at the end of the ruler represent one total foot in that scale. The small hash marks evenly divide that foot into inches and fractions of an inch.



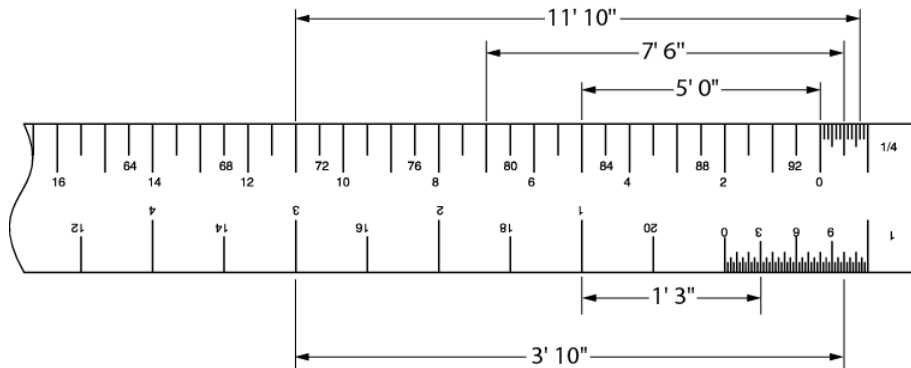
3. One face of an architect's ruler (NTS)



4. Units in an architect's scale ruler (NTS)



5. Reading dimensions using an architect's ruler (NTS)



6. Reading dimensions using an architect's ruler (NTS)



Architectural units have feet divided into inches, whereas engineering units divide feet into tenths and hundredths. Engineers' scales and metric scales are not used in theatre.

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SECTION OVERVIEW

4.2.3: Interpreting scale drawings

Interpreting drawings requires the ability to visualize and the ability to interpret what is being drawn and written. The drawing should be studied carefully before beginning any work. The reader should attempt to visualize what is being shown on the drawing and how it will be built. Mistakes can be made when the tradesperson does not take the time to become fully familiar with the drawing.

4.2.3.1: Basic layout of a drawing

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4.2.3.1: Basic layout of a drawing

The layout of most drawings is similar in that the drawing format has some standard features or components. A typical drawing format will include some or all of these features:

- title block
- bill of materials or material list
- area where the job specifications are listed
- general notes
- reference drawing list
- revision chart

These drawing components are common for some types of drawings; however, other components may be used to show the necessary information for the complete design.

Each of the listed drawing components serves a specific purpose and contains information about the job and its specifications, Figure 4.2.3.1.1

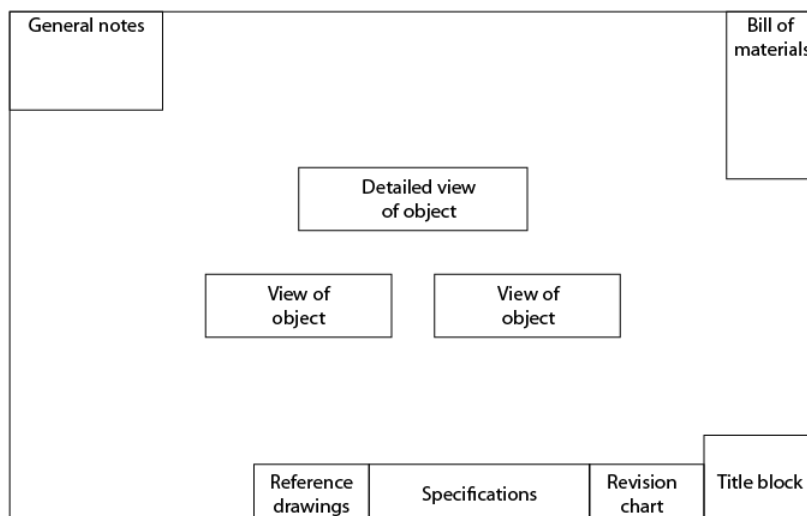


Figure 4.2.3.1.1 Drawing format

The following information is a guideline to use each time a new drawing is observed.

Title block

The title block is located in the lower right corner of the drawing and is separated from the main drawing. The contents of the title block will vary from company to company and often differ from drawing to drawing by the same company. As a standard feature, a company will have its name and logo in the title block along with other standard company information, plus particular information such as the customer's name.

The following information can be located in the title block; however, note that not all of the items listed below are necessarily included:

- job title
- name of the item to be fabricated or installed
- name of the customer
- name of the designing engineer or firm
- name or initial of draftsperson and checker
- date drawn
- drawing number
- contract number or job number
- number of revisions, if any, for the drawings
- scale of the drawing

Bill of materials

The bill of materials is usually located in the upper right corner of the drawings, above the title block. As with the title block, the bill of materials is separated from the rest of the drawing and is essentially a table with partitioned rows and columns showing:

- item number or mark number
- quantity
- material description
- material grade
- material weight
- remarks

Revision chart

The revision chart, is often located to the left of the title block, and is bordered off from the rest of the drawing. The revision chart, like the bill of materials, is divided into rows and columns. These columns identify the revision number and give a general description of the revision, who checked the revision, and the date of the revision. It is essential to make sure that you are working from the latest revision, as it is not uncommon for changes to be made from the original drawing.

Drawing specifications

The specifications section of a drawing is used to list all the design information of the item being built or installed. This section is often located to the left of the revision chart. If drawing space is a problem, it may be located elsewhere. A common location is the area below the bill of materials. (The contents of specifications are covered in more detail later.)

Drawing notes

Drawings will often contain two types of notes: general and specific. The general and specific notes should not be confused with the information found in the bill of materials, title block, revision chart, or the drawing specifications.

The general notes are usually located in the upper left corner of the drawing. A general note is information about the fabrication that refers to similar items or procedures throughout the drawing. Specific notes can be found anywhere on the drawing as needed and are most often written with a leader line pointing to the relevant part or area.

Reference drawings

A job requiring more than one drawing is called a drawing set, and it contains two or more drawings. It is a common practice to have a list of all of the drawings that make up the drawing set. This listing is referred to as the reference drawings for the project.

Often work being shown on one drawing requires you to look at or reference other drawings in the set. There is no specific area where the reference drawings are listed; however, two common locations are near the bottom of the print on the far left-hand side, and just below the bill of materials.

Specifications

Specifications in North America form part of the contract documents that accompany and govern the construction of a building. Specifications are written descriptions of the materials and procedures that must be used in constructing a building or system. These specifications translate working drawings into words to ensure that systems will be neither overdesigned nor underdesigned. They tell the contractor exactly which materials must be used. Aside from serving as a manual on how to do the job, the book of specifications has another function: it is a legal document outlining each contractor's obligations. These obligations may include the need to provide fire insurance, to pay for municipal inspections, or to complete the job by a certain deadline.

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CHAPTER OVERVIEW

5: Tools and Materials

5.1: Hand and Power Tools

5.1.1: Tool Choices and Applications

5.1.2: Measuring, Marking, Leveling and Layout Tools

5.1.3: Nails, Hammers and Pneumatic Nailers

5.1.4: Threaded Fasteners, Drivers, Pliers and Wrenches

5.1.5: Saws

5.1.6: Drills and Accessories

5.1.7: Grinders, Sanders, and Accessories

5.2: Construction Materials

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SECTION OVERVIEW

5.1: Hand and Power Tools

In general, tools are categorized based on both their type of tool (e.g. cutting, marking, and measuring) and what power them. There are three main ways tools are powered - electricity, air (pneumatic), and gas - although gas powered tools are not common in theatre. The following categories contain tools of all different power types and are organized by their purpose.

5.1.1: Tool Choices and Applications

5.1.2: Measuring, Marking, Leveling and Layout Tools

5.1.3: Nails, Hammers and Pneumatic Nailers

5.1.4: Threaded Fasteners, Drivers, Pliers and Wrenches

5.1.5: Saws

5.1.6: Drills and Accessories

5.1.7: Grinders, Sanders, and Accessories

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5.1.1: Tool Choices and Applications

Although there are numerous advantages to choosing tools based on many factors, safety should be the first factor to be considered.

Always choose the right tool for the job- Remember that tools have specific functions.

- Screwdrivers are not impact resistant and should never be used as a chisel or pry bar.
- Accessories used in cordless impact drivers must be rated for impact use.

Determine the scope of work- Consider where you will be working:

- Small or large project?
- What tasks will you be performing?
- How much space do you have to safely perform your tasks?
- What are the tools best suited to the tasks?
- What PPE is required for each task?



Figure 5.1.1.1 Construction Technology Program C3T Image 8366 is licensed under CC BY 4.0

Material type and size- Choice of tools and accessories should be based on the type and size of material being used.

Examples:

- Specially designed masonry drill bits, saw blades, and grinding wheels are used for masonry, concrete, brick and tile.
- Anchor bolts are rated by the amount of weight they will safely support, with many styles available for application with specific materials.
- A circular saw may be better suited for the task than a table or miter saw for small jobs.
- Do the material and tools to be used require an additional person to assist in the safe completion of the task due to the weight or physical size of the material?



Figure 5.1.1.1 UHMC Construction Technology Program, C3T Image 8252 is

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5.1.2: Measuring, Marking, Leveling and Layout Tools

Measuring and marking tools are common to multiple trades and ensure accuracy and quality craftsmanship in the building and construction process. Measuring devices are available in fractional and metric, with classic western construction practices adopting the fractional inch configuration. While some measuring tools have the actual fractions printed ($1/2"$, $1/4"$, and $1/8"$) next to each corresponding mark on the scale, many do not and the ability to read the scale without the printed fractions may take time to develop. This is one of many reasons for the adage: "Measure twice, cut once", which is a good habit to develop and will help to avoid costly mistakes such as over cutting and wasting material or under cutting, resulting in having to remeasure and cut the material again.

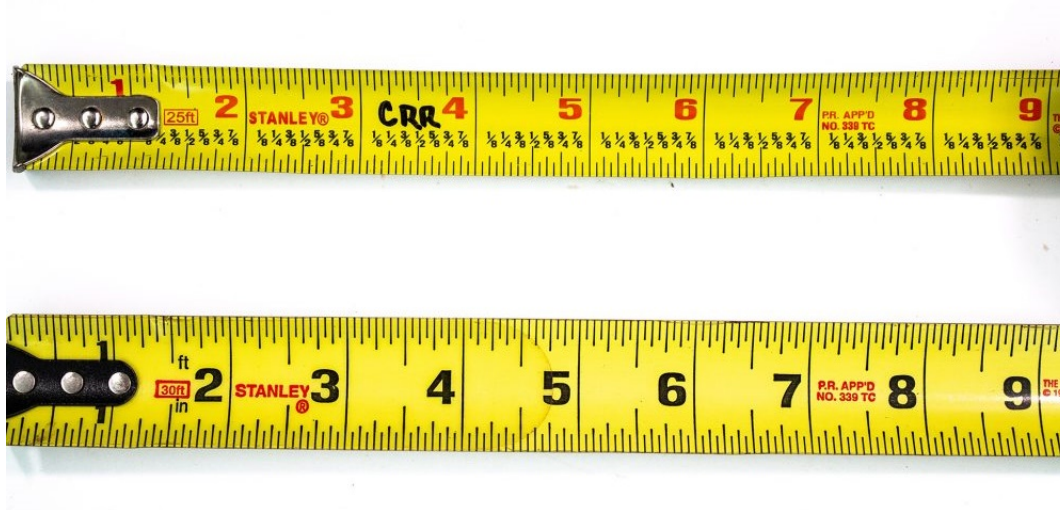


Figure 5.1.2.1 Fractional

Marked & Unmarked Tape Measures by Gwen Arkin is licensed under CC BY 4.0

While many of the following tools may be considered "carpentry" tools, the majority are regularly used in most all trades. Apparent common items to all trades include measuring devices like tape measures, rulers, and basic estimation tools; plumbers and electricians will use spirit levels, builders levels, and angle finders to ensure that piping is at an appropriate grade or conduit, fixtures, and other items are installed to meet industry codes.

Levels are used to check for **level (horizontal)** and **plumb (vertical)**. Trades persons will often use a combination of various levels and squares to complete a project.

Squares are used for layout work to mark square (90° /right angle) and other angles commonly used in building and construction trades indicated on specific types of squares. They are also used to check for squareness and other angles during assembly. Squares can be made of inexpensive molded plastic, lightweight aluminum or durable steel.

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5.1.3: Nails, Hammers and Pneumatic Nailers

Nails

Nails of all sizes are commonly used to assemble wood products when glue and adhesives are not of sufficient strength for a project. They are known by number size, the lesser the number, the smaller the length and diameter. The number is followed by the letter “d”. The d is the symbol for penny, which can be traced back as far as the Ancient Roman Empire. There are various theories as to how the measurement term came to be, but what is confirmed is that the d stands for the Roman coin denarius, or in English, the penny. The denarius was the coin which many people used in the Roman empire at the time when Rome occupied what is now England, so that’s why it’s called a penny but uses a “d” as the symbol.

Some styles of nails have larger heads for greater holding power while others have smaller or no head so that it can be set flush with or lower than material surfaces for cosmetic applications. When “headless” finish or casing nails are used, it is best to drive them to just slightly above the surface while being careful not to leave hammer marks on the material’s being nailed surface and then use a “nail set” tool to embed the nail.

Size	Length (inches)	Diameter (inches)	Standard Wire Guage	Number Per Pound
2d	1	0.072	15	900
3d	1.25	0.080	14	615
4d	1.5	0.090	12	322
5d	1.75	0.098	12	254
6d	2	0.113	11	200
7d	2.25	0.113	11	154
8d	2.5	0.131	10	106
9d	2.75	0.131	10	85
10d	3	0.148	9	74
12d	3.25	0.148	9	57
16d	3.5	0.162	8	46
20d	4	0.192	6	29
30d	4.5	0.207	5	23
40d	5	0.225	4	17
50d	5.5	0.244	3	14
60d	6	0.262	2	11

Common Nails for Building & Construction Projects

Hammers

Hammers are used to strike or cause impact and are available in traditional designs and in a variety of models, sizes, and weights to perform specific tasks. Selecting the proper hammer for a particular task can be the determining factor for being able to complete the task or be the difference between quality and sub-par craftsmanship. The following list describes the most common types of hammers and some of the types of tasks they are often used for.

General Hammer Use

No matter which type of hammer is used, employing proper techniques will help prevent injury.

- Wear safety glasses when striking any object with any type of hammer or tool.
- For hardwood, before nailing with hammer, drill pilot hole in material to prevent splitting.
- Choose a hammer weight that is comfortable.
- “Set” the nail by tapping in the point, remove the free hand before driving the nail.
- Using the center of the hammer face, drive the nail with smooth, firm blows.
- Striking face should always be parallel with the surface being hit.
- Avoid sideways or glancing blows.
- Always strike with the hammer face.
- Avoid impact with handle or shaft of hammer.

Nail Gun Safety

The following information is compiled from OSHA safety literature. Please go to https://www.osha.gov/Publications/Na..._optimized.pdf if you wish to view the brochure in its entirety.

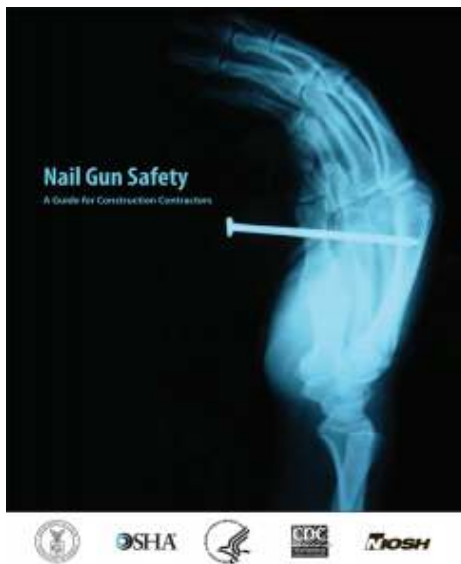


Figure 5.1.3.1

- **Department of Health and Human Services:** Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health
- **Department of Labor:** Occupational Safety and Health Administration

This guidance document is not a standard or regulation, and it creates no new legal obligations. It contains recommendations as well as descriptions of mandatory safety and health standards [and other regulatory requirements]. The recommendations are advisory in nature, informational in content, and are intended to assist employers in providing a safe and healthful workplace. The Occupational Safety and Health Act requires employers to comply with safety and health standards and regulations promulgated by OSHA or by a state with an OSHA-approved state plan. In addition, the Act's General Duty Clause, Section 5(a)(1), requires employers to provide their employees with a workplace free from recognized hazards likely to cause death or serious physical harm.

Nail guns are used every day on many construction jobs—especially in residential construction. They boost productivity but also cause tens of thousands of painful injuries each year. Nail gun injuries are common—one study found that 2 out of 5 residential carpenter apprentices experienced a nail gun injury over a four-year period. When they do occur, these injuries are often not reported or given any medical treatment. Research has identified the risk factors that make nail gun injuries more likely to occur. The type of trigger system and the extent of training are important factors. The risk of a nail gun injury is twice as high when using a multi-shot contact trigger as when using a single-shot sequential trigger nailer.

The guidance is for residential home builders and construction contractors, subcontractors, and supervisors. NIOSH and OSHA developed this publication to give construction employers the information they need to prevent nail gun injuries. Types of triggers and key terms are described. The guidance highlights what is known about nail gun injuries, including the parts of the body most often injured and the types of severe injuries that have been reported. Common causes of nail gun injuries are discussed and six practical steps that contractors can take to prevent these injuries are described. These are:

- 1) Use full sequential trigger nail guns;
- 2) Provide training;
- 3) Establish nail gun work procedures;
- 4) Provide personal protective equipment (PPE);
- 5) Encourage reporting and discussion of injuries and close calls; and
- 6) Provide first aid and medical treatment.

The guidance includes actual workplace cases along with a short section on other types of nail gun hazards and sources of additional information.

Introduction to Nail Gun Safety

How likely are nail gun injuries?

Nail guns are powerful, easy to operate, and boost productivity for nailing tasks. They are also responsible for an estimated 37,000 emergency room visits each year. Severe nail gun injuries have led to construction worker deaths.

Nail gun injuries are common in residential construction. About two-thirds of these injuries occur in framing and sheathing work. Injuries also often occur in roofing and exterior siding and finishing.

A study of apprentice carpenters found that:

- 2 out of 5 were injured using a nail gun during their 4 years of training.
- 1 out of 5 were injured twice.
- 1 out of 10 were injured three or more times.

Worksite Story – A 26-year-old Idaho construction worker died following a nail gun accident in April 2007. He was framing a house when he slipped and fell. His finger was on the contact trigger of the nail gun he was using. The nosepiece hit his head as he fell, driving a 3-inch nail into his skull. The nail injured his brain stem, causing his death. The safety controls on the nail gun were found to be intact. Death and serious injury can occur using nail guns—even when they are working properly.

More than half of reported nail gun injuries are to the hand and fingers. One quarter of these hand injuries involve structural damage to tendons, joints, nerves, and bones. After hands, the next most often injured are the leg, knee, thigh, foot, and toes. Less common are injuries to the forearm or wrist, head and neck, and trunk. Serious nail gun injuries to the spinal cord, head, neck, eye, internal organs, and bones have been reported. Injuries have resulted in paralysis, blindness, brain damage, bone fractures, and death.

Nail guns present a number of hazards and risks. NIOSH and OSHA prepared this publication to provide builders and contractors with the latest information on nail gun hazards and practical advice on the steps they should take to prevent nail gun injuries on their construction jobs.

This guide covers nail guns (also called nailers) used for fastening wood, shingles, and siding materials. The guide refers specifically to pneumatic tools but also applies to nail guns that use gas, electric, or hybrid power sources. It does NOT cover powder actuated tools used for fastening material to metal or concrete. The guide assumes that contractors are generally familiar with how nail guns work and the various types of specialized nail guns (for example, framing, roofing, flooring).

This guide is applicable to all nail guns. The emphasis is on framing (“stick” and “coil”) nail guns because they fire the largest nails, are the most powerful, and are considered to be the most dangerous to use.

Know Your Triggers

Nail gun safety starts with understanding the various trigger mechanisms. Here is what you need to know:

How Triggers Differ

All nailers rely on two basic controls: a finger trigger and a contact safety tip located on the nose of the gun. Trigger mechanisms can vary based on: 1) the order in which the controls are activated, and 2) whether the trigger can be held in the squeezed position to discharge multiple nails OR if it must be released and then squeezed again for each individual nail. Combining these variations gives four kinds of triggers. Some nail guns have a selective trigger switch which allows the user to choose among two or more trigger systems. Each trigger type is described below along with a summary of how the controls are activated.

The bottom line: contractors should check the tool label and manual for manufacturer-specific trigger names and operating information.

Worksite Story – Two framers were working together to lay down and nail a subfloor. One framer was waiting and holding the nail gun with his finger on the contact trigger. The other framer was walking backwards toward him and dragging a sheet of plywood. The framer handling the plywood backed into the tip of the nail gun and was shot in the back. The nail nicked his kidney, but fortunately he recovered. As a result of this incident, the contractor switched to using only sequential triggers on framing nail guns. Co-workers can get injured if they bump into your contact trigger nail gun. You can prevent this by using a full sequential trigger.

How do Nail Gun Injuries Happen?

Useful Terms

- **Recoil** is the rapid rebound or kickback after the nailer is fired.
- A **double fire** occurs when a second nail unintentionally fires because the nailer re-contacted the work piece after recoil. It can also occur if the safety contact slips while the user is positioning the nail gun. Several tool manufacturers offer “anti-double fire” features for their nail guns.

There are seven major risk factors that can lead to a nail gun injury. Understanding them will help you to prevent injuries on your jobsites.

1. Unintended nail discharge from double fire. Occurs with CONTACT triggers.

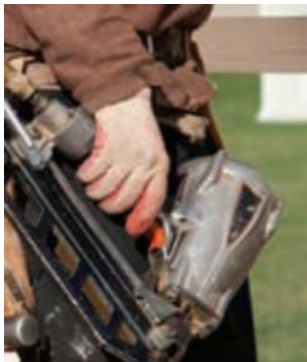
The Consumer Product Safety Commission (CPSC) found that contact trigger nailers are susceptible to double firing, especially when trying to accurately place the nailer against the work piece. They found that a second unintended firing can happen faster than the user is able to react and release the trigger. Unintended nails can cause injuries.

Double fire can be a particular problem for new workers who may push hard on the tool to compensate for recoil. It can also occur when the user is working in an awkward position, such as in tight spaces where the gun doesn't have enough space to recoil. The recoil of the gun itself can even cause a non-nail injury in tight spaces if the nail gun hits the user's head or face.

2. Unintended nail discharge from knocking the safety contact with the trigger squeezed. Occurs with CONTACT and SINGLE ACTUATION triggers.

Nail guns with contact and single actuation triggers will fire if the trigger is being held squeezed and the safety contact tip gets knocked or pushed into an object or person by mistake. For example, a framer might knock his leg going down a ladder or bump into a co-worker passing through a doorway. Contact trigger nailers can release multiple nails and single actuation trigger nailers can release a single nail to cause injury.

Holding or carrying contact trigger or single actuation trigger nail guns with the trigger squeezed increases the risk of unintended nail discharge. Construction workers tend to keep a finger on the trigger because it is more natural to hold and carry an 8-pound nail gun using a full, four-finger grip. Tool manufacturers, however, do warn against it.



Common nail gun grip by OSHA is licensed under Public Domain

3. Nail penetration through lumber work piece. Occurs with ALL trigger types.

Nails can pass through a work piece and either hit the worker's hand or fly off as a projectile (airborne) nail. A blow-out nail is one example. Blow-outs can occur when a nail is placed near a knot in the wood. Knots involve a change in wood grain, which creates both weak spots and hard spots that can make the nail change direction and exit the work piece. Nail penetration is especially a concern for placement work where a piece of lumber needs to be held in place by hand. If the nail misses or breaks through the lumber it can injure the non-dominant hand holding it.

4. Nail ricochet after striking a hard surface or metal feature. Occurs with ALL trigger types.

When a nail hits a hard surface, it has to change direction and it can bounce off the surface, becoming a projectile. Wood knots and metal framing hardware are common causes of ricochets. Problems have also been noted with ricochets when nailing into dense laminated beams. Ricochet nails can strike the worker or a co-worker to cause an injury.

5. Missing the work piece. Occurs with ALL trigger types.

Injuries may occur when the tip of the nail gun does not make full contact with the work piece and the discharged nail becomes airborne. This can occur when nailing near the edge of a work piece, such as a plate. Positioning the safety contact is more difficult in these situations and sometimes the fired nail completely misses the lumber. Injuries have also occurred when a nail shot through plywood or oriented strand board sheathing missed a stud and became airborne.



Nail penetration through the lumber is a special concern where the piece is held in place by hand. Nail gun by OSHA is licensed under Public Domain

6. Awkward position nailing. Occurs with ALL trigger types. Unintended discharges are a concern in awkward position work with CONTACT and SINGLE ACTUATION triggers.

Nailing in awkward positions where the tool and its recoil are more difficult to control may increase the risk of injury. These include toe-nailing, nailing above shoulder height, nailing in tight quarters, holding the nail gun with the non-dominant hand, nailing while on a ladder, or nailing when the user's body is in the line of fire (nailing towards yourself). Toe-nailing is awkward because the gun cannot be held flush against the work piece. Nailing from a ladder makes it difficult to position the nail gun accurately. Nailing beyond a comfortable reach distance from a ladder, elevated work platform, or leading edge also places the user at risk for a fall.



Toe-nailing by OSHA is licensed under Public Domain

7. Bypassing safety mechanisms. Occurs with ALL trigger types.

Bypassing or disabling certain features of either the trigger or safety contact tip is an important risk of injury. For example, removing the spring from the safety contact tip makes an unintended discharge even more likely. Modifying tools can lead to safety problems for anyone who uses the nail gun. Nail gun manufacturers strongly recommend against bypassing safety features, and voluntary standards prohibit modifications or tampering. OSHA's Construction standard at 29 CFR 1926.300(a) requires that all hand and power tools and similar equipment, whether furnished by the employer or the employee shall be maintained in a safe condition.

About 1 in 10 nail gun injuries happen to co-workers. This is from either airborne (projectile) nails or bumping into a co-worker while carrying a contact trigger nail gun with the trigger squeezed.

You Should Know – Studies of residential carpenters found that the overall risk of nail gun injury is twice as high when using contact trigger nail guns compared to using sequential trigger nail guns.

**Note that the studies could not quantify injury risks associated with specific tasks; it is likely that some nailing tasks are more dangerous than others.*

A voluntary ANSI standard 10 calls for all large pneumatic framing nailers manufactured after 2003 to be shipped with a sequential trigger. However, these may not always be FULL SEQUENTIAL triggers. Contractors may need to contact manufacturers or suppliers to purchase a FULL SEQUENTIAL trigger kit.

Worksite Story – A carpenter apprentice on his first day ever using a nail gun injured his right leg. He was working on a step ladder and was in the process of lowering the nail gun to his side when the gun struck his leg and fired a nail into it. He had no training prior to using the nail gun. New worker training is important and should include hands-on skills.

Six Steps to Nail Gun Safety

1. Use the full sequential trigger

The full sequential trigger is always the safest trigger mechanism for the job. It reduces the risk of unintentional nail discharge and double fires—including injuries from bumping into co-workers.

- At a minimum, provide full sequential trigger nailers for placement work where the lumber needs to be held in place by hand. Examples include building walls and nailing blocking, fastening studs to plates and blocks to studs, and installing trusses.
 - Unintended nail discharge is more likely to lead to a hand or arm injury for placement work compared to flat work, where the lumber does not need to be held in place by hand. Examples of flat work include roofing, sheathing, and subflooring.
- Consider restricting inexperienced employees to full sequential trigger nail guns starting out. Some contractors using more than one type of trigger on their jobs color-code the nail guns so that the type of trigger can be readily identified by workers and supervisors.
- Some contractors have been reluctant to use full sequential triggers fearing a loss of productivity. How do the different types of triggers compare?
 - The one available study had 10 experienced framers stick-build two identical small (8 f x 10 ft. wood structures—one using a sequential trigger nail gun and one using a contact trigger nail gun. Small structures were built in this study so that there would be time for each carpenter to complete two sheds.
 - Average nailing time using the contact trigger was 10% faster, which accounted for less than 1% of the total building time when cutting and layout was included. However, in this study the trigger type was less important to overall productivity than

who was using the tool; this suggests productivity concerns should focus on the skill of the carpenter rather than on the trigger.

- Although the study did not evaluate framing a residence or light commercial building, it shows that productivity is not just about the trigger. The wood structures built for the study did include common types of nailing tasks (flat nailing, through nailing, toe-nailing) and allowed comparisons for both total average nailing time and overall project time. The study did not compare productivity differences for each type of nailing task used to build the sheds.

2. Provide training

Both new and experienced workers can benefit from safety training to learn about the causes of nail gun injuries and specific steps to reduce them. Be sure that training is provided in a manner that employees can understand. Here is a list of topics for training:

- How nail guns work and how triggers differ.
- Main causes of injuries – especially differences among types of triggers.
- Instructions provided in manufacturer tool manuals and where the manual is kept.

Hands-on training with the actual nailers to be used on the job. This gives each employee an opportunity to handle the nailer and to get feedback on topics such as:

- How to load the nail gun
- How to operate the air compressor
- How to fire the nail gun
- How to hold lumber during placement work
- How to recognize and approach ricochet-prone work surfaces
- How to handle awkward position work (e.g., toe-nailing and work on ladders)
- How best to handle special risks associated with contact and single actuation triggers such as nail gun recoil and double fires.
For example, coach new employees on how to minimize double fires by allowing the nail gun to recoil rather than continuing to push against the gun after it fires.
- What to do when a nail gun malfunctions.

**Training should also cover items covered in the following sections of the guidance, such as company nail gun work procedures, personal protective equipment, injury reporting, and first aid and medical treatment.*

You Should Know

- Training is important: Untrained workers are more likely to experience a nail gun injury than a trained worker.
- Training does not trump triggers: Trained workers using contact triggers still have twice the overall risk of injury as trained workers using sequential triggers.

3. Establish nail gun work procedures

Contractors should develop their own nail gun work rules and procedures to address risk factors and make the work as safe as possible. Examples of topics for contractor work procedures include but are not limited to the following Do's & Don'ts:

DO's

- Make sure that tool manuals for the nailers used on the job are always available on the jobsite.
- Make sure that manufacturers' tool labels and instructions are understood and followed.
- Check tools and power sources before operating to make sure that they are in proper working order.
- Take broken or malfunctioning nail guns out of service immediately.
- Set up operations so that workers are not in the line of fire from nail guns being operated by co-workers.
- Check lumber surfaces before nailing. Look for knots, nails, straps, hangers, etc. that could cause recoil or ricochet.
- Use a hammer or positive placement nailer when nailing metal joinery or irregular lumber.
- For placement work, keep hands at least 12 inches away from the nailing point at all times. Consider using clamps to brace instead of your hands.
- Always shoot nail guns away from your body and away from co-workers.
- Always disconnect the compressed air when:
 - Leaving a nailer unattended
 - Travelling up and down a ladder or stairs

- Passing the nail gun to a co-worker
- Clearing jammed nails
- Performing any other maintenance on the nail gun
- Recognize the dangers of awkward position work and provide extra time and precautions:
 - Use a hammer if you cannot reach the work while holding the nailer with your dominant hand.
 - Use a hammer or reposition for work at face or head height. Recoil is more difficult to control and could be dangerous.
 - Use a hammer or full sequential trigger nailer when working in a tight space. Recoil is more difficult to control and double fires could occur with contact triggers.
 - Take extra care with toe-nailing.
 - Nail guns can slip before or during firing because the gun cannot be held flush against the work piece.
 - Use a nail gun with teeth on the safety contact to bite into the work piece to keep the gun from slipping during the shot.
 - Use the trigger to fire only after the safety contact piece is positioned.
- Recognize the dangers of nail gun work at height and provide extra time and precautions:
 - Set up jobs to minimize the need for nailing at height
 - Consider using scaffolds instead of ladders
 - If work must be done on ladders, use full sequential trigger nailers to prevent nail gun injuries which could occur from bumping a leg while climbing up or down a ladder.
 - Position ladders so you don't have to reach too far. Your belt buckle should stay between the side rails when reaching to the side.
 - Maintain three points of contact with the ladder at all times to prevent a fall—this means that clamps may need to be used for placement work. Holding a nailer in one hand and the work piece with the other provides only two points of contact (your feet). Reaching and recoil can make you lose your balance and fall. Falls, especially with contact trigger nailers, can result in nail gun injuries.

Don'ts

- Never bypass or disable nail gun safety features. This is strictly prohibited.
 - Tampering includes removing the spring from the safety-contact tip and/or tying down, taping or otherwise securing the trigger so it does not need to be pressed. Tampering increases the chance that the nail gun will fire unintentionally both for the current user and anyone else who may use the nail gun. Nail gun manufacturers strongly recommend against tampering and OSHA requires that tools be maintained in a safe condition.
 - There is **NO** legitimate reason to modify or disable a nail gun safety device.
- Encourage workers to keep their fingers off the trigger when holding or carrying a nail gun.
If this is not natural, workers should use a full sequential nail gun or set down the nailer until they begin to nail again.
- Never lower the nail gun from above or drag the tool by the hose.
- If the nail-gun hose gets caught on something, don't pull on the hose. Go find the problem and release the hose.
- Never use the nailer with the non-dominant hand.

4. Provide Personal Protective Equipment (PPE)



Worker using recommended PPE when working with nail guns: hard hat, safety glasses, and hearing protection. Worker by OSHA is licensed under Public Domain

Safety shoes, which help protect workers' toes from nail gun injuries, are typically required by OSHA on residential construction sites. In addition, employers should provide, at no cost to employees, the following protective equipment for workers using nail guns:

- Hard hats
- High Impact eye protection – safety glasses or goggles marked ANSI Z87.1
- Hearing protection – either earplugs or earmuff

5. Encourage reporting and discussion of injuries and close calls

Studies show that many nail gun injuries go unreported. Employers should ensure that their policies and practices encourage reporting of nail gun injuries. Reporting helps ensure that employees get medical attention. It also helps contractors to identify unrecognized job site risks that could lead to additional injuries if not addressed. Injuries and close calls provide teachable moments that can help improve crew safety.

If you have a safety incentive program, be sure that it does not discourage workers from reporting injuries. Employers that intentionally under report work-related injuries will be in violation of OSHA's injury and illness recordkeeping regulation.

6. Provide first aid and medical treatment

Employers and workers should seek medical attention immediately after nail gun injuries, even for hand injuries that appear to be minimal. Studies suggest that 1 out of 4 nail gun hand injuries can involve some type of structural damage such as bone fracture. Materials such as nail strip glue or plastic or even clothing can get embedded in the injury and lead to infection. Barbs on the nail can cause secondary injury if the nail is removed incorrectly. These complications can be avoided by having workers seek immediate medical care.

Worksite Story – A construction worker accidentally drove a 16 penny framing nail into his thigh. It didn't bleed much and he didn't seek medical care. He removed the nail himself. Three days later he felt a snap in his leg and severe pain. In the emergency room, doctors removed a sheared piece of nail and found that his thigh bone had fractured. Not all injuries are immediately visible. Failure to seek medical care can result in complications and more serious injuries.

Other Hazards

Air Pressure

Pneumatic tools and compressor use are regulated under OSHA's Construction standard at 29 CFR 1926.302(b). The provisions in this standard that are relevant for nail guns are provided below:

- 1) Pneumatic power tools shall be secured to the hose or whip by some positive means to prevent the tool from becoming accidentally disconnected.

Note: An OSHA letter of interpretation allows the use of a quick disconnect with a pull-down sleeve to meet this requirement. It is composed of a male fitting (connector) and female fitting (coupling) that has a sleeve which must be pulled away from the end of the hose to separate the two fittings to prevent the tool from becoming accidentally disconnected.

- 3) All pneumatically driven nailers, staplers, and other similar equipment provided with automatic fastener feed, which operate at more than 100 p.s.i. pressure at the tool shall have a safety device on the muzzle to prevent the tool from ejecting fasteners, unless the muzzle is in contact with the work surface.
- 5) The manufacturer's safe operating pressure for hoses, pipes, valves, filters, and other fitting's shall not be exceeded.
- 6) The use of hoses for hoisting or lowering tools shall not be permitted.

Noise

Pneumatic nail guns produce short (less than a tenth of a second in duration) but loud "impulse" noise peaks: one from driving the nail and one from exhausting the air. Most nail gun manufacturers recommend that users wear hearing protection when operating a nailer.

Available information indicates that nail gun noise can vary depending on the gun, the work piece, air pressure, and the work setting. The type of trigger system does not appear to affect the noise level. Peak noise emission levels for several nailers ranged from 109 to 136 dBA.^{15,16} These loud short bursts can contribute to hearing loss. Employers should provide hearing protection in the form of earplugs or muff and ensure that they are worn correctly. Employers should also ask about noise levels when buying nail guns—studies have identified ways to reduce nail gun noise and some manufacturers may incorporate noise reduction features.

Note: OSHA's standard for exposure to continuous noise levels (29 CFR 1926.52) addresses both the noise level and the duration of exposure. In this standard, workers exposed for 15 minutes at 115 A-weighted decibels (dBA) have the same exposure as workers exposed for 8 hours at 90 dBA.

The NIOSH and OSHA limit for impulse noise is 140 decibels: above this level a single exposure can cause instant damage to the ear.

NIOSH recommends that an 8-hour exposure should not exceed 85 dBA and a one-second exposure should not exceed 130 dBA without using hearing protection.

Musculoskeletal disorders

Framing nail guns can weigh up to 8 pounds and many framing jobs require workers to hold and use these guns for long periods of time in awkward hand/arm postures. Holding an 8-pound weight for long periods of time can lead to musculoskeletal symptoms such as soreness or tenderness in the fingers, wrist, or forearm tendons or muscles. These symptoms can progress to pain, or in the most severe cases, inability to work. No studies have shown that one trigger type is any more or less likely to cause musculoskeletal problems from long periods of nail gun use. If use of a nail gun is causing musculoskeletal pain or symptoms of musculoskeletal disorders, medical care should be sought.

Conclusion

Nail gun injuries are painful. Some cause severe injuries or death. Nail gun injuries have been on the rise along with the increased popularity of these powerful tools. These injuries can be prevented, and more and more contractors are making changes to improve nail gun safety. Take a look at your practices and use this guide to improve safety on your job sites. Working together with tool gun manufacturers, safety and health professionals, and other organizations, we can reduce nail gun injuries.

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5.1.4: Threaded Fasteners, Drivers, Pliers and Wrenches

Threaded Fasteners

Selecting the appropriate fastener for a particular application involves considering many factors to include: functionality, strength and durability, exposure to natural elements, and aesthetics. While most bolts and many screws are designed for the head to press firmly against flat surfaces of materials and parts, screws with tapered or bugle style heads are manufactured to be countersunk even with or below material surfaces. Screws, bolts and other threaded fastener accessories are normally made of brass; or mild, hardened or stainless steel; or plastics in some designed for lighter and cosmetic applications. In many cases, threaded fasteners are treated with processes such as galvanization, electroplated phosphate, or chemical primers such as zinc oxide.

Screws are taper tipped and threaded in a manner that helps wood, or other materials, draw together as the screw is inserted. They are used in place of nails when stronger joining power is needed. A screw makes its own thread pattern in the material. Screw head shapes (slotted, pan, hex, oval, flat) vary according to the application. Also the slots or drive types of screws are available in a wide variety (slotted, Phillips, Robertson, square, Pozidrive®, etc.).

Bolts are male threaded fasteners that require a female threaded counterpart (a “nut” or a threaded hole in a material) in order to secure themselves. Nuts and bolts allow for future disassembly and when used with flat and locking style washers, provide strong mechanical bonds and stability. These threaded fasteners are available in coarse and fine thread configurations which are recognized by the amount of threads per inch (**tpi**) in SAE fasteners and by pitch in metric fasteners. Cap head and stove type bolts are also rated by their hardness or shear strength. Various cast or embossed markings can be found on the head of these kinds of bolts, with each type of marking symbolizing a bolt’s capacity.



Figure 5.1.4.1 SAE Bolt Sizes by Clifford



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Figure 5.1.4.2 Metric Bolt Sizes by Clifford Rutherford is licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/)

Specialty Anchors

Specialty anchors such as eye hooks, J-hooks for drywall, masonry, tile, wood, and other materials are available in both screw and bolt designs.

Tap and Die sets can be used to thread materials to accept another fastener. **Taps** are tools made to cut female threads while **Dies** are tools designed to cut male threads on round stock materials. It is important that the drilled hole size for tapping, or the diameter of the material to be threaded with a die, be of a specific size and tolerance so that the final threaded product fits properly. Taps and dies are also individually available in each machine fastener diameter and thread count.

All of the fasteners listed above require tool to tighten when assembling projects and loosen them when disassembly is required. Drivers, pliers and wrenches facilitate the assembly of items with threaded objects such as nuts, bolts, screws, plumbing and electrical fittings and pipes. Various styles of pliers can also be used to cut, bend, pull and crimp materials and mechanical fittings. While the proper selection of tools for particular fastener or fitting will result in easier and more rapid assembly and disassembly of projects, improper tool selection may result in material, parts, and tool damage, lost time, and possible injury.

Drivers

Pliers

Pliers are primarily used to grip objects that utilize leverage. Different configurations of the jaw are also used to grip, turn, pull, crimp and sometimes cut a variety of things. Many types are commonly identified by a manufacturer brand or model name and used by workers in multiple construction trades fields (Channellock® is a registered trademark for a manufacturer that makes numerous styles of tools, however tongue and groove pliers are commonly referred to as channel-lock pliers).

Wrenches

Wrenches can be used to turn bolts, nuts, or other hard to turn items. Wrenches provide excellent leverage compared to pliers, and most are designed to fit specific sized fasteners. The choice of an appropriate wrench depends upon the torque or leverage required to perform a function or the design of a fastener. The wrong choice of a wrench for a task can cause slipping of the wrench, damage materials and parts, and result in bodily injury. As nuts, bolts, and fasteners are offered in standardized fractional (SAE (Society of Automotive Engineers) and metric (millimeter or mm.) sizes, most wrenches are designed to fit hexagonal (six-sided) or hex fasteners and mechanical fittings. Wrenches can be purchased either individually or in sets based on style or combinations of styles.

TOOL TIPS:

- *Only use bits and sockets rated for impact use with impact drivers and impact wrenches. Non-impact tools are made of materials that can crack, break, or shatter when used with impact tools.*
- Apply a penetrating oil according to manufacturer directions to rusted fasteners prior to trying to loosen them.
- “Stuck” or rusted nuts, bolts, and screws can sometimes be freed by striking them sharply on the head with a steel punch.
- Traditional fasteners turn in a clockwise direction to tighten and counter-clockwise to loosen. Fasteners of this design are also known as “right-hand” threaded fasteners.
- Specialty fasteners required for certain mechanical applications turn counter-clockwise to tighten and clockwise to loosen. These are also referred to as “left-hand” threaded fasteners.

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5.1.5: Saws

Choices

Saws should be chosen based on the material type to be cut and the particular task being performed. Each type of saw has its own purpose, may be available in a variety of sizes, and offer safety and convenience features which vary by manufacturer, style, and application. For example: Circular saws are used to cut a wide variety of construction materials with an appropriate blade. They are manufactured in a variety of sizes that can be selected according to the project. Simple projects with 1" x 4" or 1/2" plywood material may only require a 5-3/8" cordless trim saw, whereas beam construction could require a circular beam saw with a 21" course toothed blade, and cement fiber plank siding installation using a 7-1/4" circular saw with the appropriate blade.

While most stationary saw models are primarily used in the carpentry trades, most portable models are also employed in plumbing, electrical, and other construction and facility maintenance trades. As in the case of numerous hand tools and accessories, many of the saws types have become known by industry workers as common trademark, brand, or model names:

- Circular Saw- Skilsaw™ (Skilsaw Inc.)
- Reciprocating Saw- Sawzall® (Milwaukee Electric Tool Company); TigerSaw® (Porter Cable Tool Company)

Saw Blades

Blades come in various sizes and configurations. When choosing a saw for a particular cut, it is important to consider the type of material to be cut and the finish desired. Saw blades are rated in teeth per inch (t.p.i.). The lesser t.p.i., or the lower the revolutions per minute (r.p.m.), the rougher the finish of the cut will be. Always check the r.p.m. rating of both the blade and the saw to ensure they are compatible. Choosing a toothed blade or abrasive cut-off blade that is not rated for the r.p.m. rating of the saw can result in catastrophic blade failure and injury.

The thickness of the saw blade is referred to as the Kerf. This measurement is the width of the path of the cut where material will be removed. For accurate final dimensions, the kerf of the blade should always travel on the waste side of a marked line.

Additional Basic Saw Terminology

- **Rip Cut**- cut follows or goes with the grain of the material.
- **Cross cut**- cut goes across the grain of the material.
- **Push-block/Push Stick**- A hand-held device designed to push the work piece into and past cutting edges on stationary power tools.
- **Scroll action**- blade strokes perpendicular to material surface. Common to saber saws, scroll saws, and reciprocating saws.
- **Orbital action**- blade follows arcing path. Available option for saber and reciprocating saws. Aids in cutting pipe and round or circular materials.

Saw Safety

- Never disable manufacturer installed guards or safety devices.
- Always use safety glasses.
- Do not use a saw for any purpose it's features are not intended for.
- Always refer to manufacturer's operating instructions and safety procedures prior to operating any power tool.

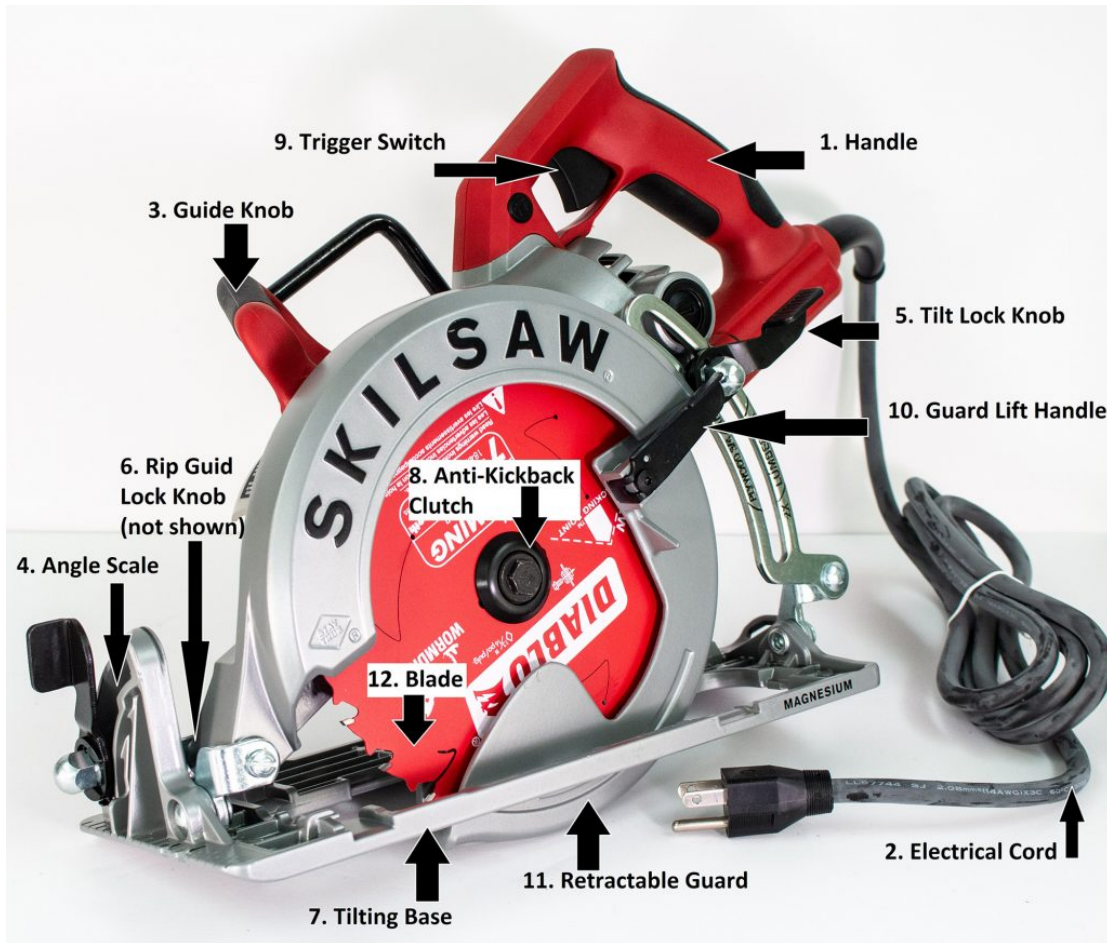
*Kickback is caused when the material binds with the blade or fence of a saw resulting in the material being forcefully ejected, often drawing the operator's hand/s toward the moving blade, creating the potential for serious injury or death. Although kickback is regularly associated with table saw use, the same potential hazard exists with circular, reciprocating, saber and any other type of saw. In addition to material being ejected and the operator being drawn toward the blade, kickback can also result in portable saws being ejected from the material toward the operator.

Saw Types and Applications

Circular Saw- portable (framing and trim)

Circular saws are used to cut a wide variety of construction materials with an appropriate blade. They are constructed in various sizes that can be selected according to the project. Simple projects with 1" x 4" or 1/2" plywood material may only require a 5-3/8"

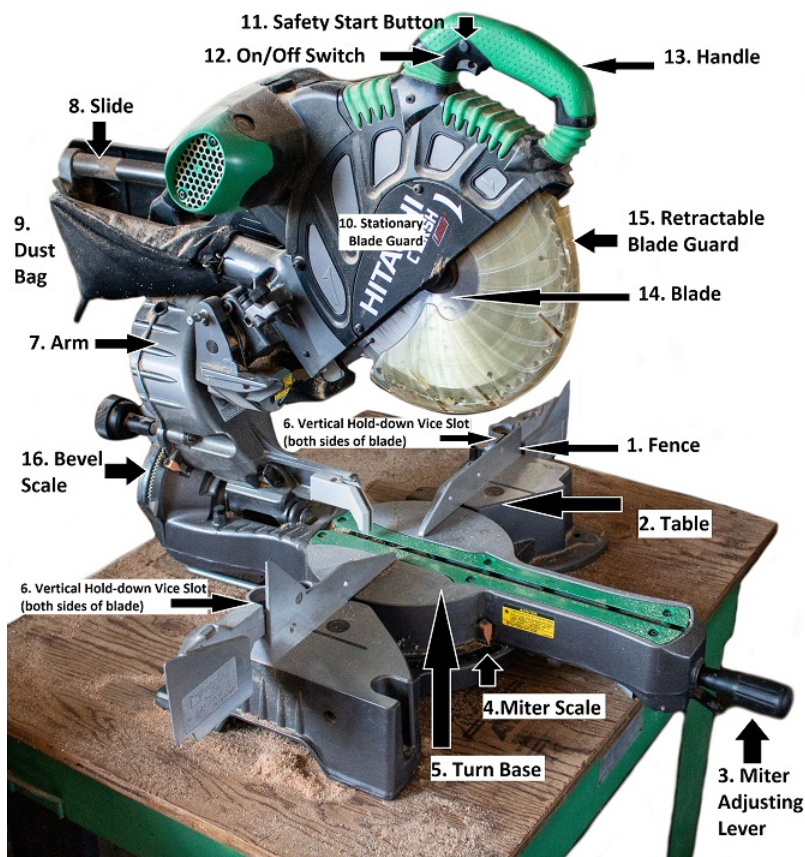
cordless trim saw, whereas beam construction could require a beam saw with a 21" course toothed blade.



Circular Saw Parts by Gwen Arkin & Clifford Rutherford is licensed under CC BY 4.0

Circular Saw Safety

Miter Saw- cuts angles, compound angles & bevels



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Miter Saw Safety

Table Saw- for rip & cross cuts of sheet goods and lumber stock

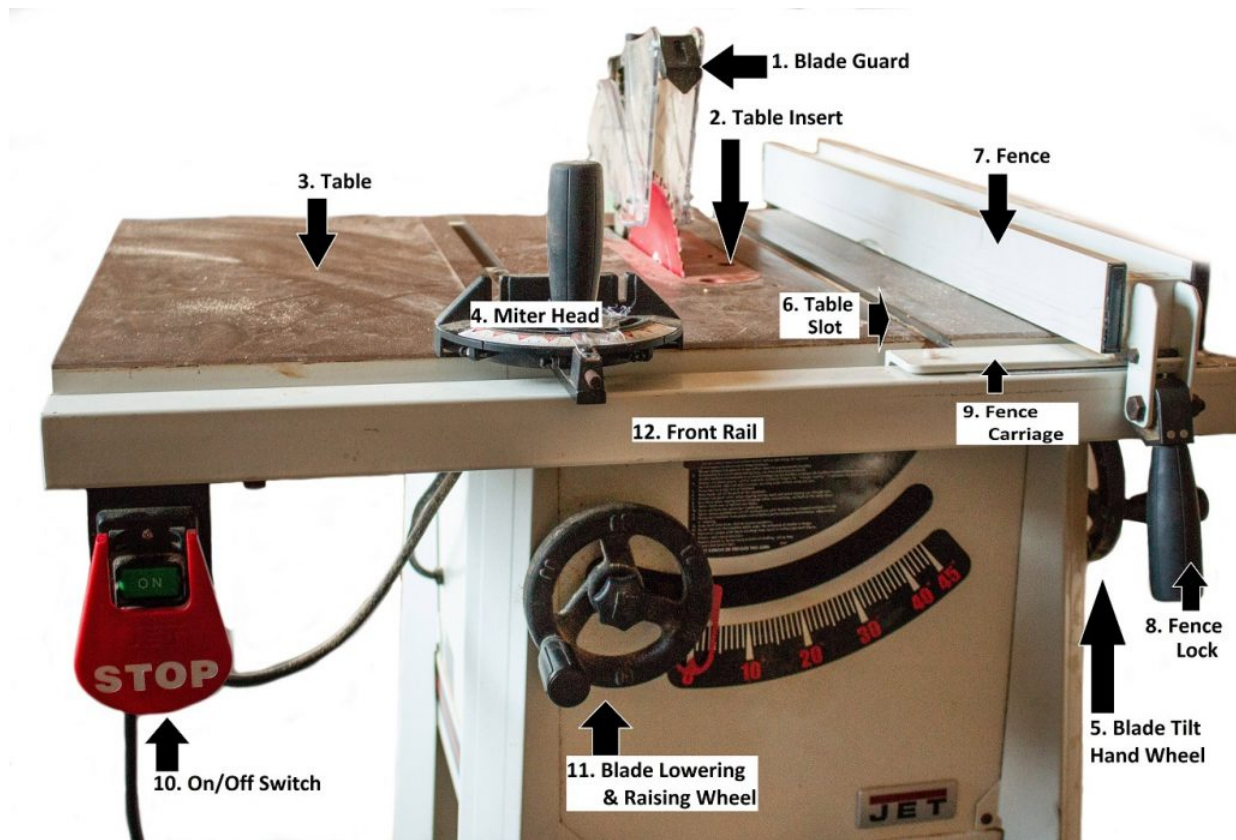


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Table Saw Safety

Sabre Saws (Jigsaw) and Scroll Saws- curved cuts, uses U-shank and/or T-shank (bayonet) blades



Jigsaw by Dexter Corpuz is licensed under CC BY 4.0

Reciprocating Saw- rough cuts and demolition



Reciprocating Saw by Gwen Arkin is licensed under CC BY 4.0

**Many jigsaws & reciprocating saws can be used in either scrolling or orbital modes*

Other Saws

A variety of saws are available for masonry and mechanical applications and may be specific to a specific trade or task. Examples:

Band Saws – vertical and horizontal models for wood, metal, & other material applications



Band Saw by Gwen Arkin is licensed under CC BY 4.0

Tile Saws – ceramic, porcelain, quarry, clay, and glass

Block Saws – concrete, brick, and glass

Masonry Saws – Blades used for tile, cement, brick, & asphalt are usually diamond coated or abrasive. They can also be used wet or dry.



Tile Saw by Clifford & Rosemary Rutherford is licensed under CC BY 4.0

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5.1.6: Drills and Accessories

Drills

Drills are used to bore holes, tighten and loosen fasteners, and, with some models and accessories, mix paint, mortar, and similar materials, and to chisel and chip mortar, concrete, and other dense or hard materials. The selection of the proper drill for a job requires knowledge of the material being worked, the types and models of drills and their purposes, and the accessories that are appropriate for the task. Tool makers offer all of the types of drills in corded models and the majority of them are also available in variable speed and battery powered models that offer greater portability and reduced tool weight with lighter weight DC brushless motor technology.

Basic Drill Parts Identification



Portable Drill Parts by Gwen Arkin & Clifford Rutherford is licensed under CC BY 4.0

Drill Safety

1. Wear safety glasses when operating with portable electric drill.
2. Disconnect the drill from the electrical supply when installing bits.
3. Clamp stock so it will not move during the drilling operation.
4. Before drilling, turn the drill on to see if the bit is centered and running true.
5. Align the bit with the desired hole location before turning the drill on.
6. Hold the drill firmly with both hands while drilling.
7. When drilling deep holes with a twist drill, move the bit up and down several times while drilling to remove cuttings and reduce overheating in the bit.
8. Do not allow the cord to become wrapped around the drill when working.
9. If the electrical cord becomes frayed or starts to separate from the drill housing, repair it immediately!
10. Remove the bit from the drill as soon as the work is completed.
11. Select the correct bit for the finish and material being drilled. Make sure the bit is securely tightened in the drill chuck.
12. Be extremely careful when using larger portable electric drills (3/8" and 1/2"). If the bit should hang or get caught the drill will twist in the operator's hands causing a sprain or bruised fingers.
13. Always remove the key from the chuck before drilling.
14. To prevent seizing, reduce the feed pressure when the drill bit is about to come through the material.

Drill Operating Procedures

1. Always center punch or make a starting indentation in the material being drilled to get an accurate starting point for the drill bit.
2. Tighten the drill bit by rotating the chuck key to all three holes in the chuck. This will help to keep the drill bit centered.
3. Apply moderate even pressure to the drill during the drilling operation. If excessive pressure is required to make the bit cut then the bit is dull and needs to be sharpened.
4. Maintain good balance at all times when drilling.

5. Use slow drill speeds for drilling metal and fast speeds for drilling wood.
6. To obtain holes that are placed accurately, drill a small pilot first then drill the final hole.

Drill Types

Bits & Accessories

Along with using the driver bits for various fasteners discussed in the previous chapter, drills can be accessorized to perform a variety of functions.

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5.1.7: Grinders, Sanders, and Accessories

Grinders

Grinders are normally used to either smooth or cut hard surfaces and materials depending upon the type of accessory and material being used. The basic grinding tool consists of a motor with an abrasive wheel, wire brush or other attachment attached to the arbor (**shaft**) by a female threaded fastener (**arbor nut**). Some manufacturers' arbor nut configuration requires a propitiatory wrench or spanner for removal and installation of their own specially designed style of fastener. Grinders are offered in both portable and stationary models, and some come with a variable speed option. Each style of grinder can be accessorized for specific applications and functions and components differ by manufacturer.

Grinder Safety

When choosing accessories for grinders, it is extremely important to note the the revolutions per minute (**r.p.m.**) rating of the accessory meets or exceeds the r.p.m. of the grinder. An inappropriately sized grinder accessory can shatter or break resulting in injury. Grinders should always be unplugged or the battery should be disconnected from the tool before changing accessories. Portable grinders, like many other rotating power tools, have the potential for kickback and operators should take the same basic precautions as when operating a portable power saw. Bench grinders have tool rests, or tables for stabilizing items being ground. These should be adjusted as close to the grinding wheel as possible to prevent injury in the event of the wheel grabbing the item and pulling the operators hand/s in the direction of the wheel. Bench grinders are also required to have adjustable, impact resistant, clear lens guards, protective eye wear should always be worn by the operator when using any grinder. Due to the wide variety of grinding tools and applications, be sure to consult manufacturer directions before operating any power tool you are unfamiliar with. Although some of these tools are also offered in special versions that can be used in the presence of water to cool the blade or stone and flush debris from the cut or material surface, most grinders are not suited for wet applications.

Types of Grinders

Grinder Accessories

Sanding Discs for grinders usually require a hard rubber backing plate to be attached to the grinder and for the disc to be attached to the backing plate by an adhesive or hook-and-loop fastening system, to create an orbital sander. The disc's sandpaper material composition should be selected according to the material being sanded (see Sandpaper Material Composition).

Buffing Bonnets and Wheels used for buffing metals, plastics, quarry stone and other surfaces can be made of cotton, microfiber, and other materials regularly used in hand polishing items. While bonnets are mounted to backing plates on portable grinders of buffers, buffing wheels are mounted to the arbor of stationary grinders with the arbor nut.

Sanders

Regardless of whether you are sanding by hand or using a power sander, identifying the right sanding tool and sandpaper to be used for a project can be a daunting task if you're unfamiliar with the capability of the sanding tools and the variety of sandpapers available for specific applications. Sanders can be used to form and shape a wide variety of materials and to strip or create fine finishes. When working with electric power sanders, when the tool is fitted with a variable speed option, the speed should be adjusted to a speed that creates the best cutting action in order to realize the full potential of the tool and sandpaper being used based on the material being sanded and the finish desired. As with other power tools, it is important to let the tool do the work. Too much pressure on the tool can slow or dampen the machine's action, creating less cutting action due to excessive friction or not allowing the tool to rotate or vibrate at all. Some sanders rotate in one continuous motion (orbital or track) that can leave sanding lines or swirl marks in materials. Random orbital and oscillating sanders work in multiple pathways that create fewer lines and finer finishes.

Types of Sanders

Sand Paper



Sandpaper Rectangle by Dexter Corpuz is licensed under CC BY 4.0

Styles

Grit is the term used to identify the coarseness (roughness) of the material on the sandpaper. Sandpapers are labeled by a number denoting their coarseness: the lower the number, the coarser the grit of the sandpaper and rougher finish; the higher the number, the finer the grit and smoother finish. The sandpaper's cutting material can consist of aluminum oxide, garnet, or silicon, and can even be used in emery cloth that resists breakdown in wet applications. For sanding items that require extensive work, it is best to start with a coarse sandpaper, graduating incrementally to finer grits to obtain the desired finish.

Material Composition

- **Garnet** quarry stone is crushed to a specified grain size and used to coat paper or cloth to make sandpaper and sanding belts commonly used for universal applications. Wears out faster than other sandpapers but is capable of creating smoother finishes.
- **Aluminum Oxide** works good for sanding wood and metal. As aluminum oxide particles flake off during use creating new sharp edges, this media lasts longer than garnet sandpaper, but does not create as smooth of a finish.
- **Silicon Carbide** is harder than garnet or aluminum oxide. This media is commonly used for metal, plastics, and fiberglass, but is a poor choice for applications with wood.
- **Emery Cloth** is a cloth material coated with a granular mineral substance normally consisting of corundum mixed with magnetite or hematite. Emery cloth is capable of holding up in wet applications and is relied upon by plumbers to clean and etch copper pipes and fittings prior to soldering.

Surface & Application		Aluminum Oxide					Garnet				Silicon Carbide				Emery Cloth		
		#0 Extra Coarse	#6 Coarse	#80 Medium	#120 Fine	#150 Extra Fine	#60	#80	#120	#150	#240 Very Fine	#320 Extra Fine	#400 Super Fine	#500 Ultra Fine	Coarse	Medium	Fine
STAINLESS STEEL	Extra Heavy	X															
	Heavy		X														
	Moderate			X													
SOFT WOODS	Light																
	Heavy		X				X										
	Moderate			X				X									
HARD WOODS	Light																
	Heavy	X	X				X										
	Moderate			X				X									
PAINTS	Light																
	Heavy				X												
	Medium					X											
	Finest						X										
METALS	Before Sealing				X												
	A-Ra Sealing					X											
	Welding Coats						X										
	After Final Coat							X									
CONCRETE	Heavy Rust Removal	X	X														
	Light Rust Removal		X	X													
	Final Sanding				X					X	X						
	Sanding for Finishing										X						
WOOD FINISHING	A-Ra Finishing																
	Final Polishing																
	Woodwater Sanding	X	X														
	Light Sanding		X														
PLASTICS	Final Sanding					X											
	Heavy Material Removal	X	X														
FINISHES	Light Material Removal	X	X	X	X					X							
	Polishing					X					X	X	X	X			

Sandpaper Selection Chart by Clifford Rutherford is licensed under CC BY 4.0

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5.2: Construction Materials

Lumber

Plywood and other **sheet goods** are important building materials for scenic construction. Plywood are made up of sheets of material that have been manufactured as a strata of layers, or “veneers.” These thin layers of wood have been peeled off long logs and then laid in a stack with the **wood grain** of each layer running perpendicular to the layer above and below. As wood is strongest along its grain fibers, crossing the grains adds strength to the ply. These layers are pressed and glued together, making for a very strong sheet of lumber. More layers add thickness to the ply, making it capable of supporting a greater load. Theatrical platforms are generally skinned with a sheet of plywood at least $\frac{3}{4}$ -inch thick to support the weight of the actors and scenery. Sheet goods also include decorative items such as paneling and materials like MDF (medium density fiberboard), which are not good materials to support weight, but have other qualities that can be useful in construction. Generally, in the United States, sheet goods are sold in panels of 4 feet by 8 feet.

Plywood is graded based on both the finish of its outermost veneers and the quality of the woods that make up its inner plies. If you want a smooth sanded surface with no mars to the wood grain, you need to purchase higher-grade plywood. Low-grade plywood may have “holidays,” or holes, in their veneers, including the exterior layers.

Interior Grade	Face	Back	Inner Plies	Use and Appearance
A-A	A	A	C	Cabinet doors, furniture where both sides show. Good natural wood finish both sides.
A-B	A	B	C	Paneling, one-sided natural wood finish. Finished face; smooth, sanded back.
A-C	A	C	C	Platforms/work seen from one side only. Finish grade face, voids on back.

Figure 5.2.1: Common plywood grade chart

Consider This To glue or not to glue? It is a good question. If you are constructing stock scenery that has elements that will either take abuse or have questionable safety or stability, then YES, glue. If, however, the construction is decorative, and you want to recoup the materials for later use, then glue will only make the job harder.

Modern scenery includes many of the architectural elements and details we use every day, like appliances that need to work, windows that will be opened, or a sink with running water. These are called **practical**. Doors are the most common practical element of scenery. They often need to function normally, but also stand up to some abuse called for by the script, which can range from hard knocking to full forced entry attempts. It can be a challenge for carpenters to support and reinforce these elements within an environment of temporarily constructed flat walls.

Many scripts call for a variety of locations to be represented within the same play. Scene designers work to find ways to transport their audience from one location to another without taking massive breaks in the action to achieve the changes. A number of rolling platform elements, known as **wagons**, can help streamline these transitions by transporting large props and scenery on and off the stage quickly. A variety of wagons are common to scenic design. A large turntable wagon that can spin to reveal a new setting is called a **revolve**. Some theatres are equipped with a built-in revolve that is permanently installed as part of their stage floor. Platform wagons that pivot onstage from a fixed point in the wings are called **jackknife platforms**. **Straight run platform wagons** roll either upstage to downstage or in and out of the wings. The wheels that these wagons operate on, known as casters, are either fixed casters or **swivel casters**. A **fixed caster** can only roll along a straight path, while swivel casters allow units to be rolled in any direction. Sometimes these wagons are guided by a track built into the stage floor.

Scenery construction methods and choice of materials vary from theatre to theatre, but standards for construction are important for every company. Standard construction methods greatly increase safety and reliability, and items built-in the same manner tend to fit together easily without modifications.

Many theatres work primarily in wood, which is relatively inexpensive and malleable. Some shops work in metals as well, though separate working spaces are often required for metal construction due to the inherent fire danger. Simple theatrical construction does not typically involve intensive wood joinery, but instead relies on abutted joint, or **butt joint**, construction methods. When working with lumber, it is important to understand the “true” or actual dimensions of the lumber in order to correctly figure the

lengths needed to be cut for a project. Lumber is sold by what we refer to as a nominal dimension. **Nominal dimensions** are the sizes to which each piece of lumber was rough cut at the mill.

Note

Most Dimensional Lumber is sold in their indicated nominal dimension. However their true literal dimension is often quite different.

Indicated Size (Nominal)	Actual Size
1x3	$\frac{3}{4}" \times 2 \frac{1}{2}"$
1x12	$\frac{3}{4}" \times 11 \frac{1}{4}"$
2x8	$1 \frac{1}{2}" \times 7 \frac{1}{2}"$

Figure 5.2.1: Nominal lumber sizes and actual material dimensions

The lumber we buy at our local supplier has then been put through a series of finishing machines that have cut the lumber into consistent rectangular planks and sanded away the rough edges. This process removes some of the wood and leaves us with a piece whose actual dimension is significantly smaller than its nominal dimension. Scene shops regularly work with sticks of lumber we refer to as “one-by-three” to build flat frames, but the carpenters must remember those pieces actually measure $\frac{3}{4}$ inch by $2 \frac{1}{2}$ inch.

Indicated Size (Nominal)	Amount Removed
1x	$-\frac{1}{4}"$
2x-8x	$-\frac{1}{2}"$
10x+	$-\frac{3}{4}"$

Figure 5.2.1: Material removed from nominal lumber sizes

Fasteners

Unless you are constructing stock scenery, most theatrical construction is temporary. It must be safe and durable, but after the show closes, we would like to recoup as much of the material as possible for reuse. Using screws as a primary fastener allows us to construct and deconstruct with little damage to the materials. Battery powered driver drills have made the use of screws rather than nails or staples a reasonable alternative for construction. **Drywall screws**, which are hard and sharp, have become widely used in theatre construction because they are faster to work with than woodscrews and have better adhesion than nails. However, they are brittle and are can be prone to breaking.

Nuts and bolts are also heavily used for theatre construction. A wide variety of bolts are available. **Carriage bolts** and **hex bolts** are the most common to theatre.



Figure 5.2.1: Fastener chart

For Further Exploration Raoul, Bill. 1998. Stock Scenery Construction : A Handbook. Louisville, KY: Broadway Press. International Alliance of Theatrical Stage Employees. n.d. Accessed August 16, 2018. <http://www.iatse.net/>.

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6: Production and Construction Techniques

Scenery encompasses all the physical decorative elements of the stage design. It includes curtains, platforms, stairs, walls, furniture, and all of the other items a show might require for its visual environment. Scenic designs are delivered to the technical director as a set of plans for the design. The technical director drafts any additional “working drawings” necessary for construction and then distributes the scaled plans to the scene shop. Drafted plans are drawn in a “language of lines” and standard graphic symbols that are generally understood by those who need to interpret them. Each draft has a **title block** in one corner that tells you what the drawing represents and how to interpret its **scale** for construction, as well as who created it and when it was drafted or last revised.

Walls that we construct as **flats** and raised **platforms** that create **levels**, also referred to as **decks**, are the most commonly constructed elements for scenery. Of course there may be lots of other items that a scenic design utilizes or requires, but these elements are standards for set construction.

Note

Often, platforms that need to be moved are bolted to casters. Casters are a mounted wheel that is already attached to an axle and steel plate so that they can easily be attached and detached to scenic units. There are two traditional types, straight casters which can only move in one linear direction, and swivel casters which can roll in any direction.

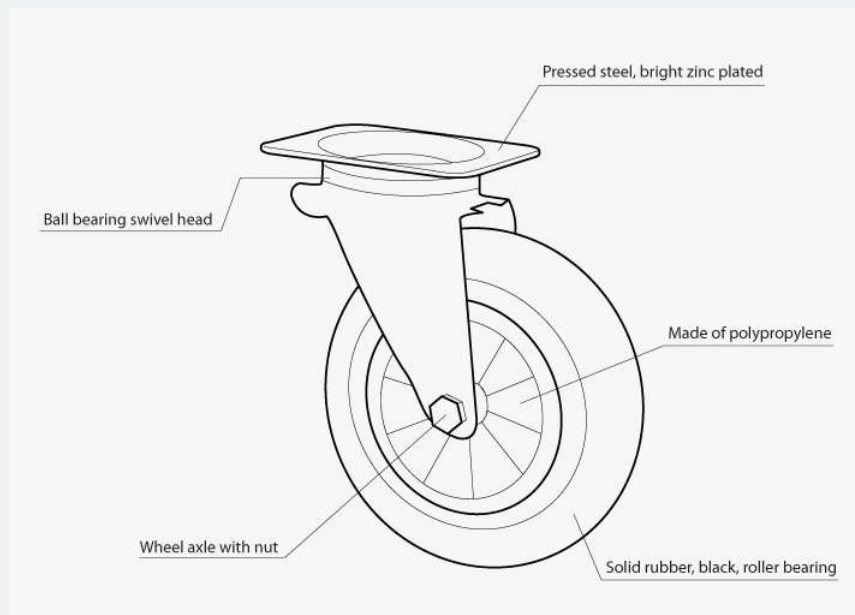


Figure 6.1: A Swivel Caster

As scenery represents a large portion of the physical needs for a production, it is often the most labor intensive of the design elements and usually makes up a significant part of the budget. It stands to reason that the less you need to build from scratch, the more time and money can be saved or allocated to other production needs. **Stock scenery** items are those that the theatre stores between productions and can be reused, redressed, or altered for a production. Companies that have allocated space to store scenic elements such as flat walls and platforms can effectively and economically reuse them. Storage, therefore, is a premium in theatre spaces, and you usually find that something is stored in every nook and cranny of a theatre space in case it might be useful in the future. Environmentally, it also makes sense to reuse as much as possible because plays tend to have relatively short performance runs, and the art form could otherwise be seen as wasteful.

To be most useful, stock scenery should be constructed in sizes that are commonly required and can be assembled in a variety of configurations. Therefore, **stock sizes** of scenery are also common. Flat walls are generally constructed in 1-, 2-, 3-, or 4-foot widths. Heights are dependent on the most useful size for a given stage space.

Some flats can be 20-feet tall or taller, while the most common sizes are 8 feet, 10 feet, 12 feet, 14 feet and 16 feet.

Flats are commonly constructed in two basic types. A **soft-cover flat** is constructed on a frame, usually of wood, but sometimes metal. A canvas is stretched over the entire plane that faces the audience. Much like a large painter's canvas, a flat can be painted to resemble any environment. Soft-cover flats are both lightweight and portable and have been traditional elements of scenery for hundreds of years. Each of the joints of the flat's frame is supported by a thin plywood brace. These **corner blocks** and **keystones** help to stiffen the relatively thin flat frames. These frames, often constructed of 1-by-3- or 1-by-4-inch lumber, are economical to construct and their minimal thickness (approximately 1 inch each) reduces storage space. However, their relative delicacy due to the soft-cover makes them an unpopular choice in modern theatre. While there was a time when it was standard for performers to act in front of the scenery, modern plays require them to interact with the scenery, making canvas walls impractical.

Hard-cover flats are also commonly built as wooden frames, but their face is covered in a thin plywood rather than canvas. This makes them more durable, but also heavier and generally more expensive to construct. The most common version of a hard-cover flat is the "studio" or "Broadway" style flat. These frames are not only stiffer than other styles, but their depth also allows them to be easily secured to one another as well as to the floor. If your production requires actors to lean on the set's walls or throw things against them, a hard-cover flat is your best choice.

Sometimes, tall flats can become unstable or "wobbly" when attached together over long distances. To keep large walls of flats from shaking technicians often attach a **stiffening batten** - sometimes also referred to as "hogs trough" because of its shape. A stiffening batten is usually a simple length of 1x3 pine attached to a flat to keep it from wobbling.

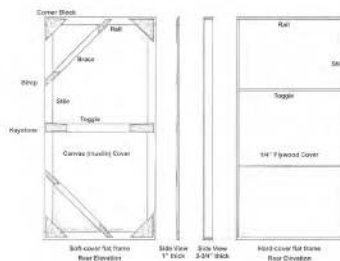


Figure 6.2: Flat frames

Flats are sometimes constructed in shapes other than rectangles. If a flat is constructed to have a shaped edge profile, we refer to it as a **profile flat**. Tree shapes and arches are common profile flats. Flats can be propped up by triangular frames called **jacks** where needed for support.

Note

In construction, carpenters often use industry specific words to describe techniques and practices and they can often be confusing to the uninitiated. **Flush**, **proud**, and **shy** are three such words.

- Flush: Smooth, level, even.
- Proud: Slightly projecting from a surface.
- Shy: Slightly recessed from a surface.

Platforms are often constructed as frames that support a full sheet of plywood as their top **skin** surface, or lid. In the U.S., plywood is sold in sheets that measure 4 feet by 8 feet, and so platforms are constructed this size or smaller. Groups of stock platforms can be assembled into larger **decks** of stage levels with support legs that set their heights above the **natural stage** floor. A **facing** can be added to these platforms that hides the legs so they appear as solid block shapes to the audience.

Typical framing for a wooden theatrical platform can be constructed from either 2-by-4 or 1-by-6-inch boards. Framed on-edge, both materials provide the necessary support the plywood lid requires. Joists that span the 4-foot width of the frame need to be installed on 24-inch **centers** in order to provide the stiffness and weight distribution required for the platform to safely support scenery and performers. A stage platform is typically skinned in $\frac{3}{4}$ -inch thick plywood and supported by a minimum of six legs. Metal platform frames are also common to large productions and touring shows.

When installing platforms on a stage floor, it can often be the case the the stage floor is not perfectly level. This unevenness can get amplified with tall platforms, leaving differences in heights of the platforms, leading to potential tripping hazards. To keep platforms level, a simple **shim** can be placed under platform legs as needed. A shim can be any piece of scrap wood or metal used to raise adjacent parts of scenery so that they are level. Waiters at restaurants often use shims to keep tables from wobbling.

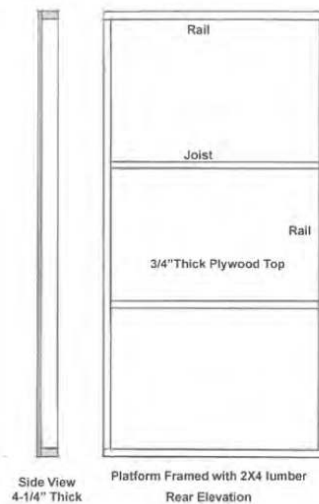


Figure 6.3: Wood framed platform with plywood lid

If we add levels to our stages, we need stairs to get from one height to another. Humans have an interesting relationship with stairs. Most of us do not need to carefully navigate each rise in a staircase, but instead have an autopilot feature that usually allows us to climb or descend them with ease. This is true until one stair is of a slightly different **rise** than the rest, then we are apt to trip and fall at this step. Designers should take care to ensure, as much as possible, that all of the stairs on a given set are of the same height so the actors can traverse them easily without great concentration. Many theatres keep stock stair units as a part of their inventory.

After all of the scenery has been constructed (often offsite in a scene shop), it is time to install it into the theatre on a **load-in** schedule. Sometimes load-in can take mere hours, while more complex production can load-in over multiple weeks. After the show has finished, technicals arrive with trucks and **strike** the show or compete **load-out**, sometimes into trucks for its next destination.

There's More to Know When constructing stairs for a set, it is helpful to use the 18-inch rule for your calculations. The rise of each tread to the next and the run or depth of each tread when added together should add up to 18 inches. Therefore, if a 6-inch rise from tread to tread is required, then your run or depth of tread should be 12 inches. If your rise is 8 inches per tread, then your stairs should each have a 10-inch run depth. This will keep the natural rhythm of human movement intact.

All Staircases should be with in 6 to 8 inches of rise.

For Further Exploration Raoul, Bill. 1998. Stock Scenery Construction : A Handbook. Louisville, KY: Broadway Press. International Alliance of Theatrical Stage Employees. n.d. Accessed August 16, 2018. <http://www.iaatse.net/>.

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CHAPTER OVERVIEW

7: Props

[7.1: Categorizing Props](#)

[7.2: Props and Effects](#)

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7.1: Categorizing Props

Updated and re-authored by:

Categories of Props

Stage properties, or “props,” are those items that are not permanently attached to the scenery, or costumes, that add to the visual picture of the shows. If that definition seems a bit vague, you may have discovered why props are such a varied and interesting section of technical theatre. Props can be divided into the following categories by their use in the final show:

- **Set Props / Furnishings:** These are large items that are rarely, if ever, moved by the cast in the course of the show. These include tables, chairs, settees etc.
- **Set Dressing (Decorative props):** These are items that are not touched by the actors but complete the look of the set. These include books on a book case, pictures on a wall, fancy plates in a china cabinet, cobwebs, etc.
- **Hand Props:** These are items carried and used by the actors in the course of stage directions or stage business. These include such things as a cell phone an actor uses, a coffee mug they drink from, a journal in which they take a note, etc..
- **Costume Props:** These are items that are not generally considered clothing, but would be designed by the costume designer and worn by the actors. These include hats, eye glasses, wallets, pocket watches, etc.

Some props have additional requirements which they must meet. These additional categories of props are a description in addition to their category above.

- **Practical Props:** A practical prop is one that must perform its real-world function. For example, a cell phone (hand prop) that an actor needs to hold and imagine that they are using to make a call is not practical. However, if that cell phone needs to ring on cue, it is now practical hand prop. Similarly, a lamp that sits on the stage is set dressing, until it is determined that it must also turn on. Generally, if the prop must light up or make a noise, especially if cued somehow from off stage, it is considered a practical prop.
- **Consumable Props:** Like practical props, consumable props fit into an additional category. A consumable is one that is “used up” over the course of one or more performances. Food that is eaten by the cast on stage is an example of a consumable prop, as are letters that are torn to pieces by the cast. If a show has a practical flash light, its batteries and lamp would be considered consumable.
- **Rehearsal Props:** Often the “real” props are not available for the rehearsal period. In those cases where the actors need certain props to rehearse, but do not have access to the real prop, a substitute, or rehearsal prop, is acquired. Rehearsal props need to be approximately the same size and weight as the real prop, but are generally a cheap substitute that does not have the correct look. For example, even though a play may be set in the 1800s, the cast could rehearse with a modern composition book instead of a period diary, assuming the composition book was approximately the same size as the final prop will be.

One of the most confusing things about props is that an item, such as a hat, may be in different categories depending on the show. For example, if the hat is attached to a mannequin in a window and never touched by the cast, it might be considered furnishings. In another show, the hat may be hanging on a hat stand, but not used by the cast, making it set dressing. In yet another show, an actor playing a maid might hand the hat to another actor who carries it off stage with them, making it a hand prop. In a final example an actor might wear the hat, making it a costume prop.

Another confusing layer is what department will supply that hat. As the costume department often has more hats in their storage, they may supply that hat regardless of its use in the show. Props may be supplied by the props department, the scenery department or the costume department depending on the prop and the production team. Some props may take collaboration between departments. For example, a table lamp may be supplied by the scenery department but may be wired and made practical by the electrics department. In all cases, clear communication between departments, facilitated by the stage manager, is essential. Often all the designers and department heads will meet to examine the prop lists developed by each department and the stage manager. At this point they will collaborate on who will supply each prop.

Creating a Prop List

A prop list, in its simplest form can be created as a simple categorized list. Sometimes the list can be created even before the production begins. If so, it might look like this:

Table 1: Initial Prop List

--

Page	Prop	Type	Note
2	Bed	Furnishings	With curtains
2	Chest of Drawers	Furnishings	
2	Table with 2 chairs	Furnishings	
2	Assorted decorations	Dressing	
2	Small Looking Glass	Hand	
3	Hat	Costume	
3	2 other hats	hand	
3	Bolster	Hand	"not very protuberant"
5	Rasher of Bacon	Hand	
5	Box of matches	hand	almost empty
5	candlestick	hand	with small candle
6	Pork Chop	Hand	
6	Gridiron	Hand	
6	Fork	hand	
7	Tea things	hand	
7	2 receipts	hand	
8	Roll	Hand	Eaten
8	Pipe	Hand	
14	2 trick dice	hand	always roll 6
15	2 trick coins	hand	always heads
15	additional coins	hand	
16	Letter in envelope from Margate	hand	envelope will need to be replaced nightly
18	Letter in envelope from Margate	hand	Envelope will need to be replaced nightly
19	Letter in envelope from Margate	hand	Envelope will need to be replaced nightly

Like many shows, this initial prop list is mostly hand props. Hand props are the most obvious props in the script. Set dressing is almost non-existent on the list. Set dressing props are determined by the scenic designer based on their design, and will often be presented as a list to the prop department.

In this example play, the gridiron is used several times in the show, yet only appears on the prop list once. That is because if it appeared several times, the prop department would supply a new gridiron for each use. Similarly, since there are three letters from Margate, the prop department will supply three, which is what the show requires.

After this list is created, the production team will decide who will be responsible for acquiring each prop. For example, there are three hats, one a costume prop and two hand props. The costume department might decide to provide all three hats so that they work together to create a pleasing image on stage. Similarly, the scene shop may decide that such a large piece as the bed is too large to be built in the prop shop, and decide that it will be created in the scene shop.

Acquiring Props

There are four methods of acquiring props for a show: pull the prop, build the prop, buy the prop, or borrow the prop. Each method has its own advantages and disadvantages. After determining which department will provide the prop, that department will examine the script to determine which method should be used to acquire the prop.

Pulling a props, refers to the simple task of going to a props storage location and "pulling" the props off the shelf. Many theatres have storage closets - sometimes entire warehouses - full of props from old productions. Often the first step for a props master is to head to the props storage to see if a prop can be pulled off the shelf. This is a great way to save time and money on low-budget productions.

Building is perhaps the easiest method to understand. The script is examined, the prop is sketched, and then the department builds it. This method allows the prop to be created to meet the exact needs of the show. In some cases, this is the only method available, especially when doing a fantasy or science fiction based show. The disadvantage of this is that it can take a great deal of time and expertise to build certain props, which may be a limiting factor. One other consideration is that it is sometimes more costly to build a prop than to buy it. For example, it is possible to melt wax and dip wicks to create the candle for the prop list. This task however would likely take a props artisan several long days to create the one candle needed for the show. It is probably much more cost effective to spend a few dollars buying a candle.

Buying the prop is often the fastest method of acquiring a prop, especially if you are doing a play set in contemporary times. With the advent of internet searches, even historical reproductions can often be quickly purchased and shipped to the theatre. The challenge with buying props is that stage performances are often much harder on a prop than real life. There is a stereotype in musicals of people dancing on tables. The average table that you buy is not strong enough to have several people tap dancing on it for 8 performances a week for many weeks on end. In that case, even if the table was purchased, the scenery or property department would have to spend time reinforcing and strengthening the table. It is not uncommon however to purchase a prop and modify it for use. For example the hats needed may be purchased as a simple hat, and the costume crafts person may add flowers, and hat bands and other embellishments to make it suit the play.

The last category is borrowing a prop. If you are located in a major theatre, film or television market there are often prop rental companies that have an extensive supply of all sorts of varied props. Often these companies have a website that you can peruse to find what you need. If you are not in a major market, it is common for props people to build a relationship with all the other theatres nearby and contact them to see if they will rent out their props to your production. When renting props, you may have to provide the rental company with proof of insurance so that if the prop is damaged, they will be able to replace it. Additionally, rental agreements usually prohibit the prop from being changed in any way. This means that if you don't like the color of the prop, or some other decoration, you are stuck with it. The other challenge with renting props is the cost. Props are generally rented by the week. To save money, producers usually do not like to rent the prop for more than a week before opening night, which means the cast will have limited abilities to rehearse with it. The producer will need to be involved in any rental as there are required legal agreements that must be signed. In general, it is the producer's responsibility to sign and pay for these items, not the prop technician's.

One last note on borrowing props: it is not a good idea for the prop technician (or any production team member) to loan a prop to a production. Too often, this is the prop that is accidentally broken. Since there is not legal agreement, or proof of insurance issued, there is no recourse or ability to have the prop repaired or replaced. Certainly, in no circumstance should a theatre ever borrow (or rent) a truly irreplaceable and unrepairable prop. There are too many things that could go wrong.

At some point, the stage manager will create a list of those props that are needed for rehearsal. In some theatre companies it is the responsibility of the stage manager to acquire rehearsal props, and in some theatres it is the responsibility of the prop department. Regardless, when that list is generated, rehearsal props need to be provided to the rehearsal room as soon as possible.

Revised Prop List

This prop list is updated by the stage manager in collaboration with each department to show how the prop will be acquired, if it is practical or consumable.

Page	Prop	Type	Note	Pract.	Cons.	Rehers	Buy	Build	Rent
2	Bed	Furnishings	With curtains					X	

Page	Prop	Type	Note	Pract.	Cons.	Rehers	Buy	Build	Rent
2	Chest of Drawers	Furnishings							X
2	Table with 2 chairs	Furnishings						X	
2	Assorted decorations	Dressing							
2	Small Looking Glass	Hand				X		X	
3	Hat	Costume				X		X	
3	2 other hats	hand						X	
3	Bolster	Hand	"not very protuberant"				X		
5	Rasher of Bacon	Hand				X		X	
5	Box of matches	hand	almost empty	X	X	X	X		
5	candlestick	hand	with small candle			X			X
6	Pork Chop	Hand				X		X	
6	Gridiron	Hand				X			X
6	Fork	hand				X			X
7	Tea things	hand							X
7	2 receipts	hand				X		X	
8	Roll	Hand		X	X		X		
8	Pipe	Hand				X			
14	2 trick dice	hand	always roll 6			X		X	
15	2 trick coins	hand	always heads			X		X	
15	additional coins	hand					X		
16	Letter in envelope from Margate	hand	envelope will need to be replaced nightly		X	X		X	
18	Letter in envelope from Margate	hand	Envelope will need to be replaced nightly		X	X		X	
19	Letter in envelope from Margate	hand	Envelope will need to be replaced nightly		X	X		X	

Prop lists are in flux throughout the rehearsal process up to opening night. The stage manager is often sending out updates, and there can be many meetings and discussions about props.

Props in the Theatre

Most productions rehearse in one location and perform in another. Eventually all the props (along with the set, and the costumes, and the actors) will move into the new theatre from the rehearsal hall. Generally props are stored in a room of their own, or in a specially constructed cabinet. It is important that the props crew organize the prop storage area so that each prop in the show (and any back-up props or additional supplies (like batteries)) have a specific place that they live. A list of all the items in the prop cabinet needs to be created. When a prop leaves the storage area it must be signed out by a prop technician. When the prop is returned, it should be signed back in. It is very easy to not bother checking props at the end of the night, but if the prop crew does not, something will eventually be lost. A helpful trick is to take a photo of the properly loaded prop storage area and keep the photo(s) with the list. People are often much faster to notice if something is out of place compared with the photo than notice an error on the list.

For the performance, props will often be placed on prop tables so that they are easily accessible and in the correct location for whomever is grabbing or replacing a prop. The prop table is laid out exactly the same way every performance so that each prop as its own, clearly defined space. One way to do this is to cover the prop table with butcher paper or craft paper. Once the prop table has been laid out, trace each prop with a thick black marker, and label what it is. This makes it easy to spot missing props, or misplaced props because the outline brings the organizational structure to everyone's attention. Ideally there will be a prop table on each side of the stage so that someone does not have a long distance to go to grab the prop they need.

Additional Materials

- [History For Hire prop shop](#)
- [Omega Cinema Props](#) (one of the largest prop companies on Los Angeles)
- [Thurston James has written one of the most comprehensive book series on theatre props.](#)

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7.2: Props and Effects

Updated and re-authored by:

In addition to the aforementioned categories of props on chapter 7.1, certain tapes of stage effects are often cataloged and utilized in similar manners as props. In fact, the term “consumable” can also be applied to anything used up or destroyed during a performance such as burning letters or blank ammunition that is fired. Confetti is also considered a consumable.

There’s More to Know Blank-firing weapons are guns that have had their barrel plugged and are not able to be loaded with a live round. These weapons are available in many styles and calibers to match common and period weapons. All replica weapons must be treated with respect and great care. Theatres should have a procedure in place for exactly how the weapon will be used and accounted for. Weapons should be kept under lock and key as much as possible, and only personnel who need to handle the weapon should be allowed to do so. Although a piece of blank ammunition does not have a bullet as a projectile, it is still a controlled explosion occurring in the chamber of the weapon and may propel its wadding and other debris at the speed of a bullet. When this explosion occurs, an envelope of hot gas and burning powder flashes out in all directions from the barrel, creating potential danger for anyone in proximity to the weapon. Blank loads are also very loud. The hearing of anyone in proximity to the weapon when fired should be protected.

Weapons are also prop-based special effects that need special care and attention. They are common to many theatre productions, and, although they have always been dangerous items to manage, the current problems facing our society in regards to public shootings have made even handling a plastic replica gun a danger for any public performance. When a blank-firing weapon is used on stage, specific training for the entire company occurs in order to ensure that everyone knows how to stay safe around such an effect. It should also be said that a weapon capable of holding a live round rather than a blank should NEVER be used in a production. Other weapons such as swords, daggers, and even kitchen knives should always have their edges dulled and tips blunted for general safety.

Special effects are associated with props. Often special effects rely on motors and machinery, and so they are also considerations for the set and lighting designer. Common theatre special effects include atmospheric effects such as theatrical fog and haze and practical effects such as snow, rain, and fire.

The responsibilities of special effects are often shared between several production departments. Water effects such as rain, ponds, showers, and sinks often involve the master electrician, both for the installation of associated electrical equipment for pumps, filters, and heaters, but also, from a safety standpoint, their expertise is needed as water and electricity don’t mix well and can add up to significant danger. When needed, a constant pressure flow to practical faucets might be accomplished via a hose to an existing water source or by creating a closed pressurized system by using a garden sprayer.

Weather-based effects have been used in theatre for many years. Thunder, though now usually recreated with a recorded sound effect, was traditionally created using a “thunder sheet,” a large sheet of thin metal that was struck or distorted to produce the sound. Practical rain can be accomplished by a system that is essentially an overhead sprinkler system. However, containing and circulating water is a tricky undertaking and has huge implications for electrical safety.

Fire effects are another area that requires specific expertise to produce a reliable and safe effect. Any live flame likely requires a special permit to be granted by your local fire marshal. Permits for small naked flames, such as those from a candle, match, or cigarette lighter, are reasonably common requests, and depending on your specific production, may be fairly easy to acquire if the proper conditions and procedures are met. LED candles and battery operated torches and fire effects have become quite convincing and are commonly available as practical and safe alternatives to live flame. Audiences today are often very put-off by smoking of any kind onstage. They have become very accepting of miming smoking without ever actually lighting a prop cigarette. Non-nicotine e-cigarettes can also be a convincing alternative.

Unlike rain, snow is a fairly easy effect to achieve onstage with convincing results. A **snow cradle** is rigged from a batten above the effect area. The cradle is then manipulated to drop a snow-like substance. Depending on your needs, a manufactured snowflake product made from plastic, Styrofoam beads (static causes these to stick to everything), or even dried potato flakes could be used. Snow cradles are also often used to drop flower petals or confetti. Snow machines that produce miniature soap bubbles are also convincing, but the collected soap can be slippery on the stage floor.

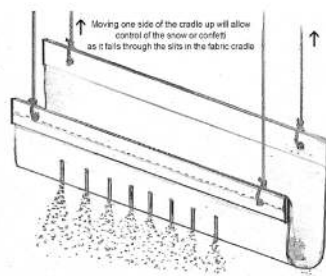


Figure 7.2.1: A simple fabric snow cradle

Breakaway props like **sugar-glass** bottles or glassware are common for fight scenes and are commercially available. These props require careful planning with the performers to keep everyone safe. The production needs to order enough of these expendable items for sufficient experimentation and practice. It is possible for an experienced prop artisan to make custom sugar-glass items for a production, but it has become an expensive and time-consuming endeavor.

There's More to Know Common prop elements such as glassware, silverware, and dishes must be carefully washed after each performance so that germs are not passed among the cast. Items like pipes or cigarette holders should be carefully labeled so they are not shared by multiple performers. All food and beverages should be refrigerated to keep them fresh and safe. In addition, people working on a production are often subject to health issues as they are getting enough rest and are stressed during production periods. Anything you can do to keep everyone healthy is a worthwhile investment.

Breakaway furniture and collapsing crates may be made either from a soft wood such as balsa, or can be pre-broken and held together lightly so actors won't be injured by their impact. Many extra breakaway objects should be kept on standby and for rehearsals.

Consider This When glassware is required onstage, it is often advisable to use a plastic or acrylic alternative to actual, breakable glass. Unless you are “clinking” glasses, they will be convincing replacements and can prevent what otherwise can be both a safety hazard and a time-consuming cleanup onstage.

Productions using weaponry or breakaway props and furniture also require an expert in **stage combat** to work with the cast and crew to carefully plan the actions involved so they are convincing for the audience as well as repeatable and safe.

Atmospheric effects, such as fog, smoke, and haze, have become very common to in productions. Theatrical fog can be produced in several ways. Fog machines that vaporize a liquid by heating it are used frequently. These units are safe, reliable, and inexpensive to run. This type of fog can be run through a cooling unit, which allows it to hang or drop toward the floor rather than rise as a vapor. Dry ice (CO₂) can be employed to create a cool fog that falls and hugs the stage floor. Liquid nitrogen can also be used to produce a pressurized fog effect that can be useful for magic appearances. Smoke and **smoke machines** are often used as interchangeable terms with fog, though smoke effects should accurately be categorized as pyrotechnic effects. Haze is used to thicken the stage atmosphere. It allows the lighting instruments' beams to be seen. The look of a rock concert is achieved through the use of haze. **Hazer** units are similar to fog machines but continuously put out a light vapor distributed over a large area.

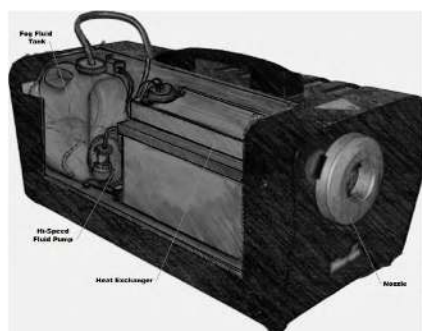


Figure 7.2.2: A fog machine

For Further Exploration James, Thurston. 1987. *The Theater Props Handbook: A Comprehensive Guide to Theater Properties, Materials, and Construction*. White Hall: Betterway Publications. “Instructables - How to Make Anything.” n.d.

Instructables.Com. Accessed August 16, 2018. <https://www.instructables.com/>.

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CHAPTER OVERVIEW

8: Design

[8.1: Design and Collaboration](#)

[8.2: The Design Process](#)

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8.1: Design and Collaboration

Where do design ideas come from? The best short answer: from the script! In the theatre, the script is our base material. When material is well chosen for your specific audience, your inspiration mostly comes from that script. The collaborative process begins once a group of theatre makers who comprise the creative team get together to discuss possibilities for their production. In preparation for this first meeting, sometimes referred to as a “design conference,” each participant will have immersed themselves in the script and familiarized themselves with any and all references made to history, people, places, or cultures—anything that may be unfamiliar to them.

There’s More to Know Like to read? Creative team members read the script for a production many times. Each reading delivers new insights and new information about the story being told. Theatre makers must know not only the story, but also the workings of the way it is told in order to effectively deliver it to an audience. The first reading should be for pleasure and to let the script work on you. Take note of what surprised or moved you on the first reading, when you are as close to the audience’s experience of the story as you will ever be. The second reading allows you to focus on the shape of the play, its imagery, and needs. Further readings will reveal more specific details about characters and story dynamics. The more you read, the clearer you will be about how you can effectively deliver the story to your audience.

Their homework done, the creative team can then discuss the themes within the play and the best way to help the audience experience the play and receive its message.

Early conversations involve thoughtful exchanges about these ideas, while also touching on production concerns such as timeline, budgetary realities, and cast size. Often the production’s director speaks about what excites them about the script, a specific theme they want to showcase, or a vision for the production. Many designers take copious notes during the first meeting so they can be sure to consider all the ideas brought to the table by their collaborators. Some bring visual samples of images, colors, or textures they have responded to while reading and researching the script. The first meeting of a creative team is successful if everyone leaves with a clearer vision of how the production might take form.

There’s More to Know There are endless ways to represent the scenic needs of plays. Scenic designs are generally categorized by one of the following styles: A single set show: A single environment supports the entire performance. Items may move within the setting, but the audience is not transported to another location through set changes. Often a three-wall interior setting is used. Such a setting is referred to as a “box set.” A unit set show: One setting serves for multiple locations with minor adjustments. A designer may find an overarching theme to represent, yet allow accommodations for small, specific elements required by scene locations. A multi-set show: In this setting elements are changeable in order to transport the audience to a number of locations. Usually full stage changes are made, which often require both time and crews to facilitate.

After the second meeting, each designer goes to work on the support materials that accompany their designs. A scenic designer develops a set of drafted, scaled plans of the theatre space and the show design and sets of colored renderings or samples of color elements. A costume designer produces a series of **color renderings** of each costume and chooses **swatches** of fabric that represent the color and texture of the costume elements. A lighting designer prepares a series of drafted views that map where the lighting equipment will be placed, the color filters it will employ, and lists of the specific equipment required. Sound designers submit a map of the equipment locations and a list of cues to be supplied or created.

By the time designers have created the backup materials to communicate their designs, meetings with the technical director, costume shop manager, and master electrician are required to then plan the execution of the designs. This may take place in individual meetings between designers and area leads or may come in the form of a **production meeting**.

Production meetings continue throughout the production process. If possible, a weekly meeting is helpful. Many professional productions have fewer meetings because creative team members are often working from different cities until closer to technical rehearsals.

The designer’s job is far from finished once they have submitted plans to the technical director. After plans are received, the process of determining the cost of realizing the design begins. Designers may be asked to alter or revise their plans to bring them into budget. Once a design has been deemed affordable, the designers begin to work closely with the shops to see that the details of the designs are realized appropriately. Daily communications from the rehearsal room also influence the design and sometimes require alterations to be made. The designer’s role at this time is to shepherd the design through this part of the process.

Once construction is completed, the process of loading the design elements into the theatre space begins. Once again the designers are on hand to ensure all of the elements are in place and properly finished. During this time, the production may hold a **spacing rehearsal**, when the director and performers are given time to explore the realized elements, which until that time may have been represented in the rehearsal room with only tape lines and rough approximations of props and costume pieces.

After everything has been installed in the theatre space, the technical rehearsal process can begin. During this time, designers work with the stage manager and technical director to finalize the elements of the show and adapt the design for any new circumstances discovered at load-in or a spacing rehearsal. We have learned to expect that adjustments need to be made once everything comes together. We hope that if we have planned and communicated well, the changes needed are achievable in the amount of work time we have prior to opening. The designers, director, and management team work to pull all aspects of the production together in a way that is most effective for the audiences.

We are all storytellers, and the technical and dress rehearsal periods are our opportunity to ensure we are all telling a cohesive story to our audience. Following each rehearsal, there are usually daily sessions of **technical notes**, in which concerns and needs are communicated to the entire **company**. Often a separate session of notes is also held involving only the performers, director, and stage manager to discuss **acting notes**.

The final part of the process involves **preview performances**. Previews are test performances. They allow the production to gauge how an audience will interact with the performance. For instance, in a comedy it is very important to allow the audience a moment to laugh, but then to keep the show's pace moving forward. If a performer cuts off the audience's reaction by speaking too soon after a laugh line, then the audience is conditioned not to laugh for fear they will miss the dialogue being spoken onstage. A preview performance allows the performers and crew the opportunity to perfect the timing of the show. Traditionally tickets for preview performances are sold at a discounted rate. In most theatres, reviewers who might write about the production are not allowed to review a preview performance. During previews, designers continue to finesse their designs, while also learning from how the audience reacts to the work. Daily production meetings or note sessions continue through the preview period.

Once opening night has arrived, designers' services are no longer needed and most move on to the next project. However, individually, designers should always take time to reflect on each production and evaluate their work, their choices, and the relative success of each.

For Further Exploration Ingham, Rosemary. 1998. From Page to Stage: How Theatre Designers Make Connections Between Scripts and Images. Portsmouth, NH: Heinemann Drama. "Theatre People | AACT." n.d. Accessed August 16, 2018. <https://aact.org/theatre-people>.

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8.2: The Design Process

Throughout our industry and beyond, design is a simple yet important and often underappreciated subject. There are entire courses, and indeed majors, dedicated to design. For our purposes, we will study the *process* a designer takes in theatre. Using a simple ordered method, we can better organize our thoughts and create a better design than we otherwise would have when taking an unstructured approach.

Engineers often follow a design process to create structures and devices. Their method usually consists of some combination of the following ordered steps: (1) define the problem, (2) research solutions, (3) prototype design, and (4) test the design; only then to repeat the process until the best design is created. In theatre, we take a similar cyclical process more suited to our theatrical needs. J. Michael Gillette defined a seven-step design process in his book *Theatrical Design and Production*.^[1] We will use his system as a groundwork for ours. Gillette's model comprises of seven phases: (1) commitment, (2) analysis, (3) research, (4) incubation, (5) selection, (6) implementation, and (7) evaluation. Easily remembered as the acronym CARISIE. This process, when orderly followed, will lead us to a better design than one we could have created without such a framework.

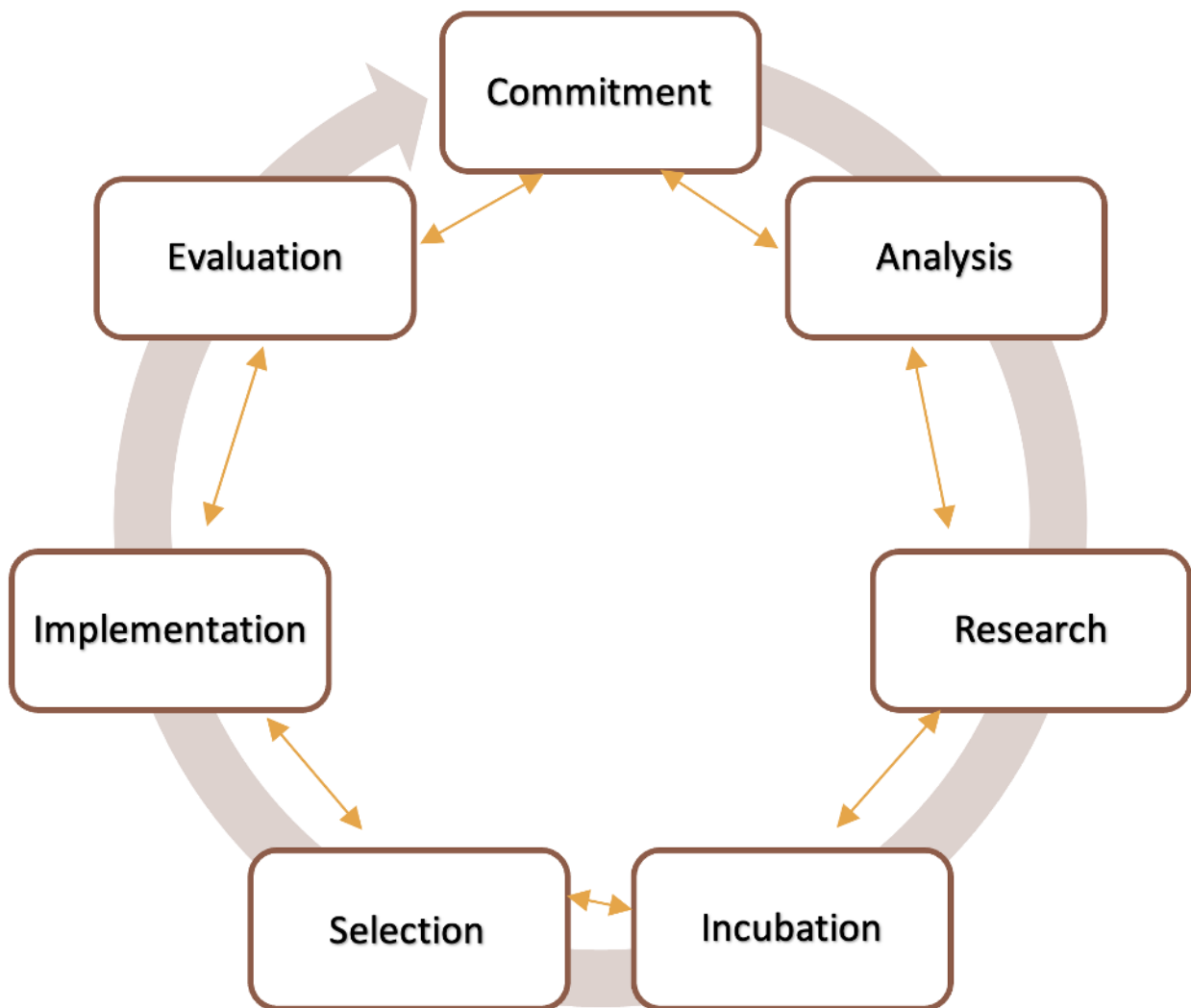


Figure 8.2.1: The Design Process Chart

Design is art, complex and messy. And to stay true to this chaotic medium, we should always use our emotions to influence our designs. As we explore the seven steps of design, remember to internalize your research and solutions. If you connect to your own emotions, so will the audience better connect your designs to their emotions.

Commitment

Commitment should always be the first step in any process. When committing to a project, you are showing dedication and resolve to complete a design. Because of this, commitment is arguably one of the most important steps of the design process. After committing, let nothing slow you down and agree to put 100% of your efforts to a design.

Commitment can take many forms; it can be a personal agreement, a promise among friends, or simply a handshake. But ideally, every project as a designer should begin with a contract, a written document that clearly describes what is being required of you as a designer, and what – if any – compensation the producer will give you in return. Take special care when attempting a design without a contract.

Analysis

Usually when designing for the stage, designers work from a script. Perhaps it is a play that was written long ago, or it could be a new work yet to be performed. Either way, the first place to begin a design is by analyzing the script. For centuries, language classes have been teaching textual analysis, and in reality, analysis for the theater is no different. We need to understand the messages and themes of the work so we can enhance them with our design. But even more than that, as a theatrical designer we need to convey emotion through our designs; and one of the best ways to do that is to follow a procedural approach to script analysis.

When analyzing a script, it is important to read it multiple times before making any decisions. We will read it three times, and with each reading extract different pieces of information to inform our design. On the first read, pay attention only to how the script makes you feel. On the second read, pay close attention to why you felt that way on the first read. And on the third reading, begin to think of what the play requires from you as a designer.

First Reading

Your first read of the script is one of the most important. It is the first time you are experiencing the story as the writer intended. Your mind is uncluttered with preconceptions of future plot points or the knowledge of any required theatrical magic. Take note of the emotions that surface as you read for the first time. Jotting specific adjectives in the margin can act as a reference for a future audience, who should feel the same way as you do now. This reading is for you to connect with the story. Do not bother crowding your mind with thoughts of technical elements or problem-solving techniques. Sit back and enjoy the story.

Second Reading

On the second reading we are still not ready to think about technical elements. We are still analyzing the story, further discovering the themes and emotion of the piece. As you read the script again, begin asking yourself questions about why you felt the way you did through the first reading. “Why did I feel sad here?”, “Why was I shocked when I learned the last name of the villain for the first time?” Answer these questions in the margins for yourself to aid in your analysis. Pay close attention to the words of the play for this reading, is there a unique rhythm, or unusual language used? Does the author create unique themes that influence your emotions? Write all of this down.

Third Reading

Finally, we can now read the script looking for the technical elements that the play requires of us. Read the script a third time and write down every technical requirement of the play that is contained in the text. Different designers may approach this a bit differently. A sound designer may focus on any aural requirements, while a set designer may pay more attention to locations. However, every technical element is important to every designer. If the location is an old, abandoned warehouse, that location can influence light and sound, just as much as it does the set.

Even if you are producing a play that calls for no scenery, like Thornton Wilder’s *Our Town*, you should still write down all the locations, sounds or times of day to help influence your design. When we get to the research phase of the design process, we can connect the technical elements with our adjectives from the first reading to begin melding all our design ideas together.

Research

Now that you have fully analyzed the text of the script, it is time to deepen your understanding of the play by researching it in greater detail. Use what you have learned from the analysis phase and let it influence your research. There are three main categories of research that designers use to deepen their understanding of a play: historical, conceptual, and image research.

Historical

Research the time period of events in the play using your knowledge of when the play was written and when and where it takes place. Begin asking questions about the play and its history. What is the audience's paradigm of that era? For some, the 1970's are only about hippies and bellbottoms, and it is important to also know their view. But it can often be much more than learning about a single fad or trend. What was the historical context at the time the play was written? Furthermore, what were the architectural trends and design aesthetics of that era? If the play calls for a library, what were libraries like in that time? Be sure to analyze what the title means. On a cursory glance, the title of August Wilson's *Gem of the Ocean*, is the name of a slave ship that brought African slaves to America, but with further research and textual understanding from your readings in step two, it can come to refer also to the liquid graves of the African's that did not make the journey and chose a watery home over a life of slavery.



Figure 8.2.2: Both set designs are of living rooms, but note the extreme difference between the images. Historically, they are very different. Left: *Present Laughter* by Noel Coward at The Theatre Group at SBCC, Scenic and Lighting Design by Patricia L. Frank. Right: *Crimes of the Heart* at The Theatre Group at SBCC, Scenic & Lighting Design by Patricia L. Frank

Historical research is not, and should not, be an excuse for you to research how other people designed this play in the past. Plagiarism of other people's projects and ideas are not design. It may be important to watch the movie version of a play like *The Wizard of Oz* as an example, because the audience may come to expect some common design elements, but that does not mean you should give it to them. You are telling your version of the play, not recreating history.

Conceptual

Conceptual research centers around a design concept; a general idea used to formulate your design plans. Traditionally this can be created in collaboration between directors and their many designers, but it can also be a great exercise for any design task. In most cases, a design concept can be condensed into a simple sentence about the play or project you are working on. Your design concept becomes the framework for all your design decisions, it is a broad umbrella of steps of how to envision a design.

Imagine how the two following concept statements could create starkly different designs for William Shakespeare's *Romeo and Juliet*:

1. "Romeo and Juliet is a play about how love can lead to one's demise."
2. "Romeo and Juliet is a play about the destructive nature of longstanding family rivalries and the tragic consequences of political interference."

A notable design begins with a good design concept. Your concept will lead your choices in color and style. It will choose your aesthetic and determine symbols and the overall atmosphere. Every design decision you make will fall back on your concept statement.

Image

If "an image is worth 1,000 words," it is easy to understand the importance of image research. Image research provides inspiration and guidance for the visual elements of a production. By looking at a wide range of images, designers can get ideas for the overall look and feel of their designs, as well as explore different design options. Image research can also help designers understand the historical context of a play and create designs that are authentic and accurate to the time period in which the play is set.

All designers can benefit from image research, even if the design medium is not specifically visual, like sound design. Images can give designers inspiration and help aid in the understanding of design elements. As an example, an image of a stormy ocean might inspire the use of specific types of sound effects to represent the rough waves and wind. As with other design elements, image

research can also be a useful tool for communicating ideas to other members of the production team. By showing specific images to the director, other designers, and the rest of the team, a sound designer can help to convey their ideas for the soundscape of the production visually.

Incubation

Letting your brain rest and allowing ideas and concepts to "incubate" for a period of time can be an important part of the design process. In its most simple form, "incubation" can be resting. Do something entirely different than working on your design task. When you have been focused on researching and analyzing a design, it can be easy to become overwhelmed or burnt out. Taking a break and allowing your brain to rest can help you to approach your work with fresh eyes and a clear mind, which can be especially helpful when you are trying to come up with creative solutions to design challenges.

During the incubation phase, your brain is still working on processing and integrating the information that you have gathered. This can lead to new insights and ideas that might not have emerged while you were actively working on the design. Incubation can also help you to see connections between different pieces of information that you might not have noticed before and can help you to come up with more holistic and cohesive design solutions.

Because the design process is iterative, incubation is a very useful step in the design process. New ideas and connections can lead you back to more research or a better analysis and improve your future selection process.

Selection

Using your concept, analysis, and research, the process of selection involves careful consideration of the various design aspects that are available to you and choosing those that will work together to create a strong and effective final design. Designers need to think about how each design decision will contribute to the final product, and how it will fit within the context of the whole project. This requires careful analysis and evaluation of the various options, and the ability to make informed and well-reasoned decisions about which elements to include in the final design.

The selection phase is a big one. When choosing design elements, designers often consider many different aspects to their designs, including feasibility, design unity and style, effectiveness, authenticity to the period of the play, functionality of design elements, and sustainability. Designers should create designs that are cohesive and consistent, rather than ones that feel disjointed or mismatched. To achieve this, designers need to make sure that all the different design aspects work together to create a unified whole. For example, if you are choosing costumes, you want to make sure that they are appropriate for the characters and the setting, and that they will help to convey the desired mood or atmosphere and connect to the concept of the design.

The selection phase is when a designer chooses what the doorbell will sound like; what colors will come from the lights; and what image will be painted on the backdrops, if there will be any at all. Once all the design elements have been chosen, it's important to review and refine the selections to ensure that they work together cohesively and effectively to create the desired look and feel for the production. This may involve making any necessary adjustments or changes to the selected elements in order to create the most successful design possible. Once the selection phase is complete, you can move on to the implementation phase, where you will begin to bring the design to life on stage.

Implementation

The implementation phase is the stage of the design process where the designer begins to bring their design to life on stage. Almost every other chapter in this book is dedicated to the implementation phase. This phase can involve several tasks, including drafting, constructing sets, making and fitting costumes, procuring props, setting up lighting and sound, rehearsing and performing. As the design elements are put in place, the actors and other members of the production team will begin rehearsing with the sets, costumes, props, and other design elements, in order to get a sense of how everything will work together on stage. Designers use this phase to get the production ready for an audience and test the systems to ensure that they are working properly. The implementation phase is a crucial step in bringing the design to life and preparing for the final production.

Through this phase, it is okay to go back to the previous steps to further refine your design. As the design is brought to life and the various elements are put in place for the first time, it can become clear what changes or adjustments might be necessary to improve the overall design. For example, you might discover that a particular set piece is not as functional as you thought it would be, or that a costume is not fitting an actor correctly. In these cases, you might need to go back to the selection phase and consider different options in order to find a solution that works better.

Going back to previous phases of the design process can also be helpful if you find that your original design is not achieving the desired look or feel, or if you want to make changes to better support the themes or ideas of the play. By revisiting your concept, analysis, and research, you can often find new ways to refine and improve your design. It is important to be open to the possibility of going back to previous phases in order to further polish your design, and to be willing to make changes and adjustments as needed in order to create the most effective and successful production possible.

Evaluation

Evaluation involves reviewing the final production and assessing how well it achieved its goals, both from a design perspective and from the perspective of the overall production. This can be a helpful process for identifying areas of strength and weakness, and for generating ideas on how to improve future productions.

One common way theatre artists evaluate their designs is to have a "post-mortem" (Latin for "after death", in the medical profession a post-mortem is a medical examination of a dead person's body in order to find out how they died) meeting after the production has closed. This is a debriefing session in which the design team and other members of the production team, or other relevant stakeholders, can discuss their thoughts on the design and share feedback on what worked well and what could have been done differently. During the post-mortem, participants can discuss their observations and impressions of the production and share feedback and ideas for how to improve future productions.

It is, of course, okay for you to reach the evaluation phase at any point through your design process. You should always be asking yourself, "Is this working the way I hoped it would?" Don't be afraid to admit that your selected design ideas did not work. Theatre is a collaborative art and should change and grow with the ideas of all collaborators.

Good design requires a combination of careful planning, creative problem-solving, and ongoing evaluation. Successful designers often navigate the steps of design in a systematic way, while also being open to new ideas and approaches. By following a structured design process, designers can create strong, effective designs that achieve their intended goals and make a positive impact on the audience. Often a structured design process leads designers to a better final design by allowing them to carefully consider their choices, think through potential challenges, and adjust as needed to create the most cohesive and effective design possible.

[1] Gillette, J. Michael. *Theatrical Design and Production: An Introduction to Scenic Design and Construction, Lighting, Sound, Costume, and Makeup*. McGraw-Hill Higher Education, 2013.

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9: Color

It could be said that illusion is central to theatrical production and, therefore, something designers try to create. Scenic painting is the artful application of paint to create visual illusions on the surfaces it covers. Whether it is mimicking a material surface such as wood or stone or adding artificial depth to a 2-D surface through painted shadows, scenic painting is the process of creating a visual illusion. The French use the term “trompe d l’oeil,” translated as “fools the eye,” to refer to the art of painted illusions. Set designers deliver paint renderings to the scenic artists who execute the designs on a much larger scale. There may be several meetings with the designer and samples may be painted before the exact methods and colors for executing the scenic painting can be established. Common painting methods are described later in this Module, but to appreciate this art we must first have an understanding of some of the basic theories regarding color that rule over the art of theatrical illusions.

Color plays a central role in creating a convincing environment and effectively transporting the audience into the world of the story. Color is found in the sets, the costumes, and the lighting, but the audience's perception of all color is influenced by the lighting. This happens in part because the choice of color filters on the lights will affect what the audience will be able to reference as “white.” We perceive most of the natural world under white light (full-spectrum light), and when we are presented with a situation in which that light is filtered, our perceptions of color are altered. The lighting designer closely controls the audience's perception of color in the sets and costumes by selecting color filters for the lights. The coordination of the lighting these elements is a central concern for the entire creative team.

There’s More to Know How our eyes perceive color: Our eyes receive light energy waves, and through the excitement the eye’s receptors, translate this light energy, which is either emitted by or reflected by an object, into the electrochemical information our brains then interpret for image and color. The light is received through two groups of nerves in our eyes: rods, which receive faint light waves and help us to see in low-light situations and at night, and cones, which receive higher energy light and respond to the specific wavelengths of red, blue, and green light.

Our sun produces an intensely bright light that is made up of a variety of color wavelengths of light. Combined, these wavelengths fall over our planet as full-spectrum “white light.” We have all seen a rainbow, and most of us have experimented with a prism and understand that it is possible to divide white light into its constituent colors. When full-spectrum light hits a colored object, the object absorbs a portion of the light energy. The portions absorbed are the wavelengths that do not resemble the inherent color of the object.

The portions of the light energy that are akin to the inherent color of the object are reflected off of the object, and those waves are reflected into our eyes, and onto our rods and cones, which interpret the image. So, if full-spectrum sunlight hits a red playground ball, the red wavelengths of that light are reflected to our eyes, and we see a red ball. The other wavelengths (all other colors) are absorbed by the ball and not reflected. This is also why darker colored objects, like a black car, become hotter when left under the sun. They absorb a lot of light energy that becomes heat energy. If we can only perceive an object’s color when the corresponding wavelength of light is available to reflect off its surface, then in an environment where full-spectrum light is not available all color information can be affected. A theatrical lighting designer controls the colors an audience perceives during a show by filtering all of the available light. You have probably noticed that it is difficult to perceive color in relative darkness. When light is limited, our cones cannot receive the levels of energy reflecting off of objects to interpret their color information. Our eyes must instead rely on our rods to interpret the light minus the color information, which makes things look a bit grey.

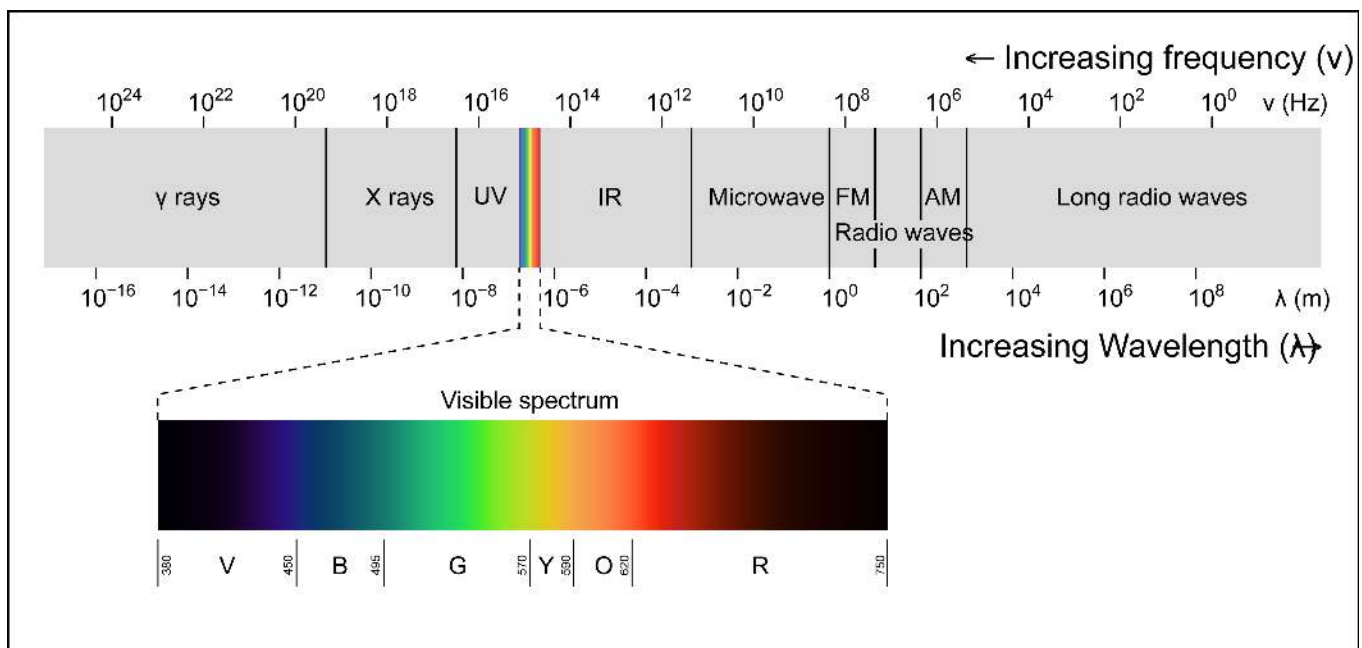


Figure 9.1: The Electromagnetic spectrum, including visual light

Image Credit: Philip Ronan, CC BY-SA 3.0, via Wikimedia Commons

We have all studied color throughout our entire lives. We learned in art classes how to mix a variety of colors from a few **primary colors**, but much of how we are affected by color may be innate to us. Our associations of color fall into two main categories: **natural associations** and **cultural associations**. Natural associations are those that we are born with and are survival-based associations. Red is a color of warning; a red object may be hot or possibly poisonous, and red is the color of spilled blood. Green is the color of vegetation, our food. Blue is the color of lifegiving water. It is beneficial to our survival to recognize the dangers these colors communicate. Other associations are cultural and are based on how we grew up and where we live. In the United States, green may be associated with money, while in other cultures green may be associated with luck or even fertility. Both natural and cultural associations are powerful in affecting all of us. We rely heavily on our visual senses to interpret the world around us, and color is an important factor in that interpretation.

Color terminology

Hue: A color or the qualities that differentiate one color from another.

Saturation (also Chroma): Relative percentage of a hue within a color mixture.

Value: The relative lightness or darkness of a color.

Tint: A high-value color achieved by adding white pigment or light.

Shade: A low-value color achieved by adding several hues or black.

Tone: A medium value color achieved by adding black and white, or by mixing it with its' complimentary hue.

There's More to Know

Color Temperature:

All color has an association with temperature; we regularly refer to cool colors and warm colors. Color temperatures are based on a scientific notion of what temperature a theoretical "black body" would have to be to emit light of a given color. A Kelvin scale provides the units of measure for color temperature. Cool colors like blues are rated at over 5000 K, while warmer colors fall between 2700-3000 K. Photography and videography is greatly affected by the color temperature of the light on their subjects, and theatrical lighting may not always appear as intended when recorded in these mediums. Theatre lighting fixtures generally use tungsten-based filaments, which burn at a fairly low color temperature even before being filtered. When film or video are used to capture theatrical presentations, the temperature of the light may need to be adjusted for the device to capture what our eyes see naturally.

You probably remember from grade school lessons that there are three primary colors: red, blue, and yellow. What you might not have learned is those are the three primary colors for **pigment**, but not for light. There is a separate color wheel that represents how color of light is organized and mixed. The difference between pigment and light is partly due to our eyes and how we, as humans, perceive color through our eyes. We have receptors in our eyes that interpret red, blue, and green light. Our brains use these three colors of light to interpret our visual perceptions of the world.

From art class, we know we can mix two primary pigment colors together to make a new color. Mixing two primary colors will result in a **secondary color**. In pigment mixing the secondary colors are orange, green, and purple. If we combine a secondary color with the primary color that it neighbors on the color wheel, we create a new **tertiary color**. In this system of pigment colors, if we **additively mix** colors together, they become darker as we add hues, and will eventually appear near black as we continue to add colors.



Figure 9.2: A color wheel for pigment

Light has its own color wheel; its primary colors include green rather than yellow. The color wheel for light is based on the human reception of visual information. Our eyes do not have a specific receptor for yellow, so when we see a yellow object our eyes read the wavelengths of the red and green light, and, in sensing a small amount of each wavelength, our brains interpret the impulse as yellow. While pigments additively mix toward black, a variety of colored lights additively mix toward white as all of the various wavelengths combine to fill in the spectrum to approach a “white” light. Through the use of color filters, lighting designers remove portions of the spectrum from an individual light that would otherwise broadcast a full-spectrum. This is called subtractive coloring. The combination of a number of these individually filtered lights onto an object additively mixes together the available light that will strike that object. If we filter all red light from an environment, then a red object will not appear red to our eyes since no red wavelengths are available to be reflected back to them. If all the light on the red object is a green wavelength, it will appear a dark color that looks grey to black because the green light is a complementary color to the red object. This kind of control over what the audience sees allows a lighting designer to affect all the colors on a stage through their choice of lighting filters.

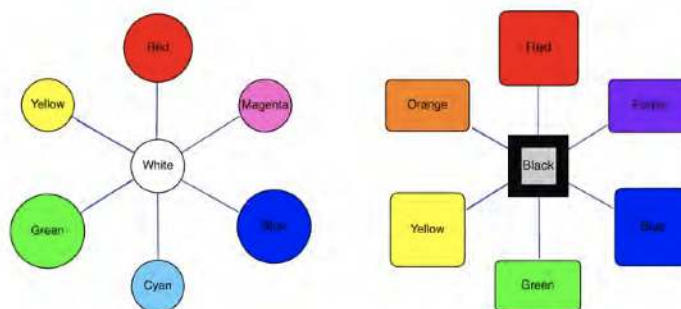


Figure 9.3: Color wheel for light (left) & color wheel for pigment (right)

Lighting filters (gels)

As we have learned, theatrical lighting instruments emit a full-spectrum, white light. Designers then use a color filters, or gels, to limit parts of the spectrum projected from the light. These filters are thin colored sheets of translucent polycarbonate or polyester that are placed in front of the light source. Only the part of the spectrum of light that is akin to the color of the filter is allowed through. All other parts of the spectrum are absorbed by the filter, resulting in the projection of a limited wavelength of light.

Because all other wavelengths are absorbed (as heat) darker filters do not last as long as lighter filters and may melt or fade with time. The relative strength of a light is greatly affected by how much energy is transmitted through a given filter. **Transmission** is the term that describes the percentage of source light that passes through a given filter. Sample decks of colored filter swatches are available from manufacturers and generally list the percentages of transmission for each color filter. A darker color filter may have a transmission of only 10-20%. Color filters are used individually in an instrument because stacking two filters only serves to diminish the amount of light that passes through the filters since each individual filter removes all wavelengths of light other than those akin to it. Lighting designers use the color wheel of light to develop a color palette that will color the production's world as intended. A designer creates a look specific to the production by picking three or more filter colors in a triad configuration on the color wheel, putting them on three separate lights, and blending them together in a single projection area where they combine to create the show's "reference white." The use of just two **complementary color** filters (those directly opposite on a color wheel) can appear to mix toward white since their opposition on the color wheel allows greater coverage of the apparent spectrum. As theatre fixtures are quite bright and can feel harsh, a mixed white light will always appear richer and more vibrant to an audience than using unfiltered full-spectrum, white light.

Color Neutralization with the Integrated Color Wheel

In order to fully understand color, we have to understand how light and color interact. We know that placing a gel in front of a white light creates light of that gel color (a form of subtractive color mixing). However, what happens when we project colored light on a surface of a different color? To better clarify the relationships of color and light we can use the Integrated color wheel, a color wheel that integrated both the colors of light and pigment together. Because all of the traditional primary colors do not have the same value, we can arrange twelve principal hues of similar values together in one graphic.

The Integrated Color Wheel

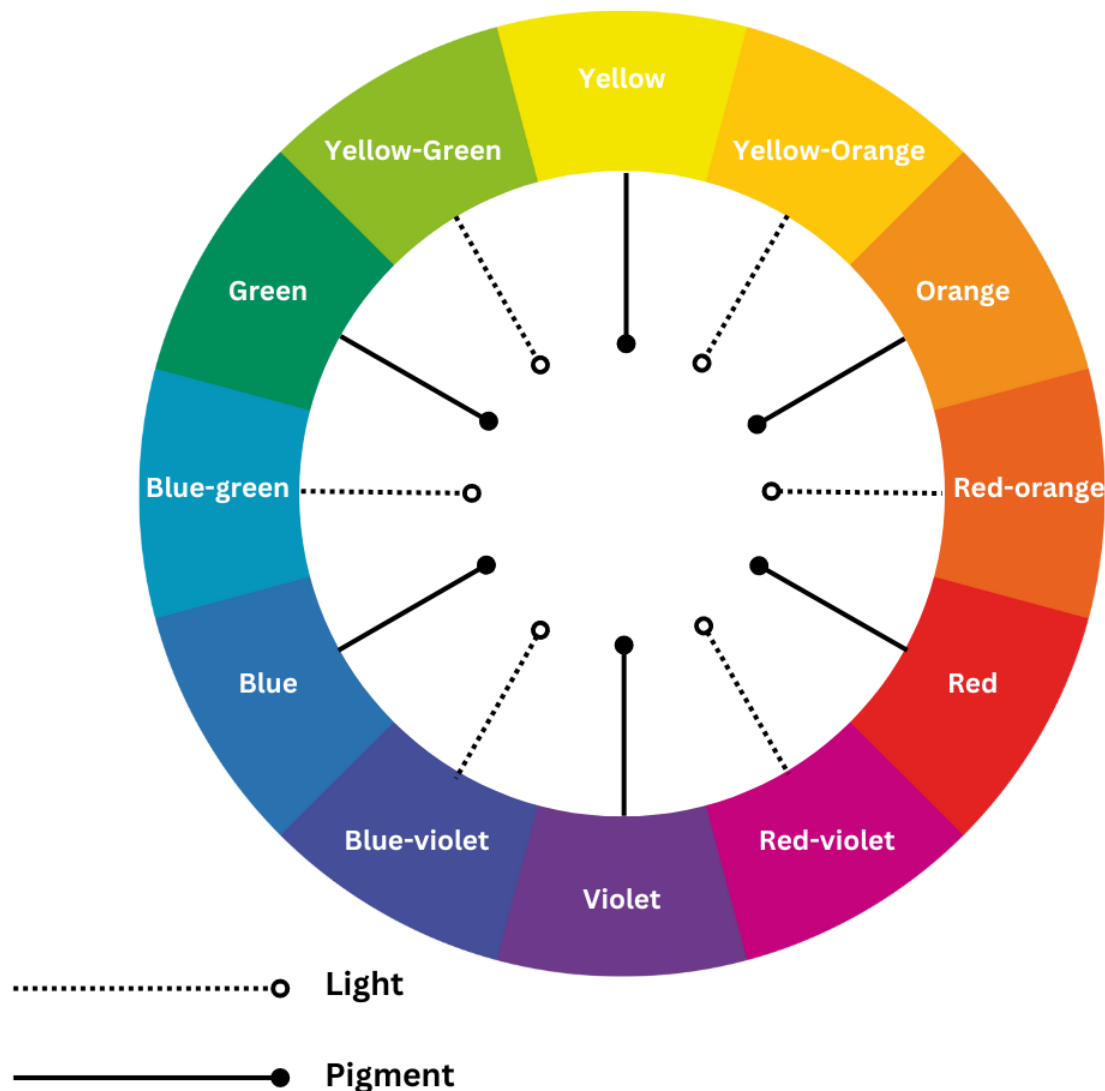


Figure 9.4: The Integrate Color Wheel

Knowing that white light is the combination of all colors of light, and black pigment is the combination of all colors of pigment, the two systems seem to be at odds. Colors opposite each other on the color wheel are complimentary colors, but if one is a color of light and the other is a color of pigment they will have no interaction at all. Let's look at two examples of a red wall: 1) a wall painted red and illuminated by white light, is reflecting red light towards your eyes. 2) Similarly, a wall painted white, with a red light projected on it also reflects red light towards your eyes. However when we begin to work with complimentary colors of light and pigment Neutralization occurs when mixing colors of the same value. If we have a wall that is painted red, but we project a green (or sometimes blue) light on that wall no light will reflect back to our eyes. Because the pigment of red has no green in the pigment, there is no pigment available to reflect that color of light off of its surface. By using subtractive color mixing and color neutralization, designers can control the very colors of objects that the audience sees. Visit [The American Meuseum of Natural History](https://www.amnh.org/exhibitions/american-meuseum-of-natural-history) to explore how colors mix and overlap.

For Further Exploration M.A, Associate Professor William H. Pinnell B. A. 2008. Theatrical Scene Painting: A Lesson Guide. Carbondale: Southern Illinois University Press. Sherwin, Stephen G. 2006. Scene Painting Projects for Theatre. Boston: Focal Press. "Color Matters." n.d. Accessed August 16, 2018. <https://colormatters.com/>.

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10: Painting

Scenic painting often takes advantage of the filtered spectrum of the lighting designer's palette in order to achieve its illusionary effects. Knowing that the lighting allows some colors to appear prominent and some to recede, the painter chooses hues that best support the illusion their paint is intended to create.

Scenic paint effects are largely achieved through the layering of colors over a surface. In order to achieve layering that allows the previously laid layers to show through, the painter must use a series of thinned paint **washes** to complete the effect.

Paint is made up of several elements. The color of paint is due to the **pigment** added to its mixture. Pigment is an often dry, colored particulate, which is suspended in a liquid to give the liquid hue. The liquid itself has two purposes: it allows the pigment to be spread over a surface and includes glue that permanently binds the pigment to the surface. The paint liquid is part **vehicle**, which allows the paint to spread and is eventually evaporated or absorbed, and part **binder**, which is the glue that adheres the particles of pigment. A fourth component that is common to house paints is **filler**, which is particulate matter that increases the opacity of the paint for better coverage and sometimes can be used to extend the paint to drop its price. Chalk is a common filler.

When creating washes by thinning paints (adding more of the vehicle component), a scenic artist has to be careful not to thin so much that the binder can no longer effectively glue the pigment to the surface, or the paint will easily rub off onto costumes and actors.

Though it is common for modern theatres to work primarily with water-based latex paints, it is possible to encounter other types of paint and solvents in a scenic paint shop. Always read labels on the products you are working with. Shops are required to keep a binder of SDS (safety data sheets) for all chemical compounds they stock. These sheets serve as guides for safe use, personal protection requirements, and cleanup of chemical products.

Most commonly, scenic artists are asked to replicate the textures of materials such as woods or stone onto scenery, though creating visual depth through manipulation of highlight and shadow is also central to the art. As temporary constructions, sets are often built of relatively light and inexpensive materials, though often they represent rather ornate interiors. So scenic artists paint wood to look like more expensive wood or wood to look like stone or metal. Scenic artists are masters of these illusions and create most of them through the use of relatively few application techniques. The most common application techniques are **wet-blend**, **scumbling**, **dry-brushing**, **spattering**, **stippling**, and **rag-rolling**. The combination of these application methods produces some amazing painted illusions. Painted light and shadow can add very convincing detail and depth to these illusions, but must be carefully coordinated with the lighting design.

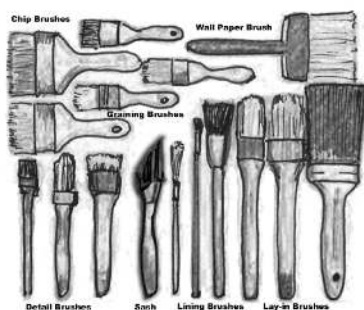


Figure 10.1: A variety of shapes and sizes of paintbrushes

Brushes

There are many different kinds of brushes that are used to paint in a production.

- *Priming*: A wide thick brush for covering large areas quickly.
- *Lay-in*: A flat-tipped brush with a thick ferule of bristles to carry large amounts of paint.
- *Graining*: A brush cut to have void areas for creating random graining.
- *Liner*: A flat edged brush for outlining and details.
- *Sash*: A steeply angled brush for cutting in against window framing.
- *Chip*: A commonly available, inexpensive brush well-suited to dry-brushing technique.
- *Roller*: A round tube capable of rolling paint onto a surface. The nap of the roller indicates the thickness of its cover and will determine the texture the roller is best suited to cover or create.

The Parts of a Brush

While there are many types of brushes, each with its own purpose in an artists toolkit, all brushes have the same named parts.

- *Tip*: The very end of the bristles that make contact with the painting surface.
- *Head*: The main body of the brush that holds the bristles and connects to the ferrule.
- *Bristles*: The thin, flexible fibers on the end of the brush that are used for painting.
- *Crimp*: The metal or plastic band that attaches the bristles to the ferrule.
- *Ferrule*: The metal or plastic tube that connects the bristles to the handle and provides support for the brush head.
- *Handle*: The long, usually wooden part of the brush that is held while painting.

The Parts of a Paint Brush



Figure 10.2: The parts of a paint brush

Paint application techniques

There are many different paint application techniques that can be used sets.

- *Wet-blend*: To blend two or more colors together often in a smooth gradient.
- *Scumble*: To wet-blend two or more colors together using multiple brushes in a random camouflage-like pattern..
- *Spatter*: To spray small dots of paint onto a surface by flicking the paint of the ends of the bristles.
- *Dry brush*: To drag a nearly dry brush across the surface of a base color in order to leave a series of streaks of paint along the surface.
- *Stipple*: Using the blunt ends of the bristles of a brush to stamp color onto a surface to provide visual texture.
- *Rag roll*: Using a length of cloth dipped into paint and wrung out to roll across a painted surface to apply a roving line. Especially useful for marble and stone effects.
- *Paint layers (coats)*: Applying multiple layers of paint are applied to a surface
- *Prime coat*: A layer intended to seal the surface of the object and provide a uniform surface for the base coat.
- *Base coat*: The foundational coat for the intended technique, it should match the hue and value of the finished product.
- *Texture coat*: A thick coat of paint, plaster or other medium applied to add a three-dimensional texture to a surface.
- *Top coat*: A final coat, usually clear or lightly tinted, to add a sheen to the finished technique.

Creating a Faux Wood Grain

First observe a sample of the wood you are attempting to replicate. Look at the quality and colors of its grain and the tones of its base colors. Begin with a two-color base coat of the extreme light and dark tones of its base colors scumbled together applied in the direction of the grain. Wood grain can be created either in a **wet-blend** or a dry technique. To wet-blend colors, the grain colors are brushed into the still wet base scumble. This technique can produce subtle results with enough time and care. Dry techniques work well when covering larger areas and can also be very controlled with practice. To use the dry technique, allow the base scumble to dry completely, then dry brush thin grain colors over the base, letting each color dry between steps. In either method, waiting for the base and grain layers to dry before applying toning glaze and/or top coat for sheen will make for a convincing effect. The toning glaze is often a thinned version of the most prominent grain color sponged over the entire piece to help blend the colors together. It can be mixed into a glaze medium that will also add sheen to the finish or can be covered with a clear top coat for sheen once dry.



Figure 10.3: Creating a faux wood grain

Creating a Faux Stone Surface

Scumble two or more colors together on the surface to supply variation to your base. Once dry, apply a series of spatter coats to add visual texture to the effect. A tint and a shade of the mid-tone from your base colors can be thinned to spatter consistencies appropriate to the size of spatter dot you are trying to achieve. Thinner paints produce larger spatter dots. If any areas look too bold after spatters are applied, applying a third layer of spatter made from the untinted mid-tone base color can break up the two previous spatters. If your final effect is that of a stone path, paint your mortar lines between stones prior to applying the shade spatter to help blend the surfaces together. Add highlights and shadows along edges of stones to add dimension.



Figure 10.4: A faux stone surface

To create a convincing sense of depth on a scenic surface, you must work in concert with the lighting designer so all shadows, both painted and those created by scenery and actors, work in the same direction. The direction of the shadows is established by the direction of key light sources of the light plot. Once the direction of the stage lighting has been established, the placement of highlights and shadows can be calculated for the scenic painting.



Figure 10.5: Light and shadow enhancement

For Further Exploration M.A, Associate Professor William H. Pinnell B. A. 2008. Theatrical Scene Painting: A Lesson Guide. Carbondale: Southern Illinois University Press. Sherwin, Stephen G. 2006. Scene Painting Projects for Theatre. Boston: Focal Press. "Color Matters." n.d. Accessed August 16, 2018. <https://colormatters.com/>.

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CHAPTER OVERVIEW

11: Electricity

[11.1: Electrical Safety](#)

[11.2: Electrical Fundamentals](#)

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11.1: Electrical Safety

Electrical Safety Considerations

Electrical Shock

Electricity flows along a circuit that consists of a power source, a load, and conductors. The human body can become a conductor and a part of the electric circuit which can result in electrical shock. Exposure to electrical energy may result in no injury at all or may result in physical and/or neurological damage or death. An minor electrical shock may cause muscle pain and may trigger mild muscle contractions or startle people, causing a fall. However, high resistance contact may cause dielectric breakdown at the skin, lowering skin resistance, causing surface damage, but more often tissues deeper underneath the skin have been severely damaged. Electric shocks can paralyze the respiratory system or disrupt heart action, causing instant death.

The outcome of an electrical shock depends on several factors that are determined by the relationship between current, voltage, and resistance, also known as Ohm's Law.

Ohm's Law

Voltage or Electrical Force (V)

Amperage or Current Flow (I)

Resistance or Ohms (Ω or R)

Current=Electrical Force/Resistance or $I=V/R$

Exposure Conditions play an important role in the extent of injuries sustained as a result of electric shock. These factors include:

- **Duration-** The longer a human body remains part of an electrical circuit, more tissue and neurological damage can occur.
- **Pathway-** Electricity is always seeking the path of least resistance to ground. If both hands of a person are part of the pathway, the current has more potential to affect the heart resulting in ventricular fibrillation. If the current chooses another path such as hand-to-foot, tissue and internal organ damage still may occur.
- **Humidity/Saturation-** Electricity can easily flow through water or moisture in the air. Humidity also can effect how much a body sweats, which can lower a persons resistance to electrical current.
- **Skin Condition-** The human body's resistance to current is affected moisture content:
 - Dry Skin- 100,000 to 500,000 ohms of resistance
 - Perspiring (sweaty hands)- 1000 ohms of resistance
 - In Water (completely wet)- 150 ohms of resistance

Amperage Kills

Current	Effect
<1 Milliampere	No sensation
1 Milliampere	Tingling sensation
5 Milliamperes	Slight shock felt
6 to 30 Milliamperes	Definite shock Could cause muscle contraction causing you to hang on
50 to 100 Milliamperes	Painful shock Breathing can stop Severe muscle contractions Possible death
1000 to 4300 Milliamperes	Ventricular fibrillation Respiratory paralysis Possible death

Current	Effect
10,000 Milliamperes	Cardiac arrest Severe burns Probable death

Example:

A worker is using a faulty 120 volt tool on a hot and humid day and is sweating heavily. The worker's body resistance is approximately 1,000 ohms.

Using Ohm's law:

- Current = 120 volts / 1,000 ohms.
- Current = 0.12 amps or 120 mA.

According to the above table, this amount of current will cause a painful shock, the workers's breathing may stop, there will be severe muscle contractions, and death is possible.

Arc Flash and Arc Blast

Arc-Flash-Arc- Flash burn can occur when an electrical equipment malfunction causes an extremely high temperature area around the arc that can reach as high as 35,000 degrees Fahrenheit. Electrical burn can also occur any time an electrical current flows through bone or tissue.

Arc-Blast- When an arc occurs, a blast causes molten metal to be thrown through the air and onto the skin or into the eyes. The speed of the molten metal in an arc-blast is estimated at approximately 700 mph.

Donnie's Accident Story

General Safety Rules for Electrical Technicians

- Safety glasses, goggles, or face shields must be worn any time a hazard exists that can cause foreign objects to get in your eyes from the front or the sides.
- Head protection must be worn whenever there is a potential for objects to fall from above, for bumps to your head from objects fastened in place, or for accidental contact with electrical hazards.
- Hand protection must be worn any time your hands are exposed to a potential hazard.
- Do not wear clothing with exposed zippers, buttons, or other metal fasteners.
- Remove rings, wristwatches, and any other metal jewelry before beginning work.
- Work with a buddy. Avoid working alone.
- Always turn power off and lock it out before working on any electrical circuits or equipment.
- Never cut off the grounding prong from a three-prong plug on any power extension cord or from a power cord to any piece of equipment.
- Do not defeat the purpose of any safety devices such as fuses or circuit breakers.
- Do not open and close switches under load unless absolutely necessary.
- **Assume all electrical equipment to be "live" and treat it as such.**

Non-Energized Testing

Never test an energized circuit when individual components of the circuit can normally be tested by other means. Most electrical components and pathways of electrical systems can be individually tested for continuity and resistance.



Remix

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11.2: Electrical Fundamentals

What is Electricity?

Electricity is a form of energy that powers the devices and machines we use every day, like the lights in our homes, the television, and the computer you might be using right now. It's created when charged particles (electrons) move through a conductor, like a wire. We can control the flow of these electrons with various devices, including: resistors, capacitors, and transistors, to perform specific tasks such as generating light, heat, and motion.

Think of it like water flowing through a hose. The water represents the electrons, and the hose represents the wire. We can turn the hose on and off with a valve, just like we can control the flow of electricity with a switch. And just as the water can power a sprinkler or a water wheel, electricity can power all sorts of devices and machines.

A basic electrical system consists of sources and loads. A **source** is the device that creates the energy, this can be a battery, a 120 volt wall outlet, or any number of electrical generators such as a solar panel. A device that converts (consumes) the power from an electrical source to another source of energy is an **electrical load**. Examples of common loads are lights, heaters, motors, fans, and even computers.

Electrical systems are powered through one of two distinct types of systems, **Alternating Current (AC)** and **Direct Current (DC)**.

AC is a type of electrical current that regularly changes direction (think of it like pushing power, then pulling power), typically at a frequency (Hz) of 50 or 60 times per second. AC power is used to power most of the electrical devices we use in our homes, such as lamps, televisions, and appliances. AC power is generated by power plants and is distributed to homes and businesses through power lines. In the United States, most household electrical systems run on 120 Volts.

DC on the other hand, is a current that flows in one direction only. Electricians use DC to power devices that require a steady and constant flow of electricity, such as batteries, electronics, and electric vehicles. DC power can be generated by batteries or by converting AC power using a device called a rectifier.

The characteristics of AC and DC power are different. AC power can travel long distances with minimal power loss, making it well-suited for use in power grids. AC power is also relatively easy to transform into different voltages, which is important for distributing power to different areas. However, AC power is more complex to generate than DC power and can be more dangerous as it is often used at very high voltages. DC power is also easier to store in batteries, which is important for portable and off-grid applications. However, DC power is far less efficient than AC power for transmitting electricity over long distances because the wires have to be larger to carry a lower voltage.

The power formula

When dealing with high voltage applications, which is most of what we work with in theatre, an especially useful formula is the **power formula**. Power is a measure of the rate at which energy is transferred or used over time. Larger devices require more power than smaller ones. We can understand the relationships of power measurements by using the power formula. $W = VA$ represents the relationship between power (W), voltage (V), and current (A) in an electrical circuit. In order to use the power formula, we must first understand its variables:

- **Power = Watts (W)**. Watts measure the rate at which energy is transferred or used over time. One watt is defined as the amount of power required to do one joule of work per second. To use the water flow analogy, power is the amount of water required to make a device work, similar to the flow of a shower head.
- **Electrical Potential = Volts (V)**. Volts measure the electrical potential energy per unit of charge in an electrical circuit. It is the force that drives the flow of electric charge in a circuit. To use the water flow analogy again, voltage can be thought of as the "pressure" that drives the flow of electricity in a circuit.
- **Current = Amps (A)**. Amps represent the rate at which electrical charge flows through a circuit. The higher the current, the greater the amount of electric charge flowing through the circuit per unit of time. To use the water flow analogy, current is the speed at which the water flows.

Power Formula

$$W = VA$$

$$V = \frac{W}{A}$$

$$A = \frac{W}{V}$$

The power formula is remarkably simple, $W = VA$. We often remember it by singing the words “West Virginia.” If we only know two of the variables, it can be rearranged to solve for any missing information.

✓ Example 11.2.1

Let’s say that we know the rating of our electrical outlet and want to know how many lights it can safely support. Let’s fill in what we know: 1) in the US, most household outlets are 120 Volts, 2) after inspecting the circuit breaker panel, we see that the outlet is rated to 15 Amps. Let’s use the power formula to find out what power that outlet is rated to?

Solution

$$W = VA$$

$$W = 120 \times 15$$

$$W = 1,800$$

After using the power formula, we find that the outlet can safely support no more than 1,800 Watts of power. That would be one 1,000W light, three 500W lights, or 18 100W lights.

American Wire Gauge and Safe Wire Loads

The United States and Canada use the **American Wire Gauge (AWG)** system to categorize the sizes and power ratings of commercially available wires. We can convert AWG sizes into the metric system of mm^2 , for use throughout the rest of the world, but for our purposes we will use this American standard. The AWG system consists of numerical values that describe wire diameter. In general, larger wire diameters are able to handle greater electrical currents. While there are many tables describing wire gauge capacity for varying applications, below is a table that shows a simplified relationship between AWG and wire capacity in Amps for use in theatre.

Gauge of Wire	10	12	14	16	18
Capacity in Amps	25	20	15	6	3

Notice that a smaller wire gauge has a greater capacity in amps. This is because the smaller the gauge number, the larger the physical wire. Let’s use this table in combination with the power formula to reveal the smallest safe cable size for a given application.

✓ Example 11.2.2

Assume you have a 1,200W theatre spotlight on a standard 120V electrical service. What is the smallest safe wire gauge you can use to power the light? Let’s use the power formula to find the light’s required current, in Amps.

Solution

$$W = VA$$

$$1,200 = 120 \times A$$

$$\frac{1,200}{120} = \frac{120 \times A}{120}$$

$$10 = A$$

Using the table above, the smallest wire gauge that can safely transmit 10 Amps is a 14 gauge cable. Choosing a cable any smaller could lead to a cable melting, starting a fire, or worse.

Types of circuits

There are two basic types of electrical circuits used to distribute electricity: series and parallel. A third more common circuit is the combination circuit which is a combination of both series and parallel.

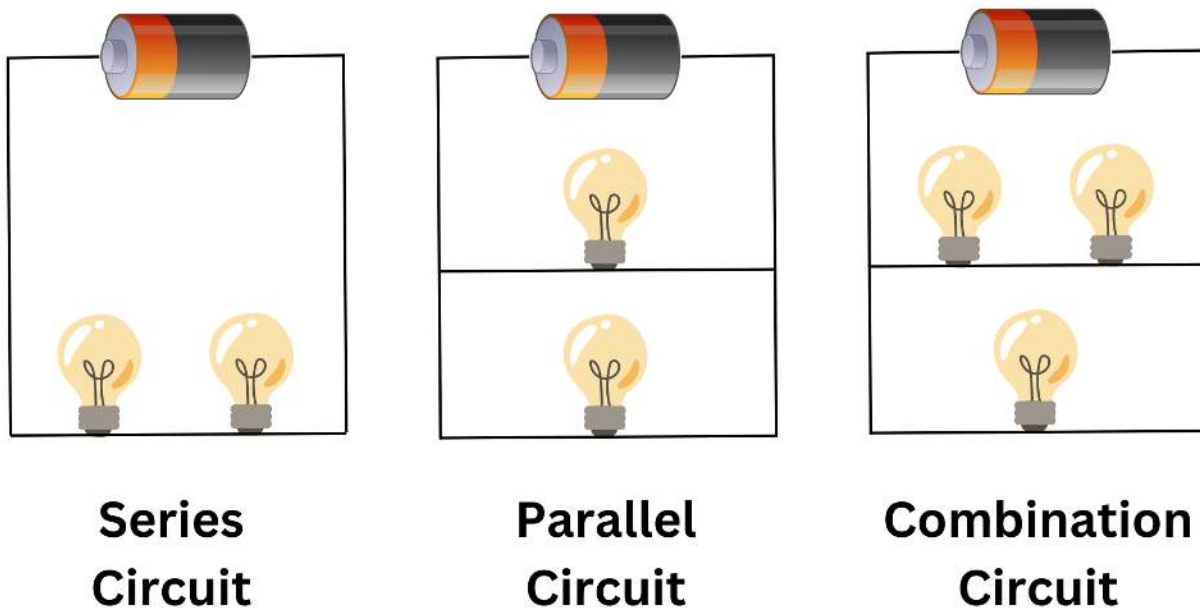


Figure 11.2.3: The three types of circuits

Series Circuit: A series circuit is a circuit in which the electrical components, such as resistors or light bulbs, are connected in a single loop or chain, with the same current flowing through each component. The total resistance of a series circuit is equal to the sum of the individual resistances of the components. In a series circuit, if one component fails or is removed, the entire circuit is broken and no current will flow.

Parallel Circuit: A parallel circuit is a circuit in which the electrical components are connected in multiple branches, with the voltage across each component being the same. The total resistance of a parallel circuit is less than the resistance of any individual component. In a parallel circuit, if one component fails or is removed, the other components continue to operate normally.

Combination Circuit: Perhaps the most common circuit used in theatre equipment, a combination circuit is a circuit that combines elements of both series and parallel circuits. In a combination circuit, electrical components are connected in both series and parallel configurations. The behavior of a combination circuit can be analyzed by breaking it down into smaller sections and analyzing each section separately, then combining the results.

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CHAPTER OVERVIEW

12: Lighting Design and Production

[12.1: Lighting Design](#)

[12.2: Lighting Equipment and Control Systems](#)

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12.1: Lighting Design

Updated and re-authored by:

Most modern theatre spaces are capable of getting quite dark when the lights are turned out. These spaces rarely have windows and when they do, they are usually heavily draped to effectively block out any outside light. Once it is dark, anything the audience sees is visible because of the work of the lighting designer. Theatrical lighting designers are masters of the unique and controlled skill of “painting” with light. As with the other designers, their art is that of a storyteller, and the choices they make for a production support the story being told. Lighting design not only provides **illumination** so we can see the performance, but also utilizes the remaining **functions of light** to create **mood**, **modeling** of the playing area, and to provide a **selective focus** so audiences know where to look in order to follow the story. Light designers manipulate the **controllable qualities of light** at their disposal—**direction** (distribution), **intensity**, **color**, and **movement**—to create their design.

Most plays are set in interiors, though epic plays and musical theatre productions are more likely to have both indoor and outdoor locations. In either case, the lighting designer recreates some version of a lighting situation that the audience is familiar with. We know what the light looks like at sunset on the beach or inside a cozy cabin bathed in firelight, and so we have an expectation of what that should look like on the stage. Therefore, part of a designer’s consideration has to be an awareness of that expectation, regardless of whether they choose to support it or take the audience in a different direction.



Light Design of The Marriage of Figaro at UCSB (Designer: Ben Crop)

A script provides the designer with information regarding place and time period, including specifics regarding years, seasons, and times of day for each scene of the play. All these elements are taken into consideration in the design. The set design, architecture of the theatre space, and the lighting positions it provides, also heavily influence the design of the lighting.

We are used to gauging light largely in terms of sunlight. Even our interiors are often partly illuminated by natural light from windows or skylights. The sun, as we know, is a very bright light source. It produces an even and consistent light over large areas. Creating a reasonable imitation of these qualities is a tall order for the lighting designer. Lighting designers are highly aware of

how natural light behaves and develop methods for representing that light with their equipment. A lighting angle of about 45 degrees above the performer produces a light that best approximates daylight from the sun and creates minimum shadows across facial features, allowing the audience to easily read the expressions of the actors.

If two lights are used at that natural 45 degree angle above the performer, but also at an angle 45 degrees out from the performer, the designer can sculpt the contours of that performer by individually adjusting the intensity of the two sources. The brighter source becomes the **key light** and is the motivated source, meaning it is replicating the hypothetical light source of the scene—the sun, a window, or fireplace, etc. The less intense, non-motivated side is the **fill light** and represents the reflected light in the environment. By filtering these two lights additional sculpting of color play becomes possible.

Therefore, many schools of thought about how best to sculpt a playing space within lighting design. The choice of angles and the distribution of light in the playing area are central to the development of the lighting design. The designer uses all of the tools in their toolkit to control the qualities of the lights to alter their function for their intended use.

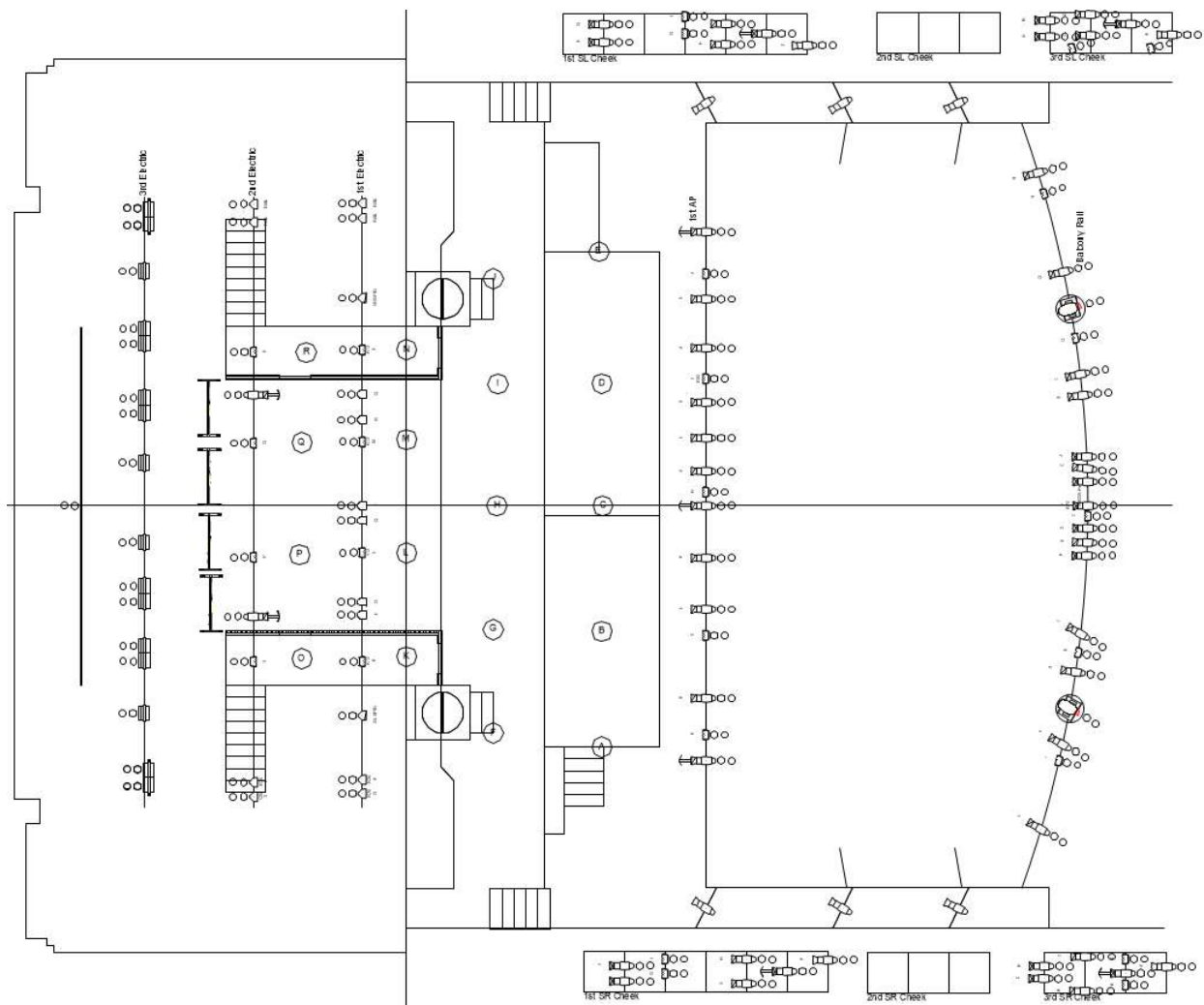
There are four *controllable qualities* of light.

- *Intensity*: Relative brightness of lights.
- *Color*: The color created by filters or combination of filtered lights.
- *Movement*: Physical movement of lighting sources and movement created by cued changes in lighting states.
- *Direction*: Angle of lighting source to its target.

There are four *functions* of light:

- *Mood*: Setting an emotional tone for a scene through use of color, angle, and intensity of light.
- *Illumination*: Providing light by which the audience can see the performance.
- *Modeling*: The use of highlight and shadow to reveal the form of the actors and the stage environment.
- *Selective focus*: Using contrast within the lighting of the stage to create a point of focus for the audience.

Eventually the lighting design is represented graphically as a light plot and its accompanying spreadsheet paperwork. The **light plot** is a **plan** that shows the lighting positions on and above the stage area. Each lighting instrument on the design is drawn to scale on the plan with labels for its purpose, color filter, accessory needs, and desired control channel. The plot is often accompanied by a centerline section, which shows the height of each lighting position. All light plots should include a legend box that serves as a key to the symbols used on the plot. This plot is delivered to the master electrician who ensures all the necessary cables, connectors, color filters, templates, pipes, and anything else needed to install the plot are acquired and delivered to the theatre for the load-in.



An Example Light Plot

A busy time in the theatre space, the load-in must be carefully planned to efficiently get the equipment installed and working on schedule. Once the lighting plot has been installed and tested and the scenery has been installed for the production, the focus call can begin. During the focus call, a crew of electricians, led by the master electrician, turns on each instrument on the plot, one by one, and guided by the lighting designer, set its position and physical attributes for the show. This process is further complicated because it involves lifts and ladders that must be moved around scenic items and the theatre architecture in order to reach the lights and move them into position. Once the lights have all been focused to the designer's specifications, the work of setting and recording individual cues for the show can begin.

There's More to Know Theatre instruments are hung on pipe battens that have electrical circuits attached to them or onto pipe battens that are rigged to carry heavy weight loads. The lights themselves clamp onto the pipes via a "C-clamp." The C-clamp wraps around the pipe to allow the light to be tightened in place without the danger of slipping off. Still, theatrical lights hung overhead should also be equipped with a safety cable that serves as a fall-arrest so even if the C-clamp fails, the safety cable wrapped though the yoke of the instrument and around the batten will prevent the instrument from falling to the ground. To hang an instrument, first hook the open C-clamp over the batten or pipe and hand tighten its bolt. Once the bolt is snug, the light cannot fall from the pipe. You can now connect the safety cable over the pipe ensuring that it is run through the yoke of the instrument. Next, use a wrench to tighten the C-clamp bolt to the pipe, then orient the fixture towards its eventual focus position. Ensure that it is right side up and all of its bolts are snug. If you are using a shuttered instrument, pull out all shutters to open the instrument. Finally, connect the instrument to a dimmer circuit and to any control cables as needed. Some designers prefer to have the color filters installed when the instruments are hung, others prefer to place them during focus. Reverse this procedure to strike the instrument.

A **cue** for lighting can be thought of as a snapshot or a single moment when a group of lights are set at various **intensities** to achieve the desired look for that on stage. The snapshot is recorded into a **lighting control console** (essentially a specialized computer), and then the next snapshot of a look of the next moment is recorded. The lighting console is then able to play back each snapshot in order and with a preset time to fade between the looks. The action of fading between two snapshot looks provides the audience a sense of movement of light as some lights fade out in one area, while others come up on another part of the stage. In this way, the lighting designer tells the audience where to look. As humans, we always look to the point of highest contrast in our field of vision, so the designer guides the audience members' eyes to the point of focus and details of the action through the use of lighting contrast. This is one of the ways lighting design helps to tell a story. Cues can also help the audience to know when scenes begin and end through the use of **blackouts**. Scene shifts may occur in a **shift light** that helps the audience to distinguish them from the central action of the play. **Bump-up** or **bump-out** cues may be used for emphasis or to signal the audience to applaud a specific moment. Designers are careful to ensure the rhythm of the lighting cues matches the natural rhythm of the unfolding story.

The designer creates moods through the manipulation of color and intensity of lights, broadcasting from a variety of angles and directions. The way a designer models the light on the performers and scenic environments with these various light sources is akin to painting the stage with light. The use of highlight and shadow allows for lighting changes from subtle to extreme. Lighting is an art that requires a great deal of calculation and equipment management to get a plot in the air and the artful manipulation of these elements to create the visuals the audience experiences.

There are five common lighting directions and angles.

Front light: Directional light coming directly towards the actors' front as they face the audience. This light is of primary importance as it allows the audience to read the actors' expressions. It can flatten the visual so performers look 2-D unless supplemented by other lighting angles.

Backlight/rim light: Directional light from behind an actor that creates a rim of light allowing them to be visually separated from backgrounds and giving them dimensionality.

Sidelight: Directional light hitting an actor from the side. This angle provides definition of shape and a sharp outline. Can be used to enhance theatricality.

Sidelight angles for dance lighting:

- *High sidelight:* High, overheard light often hung from electrics over the stage.
- *Head/shoulder light:* A sidelight at approximately 5-6 feet high.
- *Mid/waist light:* A sidelight at approximately 3-4 feet high.
- *Shin light:* A sidelight at approximately 1-2 feet high.

Top light/down light: Directional light from above an actor. Can provide a sense of isolation, but causes shadows from the nose and brow.

Up light: An unusual directional light. Can recall a sense of Vaudeville footlights.

The lighting instruments fall into several basic categories. Theatrical lighting instruments, or luminaires, are either **hard-edged** lights or **soft-edged** lights. When we think of a spotlight, we usually think of a **follow-spot**, or one that follows a performer across the stage, keeping them in the center of a bright circle of light. The clear distinction of the edge of this circle of light is what we refer to as a "hard-edged light." We can see where it stops. Often we are interested in isolating a performer from the area around them and need the definition of a sharply defined edge to show the audience this moment of separation. A soft-edged light doesn't have this clearly distinct edge, but instead has a faded edge, making it harder to discern where its light actually stops. Modern hard-edged fixtures use a lens or system of lenses to create the even field of light they produce. The adjustment of those lenses can soften their hard edges to become less discernible. This allows a designer to use a series of hard-edged instruments together by softening their edges until they blend into a large field of light. The most common types of theatrical instruments are discussed in Chapter 12.2.

For Further Exploration Essig, Linda, and Jennifer Setlow. 2012. *Lighting and the Design Idea*. Boston: Cengage Learning. "StageLightingTextbook." n.d. Accessed August 16, 2018. <https://www.stagelightingtextbook.com/>.

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12.2: Lighting Equipment and Control Systems

Here is a list of the most common fixtures, or luminaires, in use today.

Hard-edged or profile fixtures: These fixtures produce a sharply defined beam of light.

Ellipsoidal reflector spotlights (Also referred to as ERS or Leko)

These hard-edged fixtures are the traditional workhorses of theatrical lighting. They produce a narrow beam of light that can be effectively transmitted over long distances. The older units use a two-lens system and an elliptically shaped **reflector** to collect and concentrate the light. The reflector captures all the light emitted by the **lamp** and reflects it toward the two lenses. The first of these two **plano-convex** lenses (flat-planed on one side and convex on the other) gathers the light from its flat surface and concentrates (refracts) it toward its center as the beam passes through the convex shape of the lens. The second lens takes the now concentrated light and spreads it out over the flat surface as it leaves the fixture. Between the two lenses where the light has been concentrated, a set of **shutters**, a series of flat metal flags, can be used to block or limit a beam of light. This allows the light to be shaped and prevents objects that should not be seen from being illuminated. The slot between lenses also allows us to insert a template image. A **template** is a cut-out image through which the light passes to project that image over an area or surface. Templates, also known as **gobos**, come in an infinite variety of shapes, and modern gobos can either be a laser cut metal plate or a full-color image printed on glass. A template can be used to create texture in light or to project a graphic image. As the light passing through two lenses, the image turns both upside down and backwards, so the shutters operate on the opposite side of the instrument from the projected light. Also, the template pattern needs to be inserted both upside down and backwards in order to project correctly.

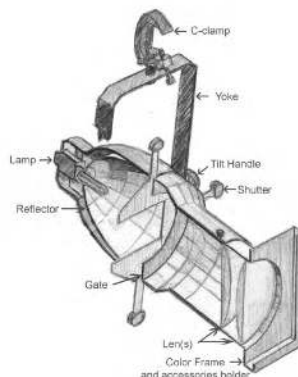


Figure 12.2.1: An axial style ellipsoidal reflector spotlight

Ellipsoidal reflector spotlights have been around for many years, and theatres may have an inventory of older units. They may be mounted axially, when the lamp enters directly through the rear of the reflector, and radially, when the lamp enters the reflector at a downward angle. Recent advances in these fixtures have made them more efficient and given them greater clarity. Better design, improved materials for the reflectors and lenses, more efficient lamps, and improvements in the user interface (the ability to move or "zoom" the lens or lenses), have vastly improved the latest fixtures. Most ellipsoidal reflector spotlights are still incandescent lamps of high wattage, though LED fixtures are improving in this market and will eventually become common.

When using an ERS, it is important for designers to consider both the instrument's **beam angle** and its **field angle**. The beam angle refers to the area within the cone of light where the strength of the beam is no less than 50% of the brightest area it produces. The field angle is the outer ring of the cone wherein the brightness dips below 50%. Designers often plot equipment so field angles overlap between instruments to make up for the brightness lost at the edges of the beams.

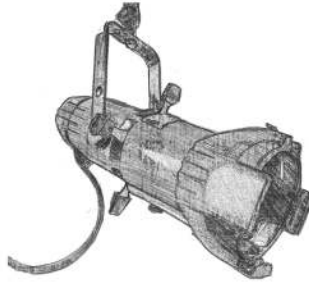


Figure 12.2.2: A modern ellipsoidal fixture

Soft-edged or wash fixtures: These fixtures produce a diffused light

Fresnel: A Fresnel can be recognized by the concentric circular pattern on its lens. This “step lens” is similar to the plano-convex lens, but rather than a thick convex face, the shape has been cut-away to create steps that maintain the curve without the thickness. The back of the lens is textured to further diffuse the source. This lens was originally invented for use in lighthouses. They produce a relatively even field of soft light. A Fresnel is equipped with an adjustable track that allows the lamp source and reflector to be moved closer to and away from the lens, thereby changing the size of the projected cone of light from spot to flood. Though these fixtures do not have the ability to use shutters to shape their light output, adding a barn door to the instrument allows the flaps of the barn door to block the light as it leaves the fixture.

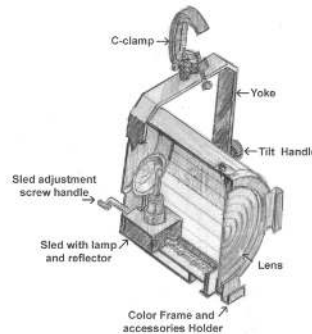


Figure 12.2.3: A cut-away view of a Fresnel

Parabolic aluminized reflector (PAR)

A PAR light uses a parabolic shaped reflector to capture the source light and redirect it toward the stage. The instrument itself is merely a housing for the lamp and reflector, which come as one solid unit much like a headlight from a car. PAR cans, as they are commonly known, produce a light shape that is elliptical rather than round. Lamps are available with varying widths of spread from very narrow to narrows to medium and wide spreads. A workhorse of rock tours, these lights are durable and very quick to focus as only the angle of the fixture and the position of the lamp inside it must be adjusted. PAR lamps are sized by measuring in 1/8” segments across the glass face. Sizes range from a PAR16, which is 2” across to PAR64, which is 8” across.



Figure 12.2.4: A PAR64

Striplight or borderlight

These units are long multi-lamp fixtures made to create a smooth wash of light for backdrops and cycloramas. Most often manufactured in three- or four-circuit styles, they allow for a pre-spaced series of cells to work together to create an even field of colored light projected onto a backdrop or stage area. These incandescent fixtures are now being replaced by LED versions that are more economical, heat-free, and capable of mixing an infinite variety of colors.



Figure 12.2.5: A striplight unit

Cyc. light (Cyclorama light)

These soft-edged fixtures are meant to light a very large area. They are calibrated to cast their light evenly across a field and hung close to the top of the projection plane. Their asymmetrical reflectors are engineered to cast more of their light toward the bottom of that vertical plane to keep the field more even. These units can be single-cell or multi-cell lights. Like strip lights, cyc. lights are also moving to LED technology for advanced color control.

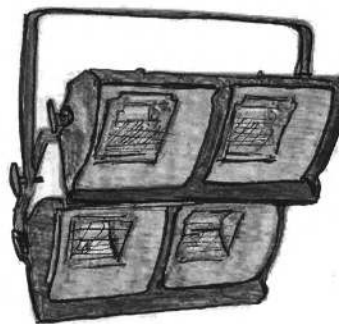


Figure 12.2.6: A multi-cell cyc. light

Incandescent cyc. lights are connected through electrical cables to a **dimmer** unit that allows the electrical flow to their lamps to be reduced so the lights can be dimmed much like the dimmers on your household lights. Theatrical dimmers carry larger loads of current. Most of today's theatrical dimmers are SCR (silicon control rectifier) units and, on average, control about 2,400 watts per dimmer (often abbreviated as 2.4K), although wattage varies, and each unit should be checked for its capacity. Each dimmer has an address much like a street address, that the control console uses to control the voltage the dimmer sends to each fixture. In some theatres, the dimmers are located backstage or in the basement, and miles of cables run out from there to all of the lighting positions of the theatre. In this type of configuration, the cables from the dimmers that appear on the electrics and through raceways to other positions end in numbered **circuits** to which the instruments are connected. These theatres usually also employ a **patch panel**. The patch panel allows for an interface wherein the dimmers and circuits can be connected in any configuration necessary so long as the dimmer's capacity is not exceeded. Some modern theatres are wired as **dimmer per circuit**, meaning no patch panel is necessary as each circuit is permanently connected to its own dimmer. Still another dimmer system hangs small dimmer units directly on the electrics and connects them to their power feed cables at those locations. The advantage to a central bank of dimmers is that the dimmers can be noisy while operating and the central bank can be located away from the stage area where the noise will not disrupt the production.

Electrical connection and lighting devices

A number of styles and sizes of electrical connectors are common to the theatre. If your show is loading in to a theatre and your equipment is meant to connect with that owned by the theatre, you need to know what style of connectors they use. If the two styles

do not match, adapter cables are required to mate the equipment. These adaptors are generally available to rent when needed. Common connectors include **twist-lock**, **stage-pin**, and **standard grounded Edison (PBG) connectors**.

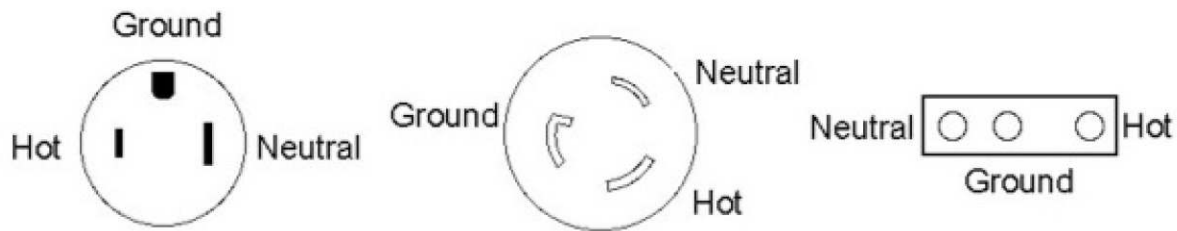


Figure 12.2.7: Edison connector, Twist-lock connector, and Stage pin connector

The dimmers are controlled by an electronic signal sent to each individual dimmer address from the lighting control console. A low-voltage electronic protocol language is used to achieve this communication. The **DMX512** (digital multiplexing for 512 channels) signal can simultaneously control 512 separate addresses.

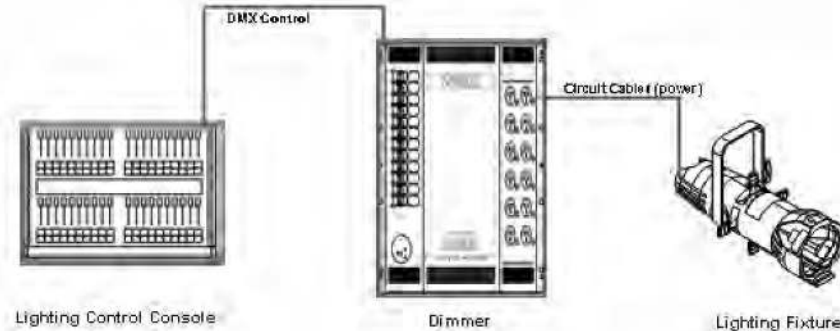


Figure 12.2.8: Lighting system path

The lighting control board uses **control channels** to interface with the operator. These channels can be arbitrarily connected to the dimmer addresses (soft-patching), so the interface at the board remains flexible. This is important because it allows the designer to organize the hundreds of control channels into a logical system, making it easier to find the channels for the individual instruments or attributes they are trying to control.

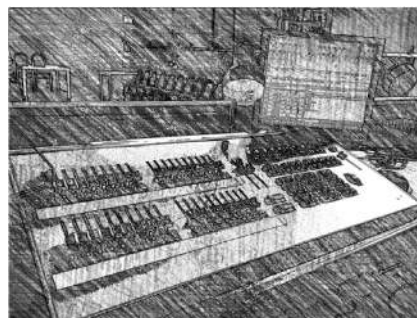


Figure 12.2.9: A lighting control console

LED fixtures

LED fixtures do not need to be connected to a dimmer because their diodes can be dimmed internally. Therefore, less equipment is needed when they are used. However, modern fixtures, including LED fixtures, do have a variety of functions or attributes that can be controlled remotely by the lighting control console. Each function typically requires a separate DMX address from the board, so a single fixture could consume as many as 20 control channels. If you run above the 512 allowed channels in your DMX

communication, you need to add a second DMX universe, which adds an additional 512 control channels. It is not unusual for large shows to run two or three DMX universes, though the lighting control console must be capable of controlling multiple universes.



Figure 12.2.10: An LED Fixture

There's More to Know Modern lighting control consoles are designed to allow a programmer working with smart lighting equipment, such as moving lights or LED color controlled equipment, to interface with the attributes of that equipment, like panning, tilting, or color changing graphically rather than by entering the information as % in individual DMX control addresses. This allows for more intuitive programming of these multiple addressed fixtures. Many consoles recognize these smart fixtures once they are connected via DMX or may offer lists of fixture choices to assign to the console's attribute controls. Once assigned, all multiple functions of the devices can be programmed from a single graphic interface. This makes the use of multiple LED fixtures and moving light units far simpler for the programmer who otherwise would have to track each change of range for every control channel the fixtures employ.

Moving light units and moving mirror units

Some fixtures are automated and have the ability to rotate, pan/tilt, change color, change size, utilize multiple templates, and strobe. Most moving lights achieve these functions by utilizing a series of motors that move the elements of the fixture. Moving mirror lights motorize only a single mirror onto which the instrument's beam is focused, allowing the light to be reflected around the stage.



Figure 12.2.11: A moving light



Figure 12.2.12: A moving mirror light

Safety for a stage electrician

Keeping safe in this environment of temporary installations requires knowledge of the equipment and its limitations and a significant amount of personal focus and discipline. Safety involves using the correct electrical connections, but there are also lifts and ladders that are used to access the equipment.

Ladders must be in good repair and must only be used where all of the ladder's feet can be placed solidly on a sturdy surface. Freestanding, portable ladders are equipped with a "step" at the top, however that step is not intended for standing. The center of gravity of the individual working on the ladder should not be placed above the ladder's recommended working height (typically listed on the ladder itself). A good rule of thumb is that your waist should not be above the top step of the ladder.

Powered lifts must be used in accordance with their safety guidelines, and outrigger supports should always be employed where possible. Electricians should empty their pockets of anything that might fall on workers below, and wrenches or other tools should be secured to the user with a fall arrest.

Keeping all electrical cables in good working order is also key to electrical safety as exposed wires can be a danger. Do not pull on electrical cables or allow the plug to carry the cable's weight. Connection points should be supported with tie line where appropriate. Never touch exposed wires while they are connected to a power source. Power services, dimmers, and cables all have power limitations that must be considered. If you have ever touched a power cable at home and found that it feels hot, that is a sign you are pulling more power through the cord than it is rated for and have a potentially dangerous situation. When more power is pulled through a cable than it is rated to carry, the cable overheats and may melt through its jacket causing an electrical short and possible fire. A cable rated to carry a larger electrical load may be all that is required to correct the problem.

For Further Exploration Gillette, J. Michael. 2007. *Theatrical Design and Production: An Introduction to Scene Design and Construction, Lighting, Sound, Costume, and Makeup*. Boston: McGraw-Hill. "ETC - Theatre, Film, Studio and Architectural Lighting." n.d. Accessed August 16, 2018. www.etcconnect.com/.

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13: Projection

Video projections are a powerful tool that – as with any design element – can be used to help tell the story of a play and create a more immersive experience for the audience. Projections are often used to enhance the world-building of a production, by providing visual elements that help to set the scene and create a sense of place. Video projections can also be used to add visual interest and dynamic movement to a production, and to create special effects that might be difficult or impossible to achieve with physical sets and props. Modern projections are so powerful, in fact, that they can be a crutch for directors and designers who often find themselves solving design challenges with the mantra “let’s just use projections for that.” Nevertheless, by carefully considering how to use video projections in a production, designers can create powerful and effective designs that enhance the overall impact of the production.

When used effectively, projections can create a sense of place and help to set the scene for the action on stage. They can also be used to create visual interest and movement, and to add special effects that help to engage the audience’s senses and create a more immersive experience. For example, projections can be used to create the illusion of a moving expansive landscape or cityscape, or to bring elements of the natural world onto the stage. They can also be used to create abstract visual effects, such as swirling patterns or pulsing light, that help to create a sense of atmosphere and mood. By using projections in these ways, designers can create an immersive experience for the audience that helps to draw them into the story and enhance their engagement with the production.

Designers can also use projections to provide additional information or context that helps to deepen the audience’s understanding and appreciation of the production. For example, projections can be used to display images or text that help to provide background information or to illustrate certain points in the story. In Nick Stafford’s *War horse* at London’s National Theatre, designers projected soldiers’ diaries above the stage in their own handwriting, so the audience could read along while the pages were being written or read onstage.

Video projections are very powerful and versatile, the possibilities are nearly endless, which is perhaps why they are so loved as a design element. They can be used as **live video feeds**, pre-recorded video displays, set design elements, and special effects. When used well, they can even be combined with other design elements such as sets, costumes, and lighting to create a unified and engaging production.

Projection History

When most people think of the term “projections,” the first thing that comes to mind are modern digital video projections. In fact, projections are over 2,000 years old, originating far before the advent of modern theatre technology. **Shadow puppetry** – the mother to modern projections – is believed to have originated during the Han Dynasty (140-87 BCE). The legend goes that the Emperor Han Wudi was devastated by the loss of his concubine so his advisor came up with the idea of using shadows to bring her image back to life. Shadow puppetry (projection) can be used to create a sense of intimacy and connection with the audience.

By simply using shadows and light, designers can create the illusion of depth, movement, and transformation, and can bring elements of the natural world or the imagination onto the stage. It is also very cost effective because its only requirements are simple paper cutouts and an imagination.



Figure 13.1: Shadow Puppetry, Photo by Stacey Gabrielle Koenitz Rozells on Unsplash

Shadow Boxes

Shadow boxes were popular in Europe in the 1800's. Not too different from shadow puppetry, Shadow Boxes were usually backlit wooden boxes with layers of wood or paper to create depth and form. In the early 1900's, artist Joseph Cornell popularized shadow box art pieces and we can see his influence in theatre. One of the most common uses of the shadow box was to create an illuminated moon with depth and form. Many artists created shadow box dioramas of forests or other scenes to show depth and further display form.

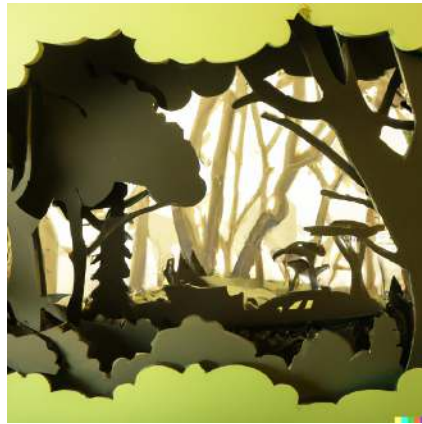


Figure 13.2: A backlit shadow box of a forest

Shadow Boxes influenced the way stories were told and the types of stories that were told in the theatre. By using abstract or symbolic imagery, shadow boxes and shadow puppetry could be used to convey ideas and themes in a more subtle and indirect way, which opened new possibilities for storytelling and allowed for more experimental approaches to theatre.

Gobos

Still widely used today, **gobos** are thin sheets of metal cut out into a shape. This template is placed in a theatrical light between the lamp and lens. Now, instead of a cutout being placed between the light and screen, designers can project a pattern of light anywhere on the stage. The pattern can move, change color or intensity, and have a greater impact on the mood and **modeling** of the play. Gobos made it even easier for audiences to suspend their disbelief. Designers can easily make it seem like light is passing through a forest canopy, or a factory ceiling. A moon pattern can project on a backdrop and fade in intensity as the designer desires. Traditionally, gobos have the limitation that they are only one solid color at a time, not a photorealistic image.



Figure 13.3: A light projecting a gobo pattern of leaves

Slide Projectors

When 35mm film was invented in 1925, technicians began placing developed images between a light source and lens, not dissimilar to the gobo, leading to the then modern **slide projector**. From the 1950's until round the 1990's, slide projectors were used in theatre. An expensive and clumsy technology, their adoption was not nearly as great as the modern digital projectors we have today. Projectors bright enough to compete with the lights on the stage could be very expensive, yet they created one of the only ways to project a full color image on to the stage. While slide projectors could only project one image at a time (aside from the reel-to-reel projectors, not commonly used), their influence in theatre was significant. They helped develop techniques that served as a baseline for modern digital projection systems.



Figure 13.4: A Slide projector and 35mm film camera, Photo by Berend van Rossum

on Unsplash

Digital Projectors

Whenever you hear that projections are being used for a show, more than likely, those projections come from digital projectors. Not to be confused with an LED display like an **LED Video Wall** or even a flat-screen TV, digital projectors focus many **pixels** through a lens as a beam of colored lights on to the stage. Traditionally controlled by computers, they can project everything from full **8K videos**, still images and even interactive video elements. Modern projectors have forever changed the way contemporary theatre is produced.

There are five primary types of digital projectors:

- Liquid Crystal Display (LCD): three (red, green, and blue) mirrored displays combined into an image. And the most economical workhorse for the stage.
- Digital Light Processing (DLP): a proprietary chip comprised of microscopic mirrors to create a higher resolution image. They are traditionally brighter than the LCD projector.
- Light-emitting diode (LED): either DLP or LCD technologies but with very long-lasting LED light sources.
- Liquid Crystal on Silicon (LCoS): a DLP-LCD hybrid which uses liquid crystal chips and a mirrored backing. They produce very **high contrast** images of high resolution, but at a great cost and can be very heavy.
- Laser projectors: they utilize a solid-state laser as a light source in place of a lamp, distinguishing them from lamp-based projectors. They have the truest blacks and brightest colors with very long lamp life, but with a major cost.

Each projector has its benefits as each contains different features at different price points. The main things to consider when choosing a projector for use with theatre are price, brightness, Resolution, and refresh rate.

Brightness

Projectors, like all light sources, measure their output in lumens. One lumen, is approximately the output of one “standard wax candle.” Projectors for theatre range from 5,000 to the rare 56,000 lumens, with most used working between 10,000 and 20,000 lumens. In comparison, a standard ETC Source 4 ellipsoidal outputs around 20,000 lumens. So, for a projector to be able to be seen onstage, it needs to be able to compete with many other bright lights or be used when the stage is dark.

Resolution

The resolution of any video source is the measurement of how many pixels appear on the screen. Technicians measure resolution in width by height (i.e. ‘Full HD’ is 1920 pixels wide by 1080 pixels tall, a total of 2,073,600 pixels). There are dozens of standard resolutions from XGA (1024 x 768) to 8K (7,680 x 4,320). The higher the resolution, the clearer the image will appear on stage, but higher resolutions require much faster computers to display them.

Aspect Ratio

Similar to video resolution is aspect ratio. Aspect ratio is the proportion of the width and height (resolution) of the image. If you were to reduce the XGA resolution above as a ratio, it would ultimately reduce from 1024:768 down to 4:3. Luckily, there are only three different aspect ratios used in most projectors, 4:3 (standard), 16:9 (widescreen), and 16:10 (a form of widescreen, actually reduces to 8:5, which is very close to the golden ratio).

Refresh Rate

Refresh rate expresses the number of times in one second that a new image is drawn on the screen, based on the video signal's incoming information. In America, traditional projector refresh rates draw a new frame 60 times in every second, or 60 Hz (Hertz). Some models work on 30Hz, or even the smoother-looking 120Hz. Changing the refresh rate can be very important if a show is to be recorded. Both the recording video camera and projector need to have the same refresh rate or flickering will appear.

Video Playback

While the early 2000's saw some video playback (or display) through DVD players, designers today control most, if not all, video playback with computers. Because there is more than one way of cueing video with live performers on the stage, a variety of control systems have evolved. Each system has its pros and cons. Some systems are better suited for live performance, while others work better for performer interaction.

Slideshow Systems

Most of us are familiar with slideshow software like MS PowerPoint or Google Slides. For the simplest and most basic shows, a playback system that simply shows one slide after the other is all that is needed. The operator presses the spacebar, and the next image is shown on stage. These applications, however, have a very hard time if there is an error or pop-up box that takes up the screen. It is hard to mask the projector's image to the shape of the screen or stage and blending videos together or starting multiple concurrent videos at different times becomes nearly impossible, oh and forget about working with live camera inputs. But luckily, it is nearly free and basically any computer can run it.

Scene-based systems

Perhaps a step (or four) above slideshow software are scene-based systems. The most popular being Isadora by Troikatronix. Isadora, and others like it, give designers access to a visual programming language with nearly endless effects and display outputs. While any programming comes with a learning curve, scene-based systems and visual languages make it easier. There are many benefits to Isadora:

1. This software can run on most any computer, so there is no need to purchase special hardware.
2. Isadora is not linear, which means that operators can jump from scene to scene going forward and backwards at will; this is especially useful for abstract performances with no script or linear flow.
3. If you can dream it, it can be programmed.

Aside from its propensity to crash on custom-built computers, one of the only major downsides to both scene and slideshow programs is that it is difficult (although not impossible) to scale the software to run multiple synchronized displays beyond what can be plugged into a single computer. So, a production like Broadway's *Spiderman: Turn Off the Dark* with a dozen or so video displays could not use a system like Isadora.

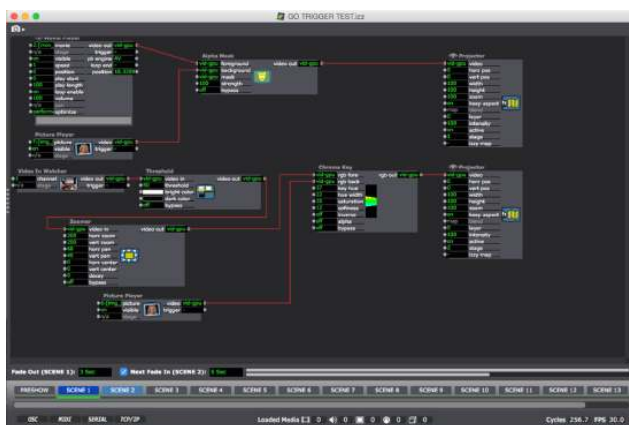


Figure 13.5: A screen shot of Isadora software

Event Driven

Perhaps the most-used audio and video playback software in theatre is Figure 53's QLab. Qlab is a cue-based software. Like light designers, Qlab programmers write cues in a spreadsheet-like interface, notating only when something needs to change. Operators can press the "Go" button every time a change in the video system needs to coordinate with action on stage. Qlab is very easy to

understand and uses nomenclature and systems very similar to all other design elements, which makes it a favorite to work with. It can only work on Apple computers and can be quite cumbersome to scale to a large number of displays.

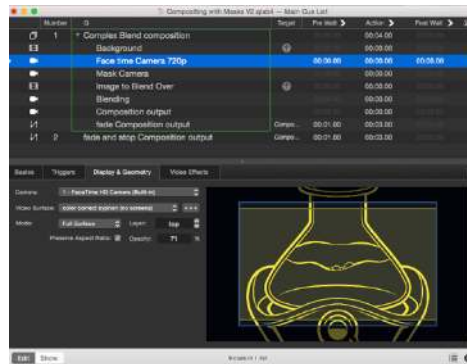


Figure 13.6: A screenshot of QLab software

Linear Systems

Most other display software is linear. Designers program a timeline of events, very similar to most movie editing software. There are multiple tracks of video, and they can be **blended** or **masked** just as they could be in Adobe Premier Pro or iMovie. **Keyframes** (sometimes ‘**tweens**’ – short for between) are placed on a track to fade it on or out, move images or change effects. A common linear display software used for the theatre is Watchout by Dataton. Watchout can be more expensive than the options above because they recommend that you use their hardware, but it is infinitely scalable to dozens of displays and is built to last, hopefully without crashing. When you press the spacebar, or the “Go” button in Watchout a play head moves along the timeline and synchronizes all videos together. It can play, pause and go in reverse. But, unlike Scene-based software, if the actors miss their cue, it can be a little cumbersome to get the timeline back on track by skipping ahead.



Figure 13.7: A computer running Watchout video playback software

Media Servers

Very similar to linear systems like Watchout, media servers are pieces of hardware (purpose-build display computers), used to output images and video to specialized projectors. Many even have their own consoles to control them, just how a light board controls the lights. A console – or master computer – controls many media servers so a designer can easily have dozens of displays synchronized and blended together. While media servers used to be unmatched in power and capability, modern personal computers have grown so greatly in power over the past several years that many of the other systems can match everything they do, expect scalability and speed.

Final Design Considerations

Hopefully by now you realize the true power that projections can bring to the stage. But with great power, comes great responsibility. When choosing to use projections for a production, make sure their use will help tell the story. In 2018, I was asked to program projections for a production of Alan Ayckbourn’s *Communicating Doors*. In this play, there is a door in a hotel room

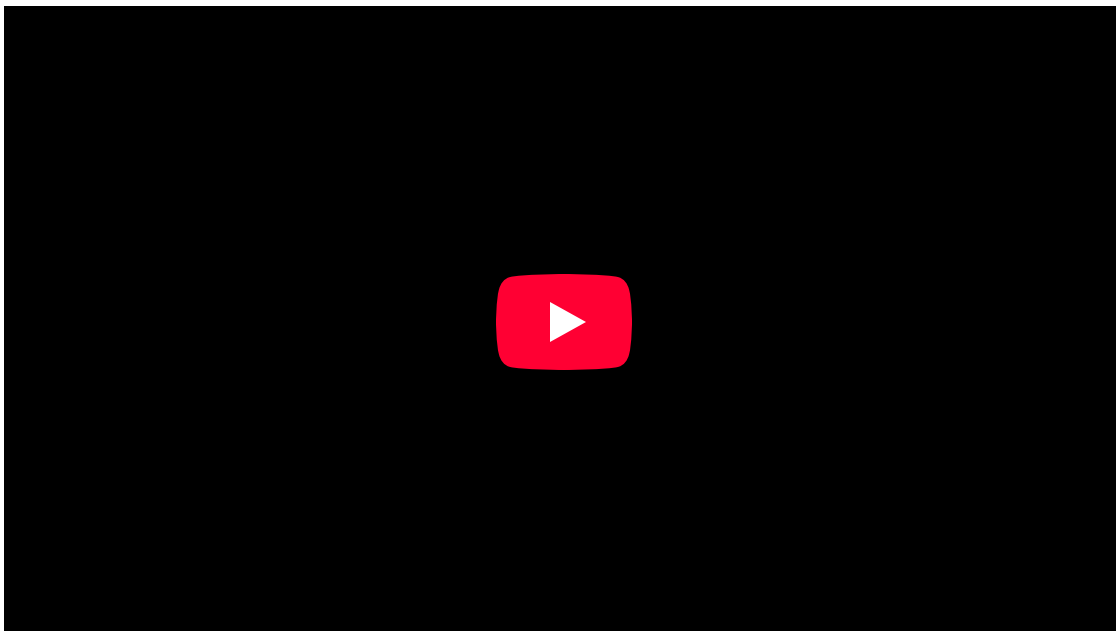
that allows the character to travel to three different decades in that same hotel room. The set designer wanted to show that the room was different as the actor traveled “through time”. So she asked that the two wall hangings change in addition to the backdrop of London seen through the window.



Figure 13.8: The set a video design of Alan Ayckbourn’s *Communicating Doors* at The Theatre Group at Santa Barbara City College. Directed by Katie Laris, Set Design by Patricia Frank.

We used Isadora with five projectors – one for each wall painting (rear projected), and three blended on a sky drop to make up the London backdrop. Did the projections look good and help tell the story? Yes. But not without limitations. At the time, 5 video feeds was too much for the video computer, so crashes and extreme latency was a constant issue. And like every computer system, when it crashes, the whole show stops. Could Greek [Periaktois](#) have replaced the wall hangings, and painted backdrops work for the London skyline? Probably, and no computers could have crashed. But it sure would have made the scenic budget much higher.

Sometimes though, projections can open a new door to the audience. They can give deeper meaning to the script and emotions of the characters. For a production of *The Curious Incident of the Dog in the Nighttime* by Simon Stephens at The Theatre Group at SBCC, I worked with the director to create projections to let the audience better understand the mind of the autistic lead character as he navigates his world. We converted all locations and scenery into math, lines, and mesh because that is how we believed he saw his world. After blending five projectors together into a three-dimensional 5K video stage, we used Isadora to coordinate video with the actors on stage to create what I think was a powerful application of video. Watch the movie below for a sample of how the projection worked with the action of this play.





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14: Sound Design and Production

- Updated and re-authored by:

Page ID 177937 Sound designers are masters of the aural arts. They are responsible for far more than preshow music and doorbells; they decide what music, effects, and vocal microphones are heard and from where. Most modern sound designers are also composers who create the sounds and write the incidental music required for their productions. When commercial recordings are used in productions that will charge for tickets, the producing organization is required to secure the rights to use that music. The high cost of acquiring these rights plus the development of digital recording technology that has put powerful tools for creating and augmenting audio files into the hands of average people has allowed designers to shift from locating appropriate recordings for use to writing original scores. This, coupled with the fact that sound and music can add so much depth to a production, has made sound design a major component of modern theatre. In general, if you can hear something in a production, the sound designer probably has a say in what that something sounds like.

Sound designers' work falls into several categories. The three main classifications are **music**, **reinforcement**, and **effects** (including **environmental soundscapes**). Music may include live musicians as well as recorded music. Music may be a primary element to a scene or may provide an underscore to enhance emotional content. Live musicians require a sound designer to balance the relatively loud sounds of the instruments against the actors and other elements that need to be heard clearly by the audience. In modern musical theatre productions, the orchestra may be in an orchestra pit, another room, or even in another building. Capturing that sound and broadcasting it into an auditorium may become a part of a sound designer's work. Such work bridges into the category of reinforcement, which also includes the sound from actors who wear a microphone during a performance. While microphones are common to musical productions, even some plays performed in larger auditoriums use microphones to pick up the actors voices and broadcast them throughout the theatre space. In this instance, the sound designer strives to have the amplified sound seem as natural as possible to the audience.

The effects category covers any recorded sounds that are played for an audience, including atmospheric sounds, weather sounds, and practical effects. Most theatres are now equipped with a computer program designed to play sounds for live entertainment. These systems allow the cues, volume levels, and routing of the sound to be entered into a playlist-style cue stack. A sound technician can then press a single "Go" button to operate the entire show in sequence. These programs often are also capable of controlling video playback and, in some cases, can be linked to the lighting control console to trigger cues in sequence. Such a program can allow a single technician to run sound, video, and lights from a single cue stack.

Sound designers must also have a deep understanding of their equipment in order to design effectively. All sound systems are composed of the same basic equipment. The sound is routed through this system and processed so it can be delivered to the ears of the audience. The path the sound follows is called the **signal path** or **signal chain**. This chain can be thought of as a series of links that must be connected properly for the chain to be functional. The basic components of a sound system are inputs, the pre-amp, the mixer, signal processor(s)/transformative effects, amplifiers, and speakers.



Figure 14.1: Example Sound Signal Path

Input or **source** devices are playback devices such as a computer, cell phone, CD player, tape deck, or microphone. If your input source is anything other than a microphone, it is likely that it is sending out an electronic signal at a signal strength known as **line level**. Computers, cell phones, and CD players often have a headphone jack. These jacks operate at this **line level** signal strength. This signal strength is enough to power the tiny speakers in your earbuds, but if you want to fill the room with sound, you will probably need an amplified speaker because the line level signal does not have enough electrical power to physically push a larger speaker to create the sound waves for you to hear.

Microphones operate on an even lower power signal we call **mic level**. Mic level signals are not even strong enough to power your earbuds because of the way a microphone picks up sounds. A microphone is a device known as a **transducer**. Its job is to capture a physical sound (a pressure wave) and transduce it into an electronic signal. Most microphones operate by using a diaphragm to absorb the pressure waves of live sound. The diaphragm is connected to an electronic or magnetic field, which is affected by the diaphragm's movement in response to the pressure waves. The difference in the affected electronic field is recorded as an electronic waveform (the sound signal) and is then processed and recreated by a speaker (another transducing element) back to a physical pressure wave that our ears can hear. Due to the relatively tiny differences in the electronic field of the microphone, the strength of this interpreted signal is low. Microphone signals must be run-through a **pre-amp** to boost them up to a level that can withstand any electric noise it might be subjected to as it runs through cables and equipment on its way through the signal chain.

Input devices are connected to a mixer and then to signal processing equipment. The **mixer** is key to both routing the signal to the correct devices/outputs and to adjusting input signals for that processing. Processing units include graphic equalizers and effect-based units such as echo and reverb processors, which are devices that alter or augment the signal itself. Most mixers have built in pre-amp functions for mic level signals. Once a signal has been mixed and processed, it is routed to an **amplifier** to further boost its signal power. The signal must be strong enough when it reaches a speaker to not just preserve itself against electronic noise, but to do the work of moving the speakers back and forth to reproduce the physical pressure waves that our ears can hear. The amplifier boosts up the signal to accomplish this work. Speakers are connected directly to the amplifiers, which are where the signal chain ends.

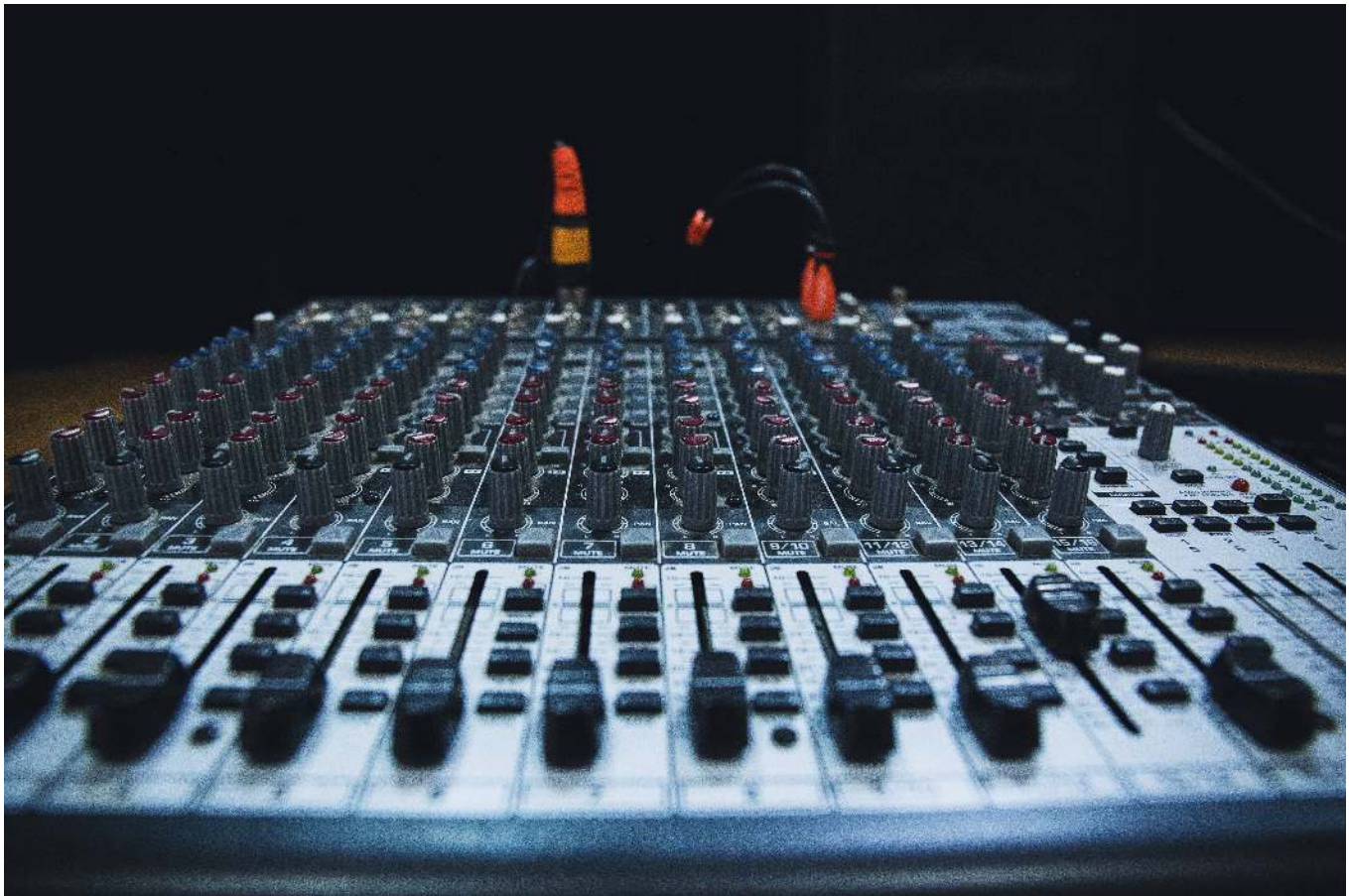


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freestocks
on
Unsplash

Figure 14.2: A standard analog sound board

In most theatres this system is already in place, though the sound designer still chooses how it will be operated, the quality of the sound that will be produced, and where the speakers will be located. It is common in modern theatres for speakers to be built in to many locations around the auditorium so that sound is both directional and can be played at lower volumes, which often seems more realistic. The sound designer, in addition to creating the sound recording medium, also creates a plot of speaker locations and how the cables are to be routed to those speakers. It is common for directors to request the use of sound in the rehearsal room prior to technical rehearsals, and so a mini sound system may be required to facilitate that playback.

It is probably not surprising that there are many varieties of all of these devices available for use. A sound designer must be familiar with many pieces of sound equipment to choose what works best for the needs of a given production.

There's More to Know

- Microphones come in a variety of styles, and each has its own specialized use.
- Dynamic microphone: Durable and inexpensive microphone for voice and instruments.
- Omni directional microphone: Usually used in recording studios, these microphones pickup sounds from all directions.
- Condenser microphone: A battery powered microphone usually used in recording studios, that is quite delicate and sensitive.
- Shotgun microphone: A microphone capable of picking up sounds from some distance.
- Wireless hand-held microphone: A hand-held microphone that sends its signal wirelessly to a remote receiver.
- Wireless lavalier/body microphone: A small, pin-on microphone that sends its signal wirelessly to a remote receiver, sometimes taped onto the skin or woven into the hair of a performer.
- PZM/PCC microphone: Boundary microphones often placed at the edge of a stage deck to pick up reflected sounds.

In addition to capturing sounds with microphones, sound designers must also provide **monitor** feeds of sound to orchestras and singers so they can keep in tune and time with one another. It may be that an individual performer does not need or want to hear the entire sound scape, but just a part of it. A singer may only need to hear the piano to sing their part and not the drums. In musical theatre, the same performers wearing a wireless body microphone may also wear a wireless in-ear monitor. These devices and their microphone counterparts work essentially like a mini radio station broadcasting from one end and receiving the signal at the other. Because a production may have many of these wireless devices working at one time, they must all be broadcasting on separate frequencies to avoid overlap. The frequencies of these devices are in the same range as those walkie-talkies, police radios, and other public broadcasters operate within. It is imperative that all frequencies are checked for cross-traffic at each venue.

There's More to Know

Stereo vs. monaural (mono) signals: In a monophonic, or “monaural,” system a single channel carries the audio signal. Thus, each speaker in the system receives the same signal information. This can help provide clarity in large systems with many speakers. Stereo, or stereophonic, systems send two independent audio channels played through two speakers (or sets of speakers). This allows the system to reproduce an image of sound in the room by manipulating the specific level and phase of each signal.

Every theatre space has its own natural sound. Some have an obvious echo, or a slap-back effect that doubles voices. Some are warm sounding and perfect for the unamplified voice. Others are better for music and mummy voices. Many of the acoustical properties of any room are created by the room's architecture and the soft and hard surfaces the sound encounters. The pressure waves that create sound are easily bounced off hard surfaces and absorbed by softer surfaces. It is common for sound levels to be set for a production in an empty auditorium during technical rehearsals and then found to be too soft when the theatre fills up with bodies that not only absorb sound, but also make quite a bit of noise themselves, even just by breathing and shifting in their seats. Sound designers must listen to each room they work in to overcome its particular acoustical difficulties.

No matter what equipment makes up the sound system, a series of devices need to be interconnected to complete the **signal path**. A series of sound specific cables connect the devices. Sound cable falls into two major categories: balanced and unbalanced. As we have learned, we must use a stronger signal than a mic level to process that signal through the system to keep electronic noise from affecting its quality. All of our connector cables are running in, around, and through powered devices. Any leaked electrical power can muddy a sound signal, and so using shielded cables in good repair and with tight solid connections can help keep the signal clear. A **signal to noise ratio** is often mentioned when talking about sound routing. You want the strongest signal with the least noise possible. When it comes to connecting cables, a **balanced cable** will do a better job of keeping out electronic noise than an **unbalanced cable**. The difference between the two is easy to detect. A balanced cable has three wires to transport the signal, while an unbalanced cable has only two. In an unbalanced cable, one wire carries part of the electronic signal and also doubles as the shielding for the core wire. The shielding wire's job is to channel any electronic noise away from the wire carrying the sound signal. A balanced cable sends the signal out on two wires; one of them carries a signal that has its phase inverted. This allows for the two signals running parallel to one another to directly cancel each other's potential to leak, resulting in less signal interference. The third wire is then free to shield the signal wires and ground out electronic interference. It makes sense to always use a balanced cable when you can to help protect your signal.

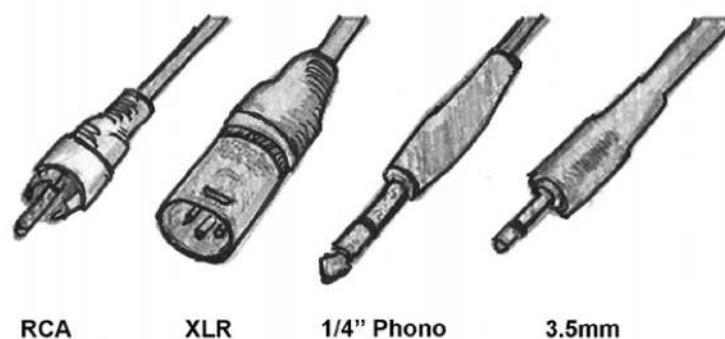


Figure 14.3: Common audio connectors

The speaker wires that connect speakers to amplifiers are not balanced cables due to the high strength of the electronic signal they carry, so they can still be affected by ambient electrical noise. Care should be taken to ensure that these cables are never routed alongside power extension cords or lighting cables, which can result in a buzz in the speakers. If the cables must cross, make sure they cross each other at a 90-degree angle and do not run along each other's length.

Sound Design Paperwork

Sound designers, like all theatrical artists, use their craft in a production to better tell the story of the play. They follow similar design processes to other designers, starting with analyzing and researching the play, followed by selecting and implementing music, sounds and effects. Sound design requires precision. A mistimed doorbell can really ruin a final soliloquy. To explain their design to technicians, sound designers - like lighting designers - use a cue sheet describing each sound and when it is to be played and to which speaker. The following is an example of a standard sound cue sheet:

Production Name: The Play That Goes Wrong

Designer: Ben Crop

Date: 11/20/2022

Sound Cue Sheet

Cue #	Page #	Prompt (Action/Line Cue)	Sound Description
1	10	Preshow	Preshow
3	10	Trevor enters	Show Preshow
4		Trevor Exits	Fade out
6	12	Chris: "At Havisham Manor."	Mysterious sting music
7	12	With lights our after Jonathan's discovery	Pause
8	12	With lights back up	Continue Q 6
9	13	Dennis: "He's Dead"	Musical Spike 1
10	14	Robert: "He's been murdered."	Musical Spike 1
11	15	Robert: "Charles Havisham!"	Musical Spike 1 longer
12	15	Auto Follow	Pause Q 11
13	15	Auto Follow	Play Q 11 to end
16	17	Dennis gets into the elevator	Elevator Up
16.5	17	Dennis gets into the elevator	Elevator Down
17	20	Trevor: "oh no." (pushes button)	Door chime

Figure 14.4: A sound cue sheet

For Further Exploration

Gillette, J. Michael. 2007. *Theatrical Design and Production: An Introduction to Scene Design and Construction, Lighting, Sound, Costume, and Makeup*. Boston: McGraw-Hill. Rossing, Thomas D., F. Richard Moore, and Paul A. Wheeler. 2001. *The Science of Sound*, 3rd Edition. San Francisco: Pearson. "Association of Sound Designers " n.d. Accessed August 16, 2018. <http://associationofsounddesigners.com/>.

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CHAPTER OVERVIEW

15: Stage Management

[15.1: The Psychology of Stage Managing](#)

[15.2: Stage Management](#)

[15.3: Blocking Notation](#)

[15.4: Production Reports](#)

[15.5: Cueing Scripts](#)

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15.1: The Psychology of Stage Managing

In his book *The Backstage Guide to Stage Management*, Thomas A. Kelly writes,

"In the simplest sense, stage managers create an environment within which highly volatile people can function freely, devoid of petty distractions and stumbling blocks - other than those of their own creation. The stage manager must execute the creative vision of each production, supporting and assisting the directors, designers, writers, and performers in the achievement of their artistic goals. The stage manager's creative energies should be focused on finding as many ways as possible to make the theatrical process simple and enjoyable..."

So we must understand that the stage manager has many different roles and responsibilities in the world of theatre. She needs to be an advocate, leader, and constant problem solver for her cast, crew and creative team.

The most important thing to know about stage management is that the director and stage manager are the ultimate team. They must both know about the workings of the production and no secrets should be kept from one another. It is only together that they are whole; apart they have less leadership and respect.

Note

The Actors and Stage Management Union, "[Actors Equity](#)", provides a guide to Stage Managers on how to conduct rehearsals and manage actors' relationship with the entire production process.

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15.2: Stage Management

Updated and re-authored by:

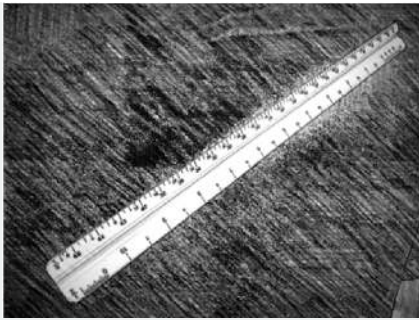
If you want to be at the center of everything and carry a great amount of responsibility and pressure, then you probably aspire to be a stage manager. The stage manager can be one of the first people to be brought on board for a production. They may become involved around the same time the **creative team** is assembled and begin by scheduling the initial meetings for a new production, which allows them to be involved with the entire production process. Or, they may be brought in just prior to the beginning of rehearsals. Regardless of when a stage manager's time with a production begins, their responsibilities and focus throughout the life of the production will go through a series of changes.

In this collaborative art of theatre, careful coordination of all of the constituent elements is crucial for success. Managing the schedules and communication of all the people involved in the production is one of the most complicated parts of the stage manager's job. From designers to crews, producers to performers, house staff to ushers, the flow of communication between individuals is central to the production. Facilitating this communication is by no means the only responsibility a stage manager assumes, but it is representative of the special glue that this person provides to a production. Coordination of calendars and schedules for an entire company is an increasingly difficult task in our modern society, yet we all must be there in the room to make this art happen. The creation of a **rehearsal calendar** often falls to the stage manager. To help facilitate communication among the company, the stage manager publishes a **contact sheet** listing each member of the company, their role in the production, and their contact information. Stage managers also frequently run the **auditions** by scheduling the actors, collecting their contact information and schedules, and ensuring everyone gets needed breaks to work at their best. Once casting decisions have been made, all rehearsal and performance schedule conflicts must be addressed, and the stage manager publishes a final rehearsal schedule along with a complete contact sheet.

As a central figure in contact with all aspects of the production, the stage manager is uniquely suited to see that something only communicated to some may need to be passed on to others who will also be affected. The best way to achieve this clarity is to always communicate through the stage manager (or at least always copy them on your communication). Think of a bicycle wheel representing communication. If the company members are the spokes along the outer rim, the stage manager is at the center hub. All of the communication coming into the center and then distributed out to all concerned. For instance, if the director decides to have a performer sit in a seat in the audience, the stage manager knows this must be coordinated with the box office so a ticket for that seat is not sold for any performance. In addition, stage managers know the lighting designer needs to be aware if actors will be performing in a nontraditional acting area.

Often the members of the creative team finalize their designs for a production around the time a play is cast. Prior to the first rehearsal, the stage manager needs to ask the designers for copies of plans and designs to facilitate the rehearsal process. The main plan required is a scaled **ground plan** of the stage design. The stage manager uses this plan to lay out a series of tapelines on the floor of the rehearsal space that represent key elements of the stage design. Tapelines stand in for walls, doors, windows, stairs, and major furniture elements. Often the rehearsal space is not as large as the stage space, and decisions about what and how to best represent the design may need to be made.

There's More to Know Laying out a tape plan for rehearsals on stage or on the rehearsal space floor requires a scaled ground plan from the set designer. This plan will be drawn to scale and may be ¼-inch, ½-inch, or another scale set. It is standard practice for the set designer to provide a "measured plan" which lists key measurements and minimizes the amount of scale measurements a stage manager needs to interpret. When laying out a space, corners and intersections are measured from the centerline of the stage. This reference line runs down the center of the stage from the upstage wall to the downstage edge of the stage. Measuring from the centerline helps ensure the elements are laid out proportionately in the space.



After organizing initial meetings with the design team, the stage manager must look forward into the process as ideas are solidified for the production's design. If the costume designer advances the idea that the central character will have many wardrobe changes during the performance, the stage manager can be thinking ahead about the number of backstage dressing crew needed to run the show. If special effects are being considered, the stage manager looks closely at the technical rehearsal schedule to ensure the necessary time is built-in to rehearse these elements. If the production uses actors who are unionized, the stage manager (who is usually represented by the same union) looks out for elements such as **raked stages** or atmospheric effects like fog—the use of which is regulated by the union contract. During this phase, a stage manager's role is to be supportive of the creative team, while at the same time informing them of the consequences of production choices.

Often a **design presentation** is scheduled for the company around the time of the first rehearsal so the creative team can describe designs to the cast.

During the rehearsal process, the stage manager ensures a safe and productive work environment, breaks are taken as needed, and records both the blocking of the actors and notes of the rehearsal so as the show's needs develop, all affected parties can adjust to support those needs. Daily **rehearsal reports** are sent to the production team with information and questions to keep the show on track.

During the rehearsal process, the creative team is invited to see a few rehearsals so they can see how the show is progressing. The first of these invited rehearsals is commonly called a **stumble-through**. This rehearsal occurs soon after the entire show has been blocked, and the actors try their best to represent all of the movement in the rehearsal so designers can get a sense of the shape of the show, of how the set is used, and, for the lighting designer, where people stand. Later, as the show continues to progress and develop, **run-throughs** are scheduled so designers can see the progress again prior to technical rehearsals.

Toward the end of the rehearsal process, it is common for productions to incorporate sound into the rehearsal room. The playback of cues and music is handled by the stage manager and allows a better integration of sonic elements prior to technical rehearsals. It may also allow the stage manager to record sound element cues into their **prompt book** (see [chapter 15.5](#)).

In order to make sure the stage manager has all the various cues recorded in their prompt book, some more complicated productions may require a paper tech session, when the director and designers are present to talk through and coordinate the placement and timing of **cue** sequences for the production. These cues are fine-tuned during the actual technical rehearsals, but may need to be discussed in advance to make the most of the time in the theatre with a full production staff. In addition to the actual cues called to make changes in lighting, sound, and shifting scenery (also: video, spotlights, effects, music), the stage manager places warning cues in their prompt book so crew who have been idle for long periods of time are made aware they have a cue coming up soon.

There's More to Know Cue light systems have become standard for many theatres. This system of colored lights allows a stage manager to communicate “warning,” “stand-by,” and “go” commands to both actors and technicians without audible communication. Lights are placed backstage in areas visible to those needing the cue, and a relay station in the stage manager's booth allows them to turn each light on and off.

After the sets and lights have been loaded into the theatre, several special rehearsals and showings may be scheduled. A **spacing rehearsal** might be scheduled to allow actors to become familiar with the set. A **lighting rehearsal** may be called in which the lighting designer shows a director preset cues or “looks” without the performers being present. A **costume parade** may be scheduled to see each character in their wardrobe under the stage lights for final adjustments. A **sitzprobe** may be scheduled for a

musical performance wherein the cast and orchestra rehearse together in the performance space (most often seated) without following show blocking.

Prior to technical rehearsals, the stage manager ensures all prop tables are set up and labeled, headsets are available for crew as needed, adequate safety lighting is available backstage, and amenities such as fresh water and off-stage chairs are set for the cast.

The technical rehearsal process requires the stage manager to change their focus from the protected environment of the rehearsal room to the busy and complicated environment of the performance space. They are now in charge of the stage crew as well as the cast and have the design team on site finalizing their work as well. Timing is usually tight with much to be accomplished. Many of the people now involved have never seen this production in rehearsal, do not know the cast, and need to be led through a process that involves a great deal of communication. Much of this communication is accomplished over a **headset system** rather than face-to-face. All of these elements must become coordinated into a working unit, and this is the new focus of the stage manager. Again, clear communication is crucial in this process.

Some productions conduct a two-part technical rehearsal process beginning with a **dry tech**, when the performers are not present, allowing the crew to become familiar with the elements they control and to rehearse their cues and shifts with stand-ins as needed to represent the cast. The next step is a **wet tech**, which incorporates the actors. There is certainly value in separating these rehearsals, especially if there are many shifts in a show or when safety is of particular concern. Other companies may begin with a wet tech, incorporating everyone at once. This choice makes more sense if the actors actually help move items in transitions or if many costume changes are integral to the performance.

Once the technical rehearsals are complete and the cues and shifts are established and properly recorded into the prompt book, the production moves into **dress rehearsals**. The stage manager's focus must adjust again. Now the entire company is engaged, and rehearsals begin to run as if they were public performances. Actors inhabit dressing rooms, calls to places are made over intercom systems and backstage monitors, and everyone works in every corner of the theatre space. The stage manager keeps all of these individuals focused and on schedule. The stage manager now takes the reins in hand to drive the performance, calling all the cues, breaks, and, if necessary, **holds**. They also continue to produce daily reports of all rehearsal activity.

Many companies hold **preview performances** prior to the official opening of a production. These previews allow the company to adjust to the presence of the audience. They can be especially important in establishing comic timing. Over a preview period it is common for the company to hold work sessions during the day to continue to refine the performance and to incorporate adjustments based on the public's response from these shows. During this time, the stage manager again switches focus from operation to rehearsal and then back to operation.

Once the show officially opens, the stage manager's focus shifts again. The director's contract is often at an end, and the stage manager now becomes responsible not only for running the show, but also for maintaining the integrity of the production. It is the stage manager's new responsibility to ensure the production looks and sounds the same on the 400th performance as it did on opening night. If an actor or operator begins to stray from that performance, it is the stage manager's job to let them know they need to come back to the work that was set by the director. Actors and stage managers are represented by the same trade union to clarify this role, which might seem disciplinary within a company. Sometimes a stage manager is called upon to run **put-in rehearsals** for replacement performers who take over roles in a running production.

During all performances the stage manager checks to ensure the stage space is safe, all necessary elements are functioning and in place, all personnel are accounted for, and the show is generally ready to entertain its audience. A half-hour before the show's start time, the stage manager makes a series of announcements to the company letting them know how long they have prior to **places call**. If required, the stage manager also runs a **fight call** to ensure actor safety prior to opening the house to the public.

Once a performance has concluded, the stage manager checks in with all departments to ensure everything is prepped for the next show. Costume repairs or any other needed work is scheduled so things will be in place for the next performance. When a show closes at the end of its run, the stage manager normally prepares the prompt book and all notes on running the production for the theatre's archives.

For Further Exploration Ionazzi, Daniel. 1992. *The Stage Management Handbook*. White Hall: Betterway Books. Kelly, Thomas A. 2009. *The Back Stage Guide to Stage Management, 3rd Edition: Traditional and New Methods for Running a Show from First Rehearsal to Last Performance*. New York: Back Stage Books. "Actors' Equity Association." n.d. Accessed August 16, 2018. <http://www.actorsequity.org>.

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15.3: Blocking Notation

What is Block Notation?

Blocking is the term for where actors are standing and what business they are doing for every moment they are on stage. Blocking notation is the documentation of the blocking. In a rehearsal room, the director will explain the action to the actors and the stage manager will take it down. The blocking is recorded in the prompt script, or prompt book. This notation becomes exceedingly important for several tasks on the show.

In long running professional productions, it is not the director's job to train replacement performers and understudies. In the United States, this task is part of the stage management team's responsibilities. The notation must be complete enough that new actors will be able to recreate the original direction.

In a similar vein, it is important to understand that the prompt script is owned by the producer. The producer can (with the payment of royalties to the original artistic staff), recreate a production. This might be for a national tour, production in a foreign country, or a revival production. In any case, the producer will use the original prompt book to recreate the staging.

A more immediate need of the blocking notation deals with the design team. Scenic, Costume, and especially Lighting designers may need to ask detailed questions about staging that the stage manager will only be able to answer with the aid of the blocking notation in the prompt book. A member of the stage management team is always in the room while directors are working with actors. Design team members are rarely present. Scenic designers may ask for details of how many people stand on a table to determine how strong it needs to be. Costume designers may ask for details of what type of action occurs in a particular costume. Lighting designers are regularly asking the stage management team where on stage a particular moment happens so that lighting can be adjusted correctly.

Preparing a script

Stage managers prepare a prompt script to take blocking notation in a specific way. First step is to photo copy the script single sided. This allows the stage manager to create more white space around the text to make notations. It also allows the original script to remain unmarked. On the blank back of each page of the copy the stage manager will copy the ground plan. This allows stage managers to lay out their book so they see one page of text and one page of ground plan. The side with the ground plan looks like this:

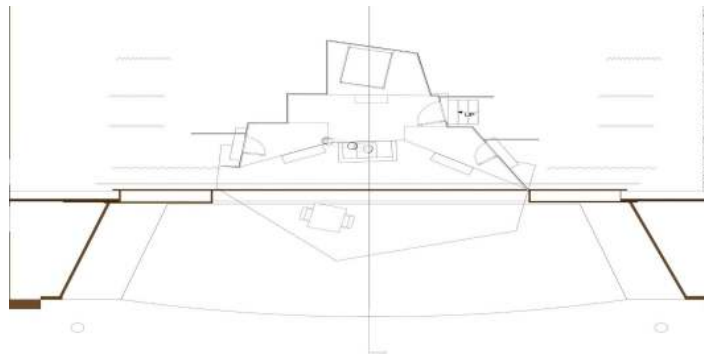


Figure 15.3.1: . Ground Plan featuring blank space for stage managers notes.

Notice how the plan is small at the top of the page allowing room underneath the plan for the stage manager to take notes. Traditionally, it is set up so the text will be on the right side page, and the picture will be on the left side page. Some stage managers find it easier, especially if they are right handed, to put the ground plan on the right hand page because it makes diagramming the blocking easier.

Notation Styles/Symbols

Every stage manager develops their own system of symbols to make the taking of blocking notation easier. These symbols create a kind of short hand. As they are unique to each individual stage manager, it is vital that a key be provided at the front of the script. Each character must have a symbol so that notes can be taken quickly. This is often the first letter or the initials of the character with a box drawn around the initials to denote that it is a character. Complicated sets may number all the doors or entrances/exits so that they can be noted quickly. Below is a key for a production of Box and Cox. Notice how there is a quick sketch of a stage showing Stage Left (SL), Stage Right (SR), Down Center (DC) etc.

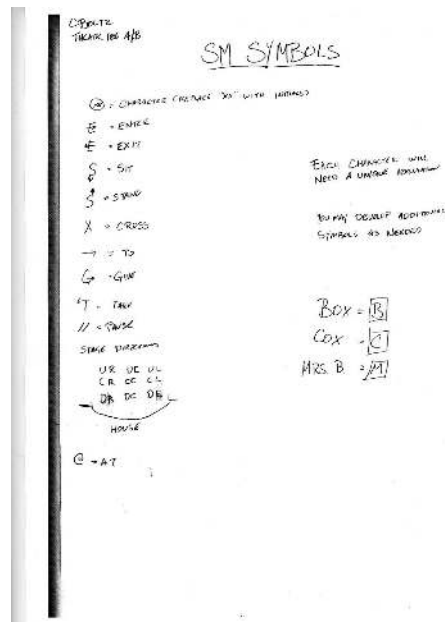


Figure 15.3.2: . Stage Manager Symbols

Each production will need to add or delete symbols from the above to be efficient for that show.

Coordinating Words and Actions

Once the script and initial key are prepared, it is time to observe rehearsals and take the blocking notation. Each place there is action in the text it is marked with a number. On the opposite page, each number coordinates with a written description of the action. The description is usually done with the symbols prepared above. The last step is to translate the descriptions into a visual representation on the ground plan at the top of the page.

On the ground plan, each character symbol is shown at their spot at the top of the page (or just off the stage if they will enter on the page). Then there moves are marked with arrows which can often give a clearer idea of the path the actors take than just the description. Each move is marked with a number that corresponds to the markings in the text. If a character doesn't move with a number, then that number is just skipped for that character. Even if a character doesn't move on a particular page (but appears on stage), they should be noted on the ground plan at the top of the page. This allows the stage manager to quickly know at a glance that everyone is where they are supposed to be during rehearsal.

A prepared page of Box and Cox might look like this:

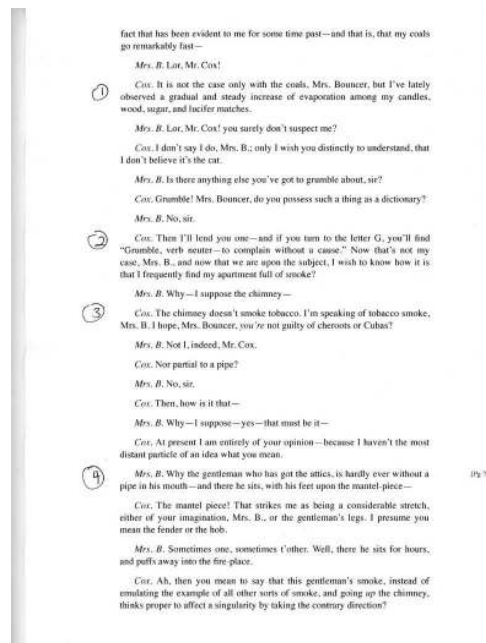


Figure 15.3.3: . Staged Managers Prepared page, a.

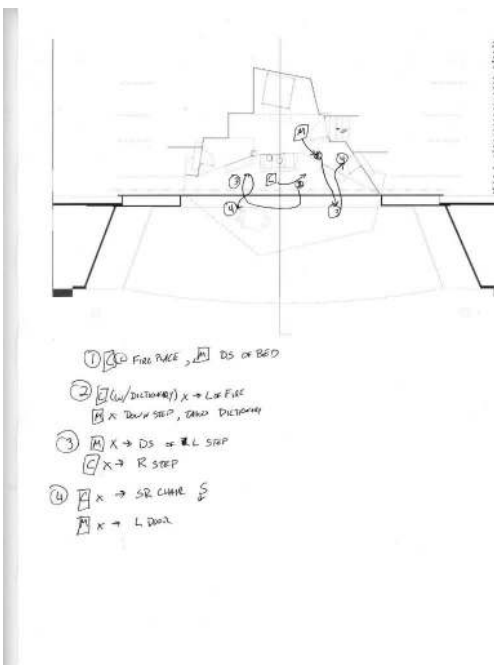


Figure 15.3.4: . Staged Managers Prepared page, b.

Additional Reading

- [The Awesome Stage Manager Blog on Blocking Notation](#)

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15.4: Production Reports

15.4.1 Function and Distribution

As was noted previously, the director, stage manager and performers are the folks in the rehearsal room. Many others, such as producers, designers and technicians need to be kept abreast of what is happening in the rehearsal room. To accomplish this task, the rehearsal report. Rehearsal reports are distributed to the producers, and the entire creative team. In professional productions, the rehearsal report also serves as the time card for the actors, allowing them to be paid correctly.

For a performance, the stage manager, the performers, and the crew are the only people guaranteed to be there. Since directors, producers, and designers need to know about problems, issues etc. the performance report serves a similar purpose as the rehearsal report.

Traditionally these reports were generated, photocopied and hand distributed or faxed to the key personnel. Today they are more likely to be distributed via email. The email distribution has caused a change in how some reports are generated. Traditionally a form would be created and hand filled in by the stage manager at the rehearsal or performance. The next evolution was the form being created in a word processor and filled in on a lap top. The word processor version would need to be sent as an attachment in Email. Some productions feel it is better to just copy and paste the information into a body of an email instead of attaching a file. Whatever version the production team decides is best, the information on the report remains the same.

With so much information that will be eventually placed on the report, it is important that the layout is consistent from day to day. Although all production team members should read the report in its entirety, most will only look at the sections that directly pertain to their duties. With this in mind, if there are no notes or information for a particular department, that department still needs to be listed on the report, with a simple indication of “no notes.” Additionally, information that pertains to two or more departments (such as a particular prop needing to fit into a pocket of a costume) needs to appear with the notes for each department (in the example props and costumes). One other note that is important to remember: these reports are widely distributed. Some information, especially that of a sensitive nature about a cast member, should not appear on a production report. If that information needs to be shared, it should be shared via a separate email to the key people that need it, or over the phone.

15.4.2 Rehearsal Reports

As stated above, each production will develop its own report structure and lay out. Regardless, the following information needs to be on every report:

- Header
 - Including the production name, date of rehearsal, name of the stage manager who prepared the report.
- Schedule/Agenda
 - Detailing what the plan was for the rehearsals.
 - Notes of the actual start, end and break times. These are important for payroll.
- Cast/Crew called. This is who was expected to be at the rehearsal.
- Late/Absent cast or crew. People who are not there for the full call time are often paid less than those were.
- Accomplishments. This is a list of what items were rehearsed. This differs from the Agenda which discusses what was planned.
- Next Rehearsal: Call time/location of the next rehearsal and what is planned for that rehearsal
- NOTES: The notes are broken down by department. Depending on the organizational structure of a particular production there may be some additional departments, or some listed departments may be merged together.
 - General Notes: These are notes to everyone reading the production report. Some stage managers list weather conditions, positive information (cast member birthdays) or an overall assessment of the mood of the cast.
 - Accidents/Incidents: These include injuries or other unforeseen problems of a general nature. (i.e. rehearsal interrupted by a fire alarm, or the inability to unlock the door).
 - Scenery
 - Props
 - Costumes
 - Hair/Make-up
 - Sound
 - Lighting

- Projection
- Fight/Choreography/Other specialty staging
- Producer/Marketing/Publicity
- Distribution: Many stage managers put a complete distribution list at the bottom of the report. This allows individuals to know who will read the report.

15.4.3 Performance Reports

Performance reports function very similarly to rehearsal reports, except that they are more focused on what happened at each performance. The format must be consistent from performance to performance.

- Header: including the name of the show, the scheduled date and time of the performance, name and contact information for the stage manager preparing the report
- Schedule including call times for cast and crew, the start and end times of each act, the overall run time of the show (from start until the conclusion of bows)
- Cast and crew called for the performance
- Late/absent cast and crew. This is also the area to note if understudies were used for the performance
- Next Rehearsal (if one is called), location, cast and crew that are called, what will be rehearsed
- Next Performance (date/time, and if the show is a tour list the location)
- NOTES
 - General notes: Overall assessment of the performance/audience response
 - House: How many people were in the audience (The house manager will provide this information), any issues getting the audience in or out, and injuries or accidents involving the audience
 - Incidents/Accidents: Any unusual incidents that apply to all production team members (starting late due to fire trucks being called for the building across the street), accidents or injuries involving the cast and crew
 - Scenery
 - Props
 - Costumes
 - Hair/Make Up
 - Lighting
 - Sound
 - Projection
 - Producer/Marketing/Publicity
- Distribution list.

Items such as issues with the house are important for the producer to be aware of. The run time of the show often gives directors a good idea if the show is being performed as directed. Professional productions generally vary less than 2 minutes between performances. Anything that might cause a huge shift in the run time should be noted.

Additional Reading

- [Headset Chatter website on Stage Management forms](#) (including Rehearsal and Performance Reports)

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15.5: Cueing Scripts

Calling the Show

One of the primary functions of the stage manager is calling the cues for the show. All the technicians will wait to execute all of their lighting, sound, fly, deck and other cues until the stage manager instructs them to.

At a process known as “paper tech,” the stage manager will talk through all the cues with the designers and the director. Each cue will be discussed and named. Lighting cues are generally numbered as light boards work by number. Sound cues are typically lettered to differentiate them from the lighting cues. With today’s technology, however each designer will discuss how they want the cues designated. The director and designers will make best guesses where each cue will be called in the script and a short concept of what each cue will be. These discussions will make technical rehearsals more efficiently, as there will be less changes. Even so, all cues should be marked in pencil because they may move during the technical rehearsals

Preparing the Script

Frequently, the stage manager will continue to use the blocking script, but using the outside edge of the page with the text to mark the cues. If the stage manager chooses to use a clean script, they can, but it is generally prepared the same way, i.e. copying the script on to 8 ½” by 11” paper.

It is important that there be plenty of room as some shows involve many cues for the stage manager to call. If there have been any additions or deletions of text or stage business, these must be clearly marked in the script, because it is possible that a designer will place a cue on the additional text or action.

Marking the Script

The cueing script is marked with three types of calls: Warnings, Stand-bys and Cues. A warning is a call to let certain technicians know that we are approaching the time a cue will happen. These are generally needed when a technician has not had a cue for several pages, or when a technician has a particularly challenging cue sequence to execute. The warning gives the technician time to prepare. A Stand-by means that the cue will be called imminently. Technicians at this point are fully ready to execute the cue on a moment’s notice. Warnings and Stand-bys are placed generally in the script as their calling does not need to be precise. The cues on the other hand are marked on a specific word or action. It is on this word or action that the “Go” for the cue needs to be called. Sometimes two cues may happen at the same time, or they may happen separately. If together the stage manager will say “Light 15 and Sound D ... GO.” If they are to happen independently, but near to each other the stage manager will say “Lights 15 ... GO, Sound D ... GO.”

Stage manager often indicate the types of cue (such as light cue or sound cue) with the cue name. The cue types are often abbreviated: SQ for sound cue, LQ for light cue etc. Look at the sample cue page on the next page.

Mrs. B. Why—

Cox. Then, I suppose, the gentleman you are speaking of, is the same individual that I invariably meet coming up stairs when I'm going down, and going down stairs when I'm coming up! WARN SQ D

Mrs. B. Why—yes—I—

Cox. From the appearance of his outward man, I should unhesitatingly set him down as a gentleman connected with the printing interest.

Mrs. B. Yes, sir—and a very respectable young gentleman he is.

Cox. Well, good-morning, Mrs. Bouncer!

Mrs. B. You'll be back at your usual time, I suppose, sir? STANDBY LQ 19

Cox. Yes—nine o'clock. You needn't light my fire in future, Mrs. B.—I'll do it myself. Don't forget the bolster! *[Going, stops.]* A halfpenny worth of milk, Mrs. Bouncer—and be good enough to let it stand—I wish the cream to accumulate. [LQ 19]

[Exit at L.C.]

Mrs. B. He's gone at last! I declare I was all in a tremble for fear Mr. Box would come in before Mr. Cox went out. Luckily, they've never met yet—and what's more, they're not very likely to do so; for Mr. Box is hard at work at a newspaper office all night, and doesn't come home till the morning, and Mr. Cox is busy making hats all day long, and doesn't come home till night; so that I'm getting double rent for my room, and neither of my lodgers are any the wiser for it. It was a capital idea of mine—that it was! But I haven't an instant to lose. First of all, let me put Mr. Cox's things out of Mr. Box's way. *[She takes the three hats, Cox's dressing gown and slippers, opens door at L. and puts them in, then shuts door and locks it.]* Now, then, to put the key where Mr. Cox always finds it. *[Puts the key on the ledge of the door, L.]* I really must beg Mr. Box not to smoke so much. I was so dreadfully puzzled to know what to say when Mr. Cox spoke about it. Now, then, to make the bed—and don't let me forget that what's the head of the bed for Mr. Cox, becomes the foot of the bed for Mr. Box—people's tastes do differ so. *[Goes behind the curtains of the bed, and seems to be making it, then appears with a very thin bolster in her hand.]* The idea of Mr. Cox presuming to complain of such a bolster as *[this]*—[SQ D]

[She disappears again, behind curtains.]

Box. *[Without.]* *[Pooh—pooh!]* Why don't you keep your own side of the staircase, sir? *[Enters at back, dressed as a Printer. Puts his head out at door again, shouting.]* It was as much your fault as mine, sir! I say, sir—it was as much your fault as mine, sir! [LQ 20]

Mrs. B. *[Emerging from behind the curtains of bed.]* Lor, Mr. Box! what is the matter? STANDBY LQ 21

Box. Mind your own business, Bouncer!

In the example on the previous page, we see that the stage manager plans to call the Stand-bys for D and 20 together, even though the two cues will actually called separately. Light cues 19 and 20 are called on specific actions, while sound cue D is called on the word “this.” It is important to notate all stand-bys and warnings be noted in the script, that way the stage manager won’t forget to call them.

Additional Reading

- [Theatre Crafts on Cue Scripts](#)
- [Hear a San Diego stage manager calling cues for “Hairspray”](#)

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Index

A

A2 (Audio 2)
1.2: Organizational Structures

Aavas
3: Equipment Through History

Acting notes
8.1: Design and Collaboration

Additive color mixing
9: Color

Alan Ayckbourn
13: Projection

Alternating Current (AC)
11.2: Electrical Fundamentals

American Wire Gauge
11.2: Electrical Fundamentals

amphitheater
3: Equipment Through History

Amplifier
14: Sound Design and Production

Amps
11.2: Electrical Fundamentals

analysis
8.2: The Design Process

Anchors
5.1.4: Threaded Fasteners, Drivers, Pliers and Wrenches

ANSI
2.2: Navigating the Stage

Apron
2.2: Navigating the Stage

Arc Flash
11.1: Electrical Safety

Architect's scale ruler
4.2.2.1: Prelude to Scales
4.2.2.2: Using an Architects Scale Ruler

Arena stage
3: Equipment Through History

Arena Theatre
2.1: Theatre Spaces
3: Equipment Through History

Arrowheads
4.1.4: Dimensioning

Artificial intelligence (AI)
3: Equipment Through History

Artistic Director
1.2: Organizational Structures

Aspect Ratio
13: Projection

Assistant Director
1.2: Organizational Structures

Assistant Stage Manager
1.2: Organizational Structures

Audio playback
3: Equipment Through History

Auditions
15.2: Stage Management

Auditorium
2.2: Navigating the Stage
3: Equipment Through History

August Wilson
8.2: The Design Process

Automation
2.2: Navigating the Stage

Automation Operator
1.2: Organizational Structures

B

Backdrops
3: Equipment Through History

Backlight
12.1: Lighting Design

Balanced cable
14: Sound Design and Production

Band Saw
5.1.5: Saws

Beam angle
12.2: Lighting Equipment and Control Systems

Bill of materials
4.2.3.1: Basic layout of a drawing

Binder
10: Painting

Black Box Theatre
2.1: Theatre Spaces
3: Equipment Through History

Blackout
3: Equipment Through History
12.1: Lighting Design

Blending
13: Projection

Block Saw
5.1.5: Saws

blocking
15.2: Stage Management
15.3: Blocking Notation

Blocking Notation
15.3: Blocking Notation

Board of Directors
1.2: Organizational Structures

Board Operator (Light, Sound, Video, etc.)
1.2: Organizational Structures

Bolt
5.1.4: Threaded Fasteners, Drivers, Pliers and Wrenches

Booth Stage
3: Equipment Through History

Border Line
4.1.1: The Language of Lines

Borders
2.2: Navigating the Stage
3: Equipment Through History

Break Line
4.1.1: The Language of Lines

Breakaway props
7.2: Props and Effects

Brightness
13: Projection

Brushes
10: Painting

Butt joint
5.2: Construction Materials

C

Cable drum
2.2: Navigating the Stage

CAD
4.2.1.2: Computer drafting printing

Calling
15.5: Cueing Scripts

Candlelight

3: Equipment Through History

Carpenters
1.2: Organizational Structures

Carriage bolts
5.2: Construction Materials

cast
1.1: Theatre- A Collaborative Art
15.4: Production Reports

Caster
6: Production and Construction Techniques

Center Line
4.1.1: The Language of Lines

Center Stage
2.2: Navigating the Stage

channels
12.2: Lighting Equipment and Control Systems

Chip brush
10: Painting

choreographer
1.2: Organizational Structures

Church
3: Equipment Through History

Circuits
11.2: Electrical Fundamentals
12.2: Lighting Equipment and Control Systems

Circular Saw
5.1.5: Saws

collaboration
1.1: Theatre- A Collaborative Art

color
9: Color
12.1: Lighting Design

Color Neutralization
9: Color

Color renderings
8.1: Design and Collaboration

Color Temperature
9: Color

Combination Circuit
11.2: Electrical Fundamentals

commitment
8.2: The Design Process

community theatre
1.1: Theatre- A Collaborative Art

compass
4.2.1.1: Tools

Complementary color
9: Color

Condenser microphone
14: Sound Design and Production

Consumable Props
7.1: Categorizing Props

Contact sheet
15.2: Stage Management

Controllable qualities of light
12.1: Lighting Design

Corner blocks
6: Production and Construction Techniques

Costume Designer
1.2: Organizational Structures

Costume parade
15.2: Stage Management

Costume Props
7.1: Categorizing Props

Costume Shop Manager

1.2: Organizational Structures

Counterweight System

2.2: Navigating the Stage

Creative team

1.1: Theatre- A Collaborative Art
15.2: Stage Management

crew

15.4: Production Reports

Cue

12.1: Lighting Design
15.2: Stage Management
15.5: Cueing Scripts

Cue sheet

14: Sound Design and Production

Cueing Script

15.5: Cueing Scripts

Curtains

2.2: Navigating the Stage

Curved Surfaces

4.1.2: Visualization

Cutter

1.2: Organizational Structures

Cutting Disc

5.1.7: Grinders, Sanders, and Accessories

Cutting Plane

4.1.5: Sectional Views

Cutting Plane Line

4.1.1: The Language of Lines

Cyc light

12.2: Lighting Equipment and Control Systems

Cyclorama (Cyc)

2.2: Navigating the Stage

D

Dataton

13: Projection

Death Wagon

3: Equipment Through History

Decks

6: Production and Construction Techniques

Decorative props

7.1: Categorizing Props

Deep learning

3: Equipment Through History

design

8.1: Design and Collaboration
8.2: The Design Process

Design presentation

15.2: Stage Management

Design Process

8.2: The Design Process

designers

1.1: Theatre- A Collaborative Art
8.2: The Design Process

Digital Light Processing (DLP)

13: Projection

Digital Projectors

13: Projection

Digital video projectors

3: Equipment Through History
13: Projection

Dimension Line

4.1.1: The Language of Lines

Dimension Lines

4.1.4: Dimensioning

Dimensions

4.1.4: Dimensioning

Dimmer

12.2: Lighting Equipment and Control Systems

Direct Current (DC)

11.2: Electrical Fundamentals

Director

1.2: Organizational Structures

Dividers

4.2.1.1: Tools

DMX512

12.2: Lighting Equipment and Control Systems

Downstage

2.2: Navigating the Stage

drafting

4.1.2: Visualization
4.1.3: Technical Sketching
4.1.4: Dimensioning
4.1.5: Sectional Views
4.2.1: Drafting Tools and Materials
4.2.1.1: Tools
4.2.1.2: Computer drafting printing
4.2.2.1: Prelude to Scales
4.2.2.2: Using an Architects Scale Ruler
4.2.3: Interpreting scale drawings
4.2.3.1: Basic layout of a drawing

Drafting board

4.2.1.1: Tools

Drafting machine

4.2.1.1: Tools

Drafting table

4.2.1.1: Tools

Draper

1.2: Organizational Structures

Drawing notes

4.2.3.1: Basic layout of a drawing

Drawing pencils

4.2.1.1: Tools

Drawing specifications

4.2.3.1: Basic layout of a drawing

Dress rehearsal

15.2: Stage Management

Dressers

1.2: Organizational Structures

Drill Bit

5.1.6: Drills and Accessories

drills

5.1.6: Drills and Accessories

Drivers

5.1.4: Threaded Fasteners, Drivers, Pliers and Wrenches

Dry ice

7.2: Props and Effects

Dry tech

15.2: Stage Management

Dusting brush

4.2.1.1: Tools

Duvetyn

2.2: Navigating the Stage

Dynamic microphone

14: Sound Design and Production

E

Eccyclema

3: Equipment Through History

Echo

14: Sound Design and Production

Edison

12.2: Lighting Equipment and Control Systems

egyptian

3: Equipment Through History

Electrical load

11.2: Electrical Fundamentals

Electrician

1.2: Organizational Structures
11.1: Electrical Safety
12.2: Lighting Equipment and Control Systems

Electricity

11.1: Electrical Safety
11.2: Electrical Fundamentals

Electromagnetic spectrum

9: Color

Elevator traps

3: Equipment Through History

Ellipsoidal reflector spotlights (ERS)

12.2: Lighting Equipment and Control Systems

Environmental soundscapes

14: Sound Design and Production

Erasers

4.2.1.1: Tools

Erasing shields

4.2.1.1: Tools

evaluation

8.2: The Design Process

Executive Director

1.2: Organizational Structures

Extension Line

4.1.1: The Language of Lines

Extension Lines

4.1.4: Dimensioning

F

Facing

6: Production and Construction Techniques

False proscenium

2.2: Navigating the Stage

Fasteners

5.2: Construction Materials

Field Angle

12.2: Lighting Equipment and Control Systems

Fight call

15.2: Stage Management

Fight Choreographer

1.2: Organizational Structures

Figure 53

13: Projection

Fill light

12.1: Lighting Design

Filler

10: Painting

Fire effects

7.2: Props and Effects

First Hand

1.2: Organizational Structures

Fixed caster

5.2: Construction Materials

Flats

6: Production and Construction Techniques

Flush

6: Production and Construction Techniques

Fly Crew

1.2: Organizational Structures

Fly gallery

2.2: Navigating the Stage

Fly systems

2.2: Navigating the Stage

Flying

3: Equipment Through History

Flying effects

3: Equipment Through History

focus

12.1: Lighting Design

Forced perspective

3: Equipment Through History

Forstner Bit

5.1.6: Drills and Accessories

Found Spaces

2.1: Theatre Spaces

3: Equipment Through History

French curves

4.2.1.1: Tools

Frequency

14: Sound Design and Production

Fresnel

12.2: Lighting Equipment and Control Systems

Front light

12.1: Lighting Design

Functions of light

12.1: Lighting Design

Furnishings

7.1: Categorizing Props

G

Gas Lighting

3: Equipment Through History

Glass box

4.1.2: Visualization

Globe Theatre

3: Equipment Through History

Go

15.5: Cueing Scripts

Gobo

12.2: Lighting Equipment and Control Systems

Gobos

13: Projection

Google Slides

13: Projection

Grand Drape

2.2: Navigating the Stage

Greek

3: Equipment Through History

Grinder

5.1.7: Grinders, Sanders, and Accessories

Ground plan

15.2: Stage Management

Guns

7.2: Props and Effects

H

Hammer

5.1.3: Nails, Hammers and Pneumatic Nailers

Hand Props

7.1: Categorizing Props

Hatch

4.1.5: Sectional Views

Hazer

7.2: Props and Effects

Headset system

15.2: Stage Management

help tell the story

2.1: Theatre Spaces

Hex bolts

5.2: Construction Materials

Hidden Line

4.1.1: The Language of Lines

Hidden Surfaces

4.1.2: Visualization

history

3: Equipment Through History

Hogs trough

6: Production and Construction Techniques

Hole Saw

5.1.6: Drills and Accessories

Holographic projection

3: Equipment Through History

hue

9: Color

I

Illumination

12.1: Lighting Design

Image research

8.2: The Design Process

Impact Driver

5.1.6: Drills and Accessories

Implementation

8.2: The Design Process

In the round

2.1: Theatre Spaces

Incandescent

12.2: Lighting Equipment and Control Systems

Inclined Surfaces

4.1.2: Visualization

Incubation

8.2: The Design Process

Industrial Revolution

3: Equipment Through History

input

14: Sound Design and Production

Integrated Color Wheel

9: Color

Intensity

12.1: Lighting Design

Isadora

13: Projection

Isometric

4.1.2: Visualization

J

Jackknife platforms

5.2: Construction Materials

Jacks

6: Production and Construction Techniques

Japan

3: Equipment Through History

K

Kabuki

2.2: Navigating the Stage

3: Equipment Through History

Kabuki Drop

3: Equipment Through History

Kelvin

9: Color

Key light

12.1: Lighting Design

Keyframes

13: Projection

Keystones

6: Production and Construction Techniques

Knives

7.2: Props and Effects

L

Lamp

12.2: Lighting Equipment and Control Systems

Laser projectors

13: Projection

Layout tools

5.1.2: Measuring, Marking, Leveling and Layout Tools

Leader Line

4.1.1: The Language of Lines

LED

12.2: Lighting Equipment and Control Systems

Legs

2.2: Navigating the Stage

3: Equipment Through History

Leko

12.2: Lighting Equipment and Control Systems

Lettering

4.1.3: Technical Sketching

Levels

5.1.2: Measuring, Marking, Leveling and Layout Tools

Light

9: Color

Light Design

12.1: Lighting Design

12.2: Lighting Equipment and Control Systems

Light plot

12.1: Lighting Design

lighting

12.2: Lighting Equipment and Control Systems

Lighting control console

12.1: Lighting Design

lighting designer

1.2: Organizational Structures

12.1: Lighting Design

Lighting filters (gels)

9: Color

Lighting rehearsal

15.2: Stage Management

Line level

14: Sound Design and Production

Liquid Crystal Display (LCD)

13: Projection

Liquid Crystal on Silicon (LCoS)

13: Projection

Live camera inputs

13: Projection

Live video feeds

13: Projection

Lumber

5.2: Construction Materials

Lumens

13: Projection

M

Machina

3: Equipment Through History

Makeup Crew

1.2: Organizational Structures

Makeup Designer

[1.2: Organizational Structures](#)

Managing Director

[1.2: Organizational Structures](#)

Mansions

[3: Equipment Through History](#)

Marking

[5.1.2: Measuring, Marking, Leveling and Layout Tools](#)

Masking

[13: Projection](#)

Masonry Saw

[5.1.5: Saws](#)

Master Carpenter

[1.2: Organizational Structures](#)

Master Electrician

[1.2: Organizational Structures](#)

Measuring

[5.1.2: Measuring, Marking, Leveling and Layout Tools](#)

Mechane

[3: Equipment Through History](#)

Media Server

[13: Projection](#)

medieval

[3: Equipment Through History](#)

Mic level

[14: Sound Design and Production](#)

Microphone

[14: Sound Design and Production](#)

Milner

[1.2: Organizational Structures](#)

Miter Saw

[5.1.5: Saws](#)

Mixer

[14: Sound Design and Production](#)

Modeling

[12.1: Lighting Design](#)

[13: Projection](#)

Monitor

[14: Sound Design and Production](#)

Mono

[14: Sound Design and Production](#)

mood

[12.1: Lighting Design](#)

Motorized Flying Systems

[2.2: Navigating the Stage](#)

movement

[12.1: Lighting Design](#)

Moving lights

[3: Equipment Through History](#)

[12.2: Lighting Equipment and Control Systems](#)

MS PowerPoint

[13: Projection](#)

Music

[14: Sound Design and Production](#)

Musical Director

[1.2: Organizational Structures](#)

N

Nails

[5.1.3: Nails, Hammers and Pneumatic Nailers](#)

Nick Stafford

[13: Projection](#)

Noh (Nō) Theatre

[3: Equipment Through History](#)

Nominal dimensions

[5.2: Construction Materials](#)

notes

[4.1.4: Dimensioning](#)

Numerals

[4.1.4: Dimensioning](#)

Nut

[5.1.4: Threaded Fasteners, Drivers, Pliers and Wrenches](#)

O

Object line

[4.1.1: The Language of Lines](#)

Oblique

[4.1.2: Visualization](#)

Offstage

[2.2: Navigating the Stage](#)

Ohm's Law

[11.1: Electrical Safety](#)

Omni directional microphone

[14: Sound Design and Production](#)

Orchestra

[3: Equipment Through History](#)

Orchestra Pit

[2.2: Navigating the Stage](#)

organization (org) chart

[1.1: Theatre- A Collaborative Art](#)

[1.2: Organizational Structures](#)

Orthographic Projection

[4.1.2: Visualization](#)

P

Pageant Wagons

[3: Equipment Through History](#)

Paint Crew

[1.2: Organizational Structures](#)

painting

[10: Painting](#)

Paper tech

[15.5: Cueing Scripts](#)

Parabolic aluminized reflector (PAR)

[12.2: Lighting Equipment and Control Systems](#)

Parallel Circuit

[11.2: Electrical Fundamentals](#)

Patch panel

[12.2: Lighting Equipment and Control Systems](#)

Performance report

[15.4: Production Reports](#)

Performer flying

[2.2: Navigating the Stage](#)

Periaktoi

[3: Equipment Through History](#)

[13: Projection](#)

Perspective

[4.1.2: Visualization](#)

Phantom Line

[4.1.1: The Language of Lines](#)

Pigment

[9: Color](#)

[10: Painting](#)

pixels

[13: Projection](#)

Places call

[15.2: Stage Management](#)

Plagiarism

[8.2: The Design Process](#)

platforms

[6: Production and Construction Techniques](#)

playwright

[1.2: Organizational Structures](#)

Pliers

[5.1.4: Threaded Fasteners, Drivers, Pliers and Wrenches](#)

Plywood

[5.2: Construction Materials](#)

Pneumatic Nailers

[5.1.3: Nails, Hammers and Pneumatic Nailers](#)

Power formula

[11.2: Electrical Fundamentals](#)

PPE

[5.1.3: Nails, Hammers and Pneumatic Nailers](#)

practical

[5.2: Construction Materials](#)

Practical Props

[7.1: Categorizing Props](#)

Preproduction

[1.1: Theatre- A Collaborative Art](#)

Preview performance

[8.1: Design and Collaboration](#)

[15.2: Stage Management](#)

Primary colors

[9: Color](#)

Priming

[10: Painting](#)

Prodcenium

[2.2: Navigating the Stage](#)

Producer

[1.2: Organizational Structures](#)

Production concept

[1.1: Theatre- A Collaborative Art](#)

[8.1: Design and Collaboration](#)

Production Design Team

[1.1: Theatre- A Collaborative Art](#)

Production Manager

[1.2: Organizational Structures](#)

Production meeting

[8.1: Design and Collaboration](#)

Production Sound Engineer

[1.2: Organizational Structures](#)

Production Stage Manager (PSM)

[1.2: Organizational Structures](#)

Profile flat

[6: Production and Construction Techniques](#)

Programmer (lights/video)

[1.2: Organizational Structures](#)

Projections

[13: Projection](#)

Projections Designer

[1.2: Organizational Structures](#)

Projectors

[3: Equipment Through History](#)

Prompt book

[15.2: Stage Management](#)

[15.3: Blocking Notation](#)

Prop Designer

[1.2: Organizational Structures](#)

Prop List

[7.1: Categorizing Props](#)

Prop Master

[1.2: Organizational Structures](#)

Prop workers/carpenters

[1.2: Organizational Structures](#)

props

- 3: Equipment Through History
- 7.1: Categorizing Props

Props Crew

- 1.2: Organizational Structures

Proscenium arch

- 2.1: Theatre Spaces

Proscenium Theatre

- 2.1: Theatre Spaces
- 3: Equipment Through History

Protractor

- 4.2.1.1: Tools

Proud

- 6: Production and Construction Techniques

Pyrotechnics

- 3: Equipment Through History

PZM/PCC microphone

- 14: Sound Design and Production

Q

Qlab

- 13: Projection

Quick changes

- 2.2: Navigating the Stage

R

Rain

- 7.2: Props and Effects

Raked seating

- 3: Equipment Through History

Raked stage

- 3: Equipment Through History
- 15.2: Stage Management

RCA

- 14: Sound Design and Production

Reciprocating Saw (Sawsall)

- 5.1.5: Saws

Reference drawings

- 4.2.3.1: Basic layout of a drawing

Reflector

- 12.2: Lighting Equipment and Control Systems

Refresh Rate

- 13: Projection

rehearsal

- 1.1: Theatre- A Collaborative Art

Rehearsal calendar

- 15.2: Stage Management

Rehearsal Props

- 7.1: Categorizing Props

Rehearsal reports

- 15.2: Stage Management
- 15.4: Production Reports

reinforcement

- 14: Sound Design and Production

Renaissance

- 2.1: Theatre Spaces
- 3: Equipment Through History

research

- 8.2: The Design Process

resolution

- 13: Projection

restoration

- 3: Equipment Through History

Retina

- 9: Color

Reverb

- 14: Sound Design and Production

Revision chart

- 4.2.3.1: Basic layout of a drawing

Revolve

- 2.2: Navigating the Stage
- 5.2: Construction Materials

Revolves

- 2.2: Navigating the Stage
- 3: Equipment Through History

Rigging

- 2.2: Navigating the Stage

Rise

- 6: Production and Construction Techniques

ritual

- 3: Equipment Through History

Roman

- 3: Equipment Through History

Rounds, festival

- 3: Equipment Through History

S

Sabre Saws (Jigsaw)

- 5.1.5: Saws

Safe Wire Load

- 11.2: Electrical Fundamentals

safety

- 5.1.3: Nails, Hammers and Pneumatic Nailers
- 5.1.5: Saws
- 5.1.6: Drills and Accessories
- 5.1.7: Grinders, Sanders, and Accessories
- 11.1: Electrical Safety
- 12.2: Lighting Equipment and Control Systems

Sand Paper

- 5.1.7: Grinders, Sanders, and Accessories

Sander

- 5.1.7: Grinders, Sanders, and Accessories

Saturation (chroma)

- 9: Color

Saw

- 5.1.5: Saws

Saw Blade

- 5.1.5: Saws

Scaenae frons

- 3: Equipment Through History

scale

- 4.2.2.2: Using an Architects Scale Ruler
- 6: Production and Construction Techniques

Scale Drawing

- 4.2.3: Interpreting scale drawings

Scale ruler

- 4.2.1.1: Tools
- 4.2.2.1: Prelude to Scales

Scenery

- 6: Production and Construction Techniques

Scenic Artist

- 1.2: Organizational Structures

Scenic Designer

- 1.2: Organizational Structures

Scenic painting

- 10: Painting

schedule

- 15.4: Production Reports

Screws

- 5.1.4: Threaded Fasteners, Drivers, Pliers and Wrenches
- 5.2: Construction Materials

Scrim

- 2.2: Navigating the Stage

Script

- 1.1: Theatre- A Collaborative Art
- 15.3: Blocking Notation
- 15.5: Cueing Scripts

Scroll Saws

- 5.1.5: Saws

Scumbling

- 10: Painting

Secondary color

- 9: Color

Secrets

- 3: Equipment Through History

Section Line

- 4.1.1: The Language of Lines

Sectional Views

- 4.1.5: Sectional Views

Selection

- 8.2: The Design Process

Series Circuit

- 11.2: Electrical Fundamentals

Set Dressing

- 7.1: Categorizing Props

Set Props

- 7.1: Categorizing Props

Shade

- 9: Color

Shadow Boxes

- 13: Projection

Shadow puppetry

- 13: Projection

Shakespeare

- 3: Equipment Through History

Shift Crew (Stage Crew)

- 1.2: Organizational Structures

Shift light

- 12.1: Lighting Design

Shim

- 6: Production and Construction Techniques

Shotgun microphone

- 14: Sound Design and Production

Shutters

- 12.2: Lighting Equipment and Control Systems

Shy

- 6: Production and Construction Techniques

Sidelight

- 12.1: Lighting Design

Sight lines

- 2.2: Navigating the Stage

Signal chain

- 14: Sound Design and Production

Signal path

- 14: Sound Design and Production

Signal to noise ratio

- 14: Sound Design and Production

Single Stroke Gothic

- 4.1.3: Technical Sketching

Single View

- 4.1.2: Visualization

Sitzprobe

- 15.2: Stage Management

Skene

- 2.1: Theatre Spaces
- 3: Equipment Through History

Sketching

- 4.1.3: Technical Sketching

Skin

- 6: Production and Construction Techniques

Sky drops

[2.2: Navigating the Stage](#)

Slide Projectors

[13: Projection](#)

Slideshow Systems

[13: Projection](#)

Slip stages

[2.2: Navigating the Stage](#)

Smoke machines

[7.2: Props and Effects](#)

Snow cradle

[7.2: Props and Effects](#)

Sound board

[14: Sound Design and Production](#)

Sound Crew

[1.2: Organizational Structures](#)

sound design

[14: Sound Design and Production](#)

Sound Designer

[1.2: Organizational Structures](#)

[14: Sound Design and Production](#)

Sound effects

[14: Sound Design and Production](#)

Spacing rehearsal

[8.1: Design and Collaboration](#)

[15.2: Stage Management](#)

Spattering

[10: Painting](#)

special effects

[7.2: Props and Effects](#)

Specifications

[4.2.3.1: Basic layout of a drawing](#)

spectacle

[3: Equipment Through History](#)

Splines

[4.2.1.1: Tools](#)

Squares

[5.1.2: Measuring, Marking, Leveling and Layout Tools](#)

Stage combat

[7.2: Props and Effects](#)

Stage directions

[2.2: Navigating the Stage](#)

Stage Equipment

[2.2: Navigating the Stage](#)

Stage Left

[2.2: Navigating the Stage](#)

[15.3: Blocking Notation](#)

Stage Management

[15: Stage Management](#)

[15.2: Stage Management](#)

[15.5: Cueing Scripts](#)

Stage Manager

[1.2: Organizational Structures](#)

[15.3: Blocking Notation](#)

[15.4: Production Reports](#)

Stage Right

[2.2: Navigating the Stage](#)

[15.3: Blocking Notation](#)

Staircase

[6: Production and Construction Techniques](#)

Step lens

[12.2: Lighting Equipment and Control Systems](#)

Stereo

[14: Sound Design and Production](#)

Stiffening batten

[6: Production and Construction Techniques](#)

Stippling

[10: Painting](#)

Stitcher

[1.2: Organizational Structures](#)

Stock scenery

[6: Production and Construction Techniques](#)

storytelling

[1.2: Organizational Structures](#)

[3: Equipment Through History](#)

strike

[6: Production and Construction Techniques](#)

Striplight

[12.2: Lighting Equipment and Control Systems](#)

Subtractive color mixing

[9: Color](#)

Swatches

[8.1: Design and Collaboration](#)

Swivel casters

[5.2: Construction Materials](#)

[6: Production and Construction Techniques](#)

T

Table Saw

[5.1.5: Saws](#)

Tap and Die

[5.1.4: Threaded Fasteners, Drivers, Pliers and Wrenches](#)

Tape Measure

[5.1.2: Measuring, Marking, Leveling and Layout Tools](#)

Teatro Olimpico

[3: Equipment Through History](#)

Technical Director

[1.2: Organizational Structures](#)

Technical notes

[8.1: Design and Collaboration](#)

Technical rehearsal

[8.1: Design and Collaboration](#)

[15.2: Stage Management](#)

technology

[3: Equipment Through History](#)

Template

[12.2: Lighting Equipment and Control Systems](#)

templates

[4.2.1.1: Tools](#)

Tertiary color

[9: Color](#)

Thorton Wilder

[8.2: The Design Process](#)

Thrust Theatre

[2.1: Theatre Spaces](#)

[3: Equipment Through History](#)

Thumbnail sketches

[8.1: Design and Collaboration](#)

Thunder sheet

[7.2: Props and Effects](#)

Tile Saw

[5.1.5: Saws](#)

Tint

[9: Color](#)

Title block

[4.2.3.1: Basic layout of a drawing](#)

[6: Production and Construction Techniques](#)

tone

[9: Color](#)

tools

[5: Tools and Materials](#)

[5.1: Hand and Power Tools](#)

[5.1.1: Tool Choices and Applications](#)

[5.1.3: Nails, Hammers and Pneumatic Nailers](#)

[5.1.4: Threaded Fasteners, Drivers, Pliers and](#)

[Wrenches](#)

[5.1.5: Saws](#)

[5.1.6: Drills and Accessories](#)

[5.1.7: Grinders, Sanders, and Accessories](#)

Top light

[12.1: Lighting Design](#)

Transducer

[14: Sound Design and Production](#)

Traps

[2.2: Navigating the Stage](#)

Traveler

[2.2: Navigating the Stage](#)

Traverse

[2.1: Theatre Spaces](#)

triangle

[4.2.1.1: Tools](#)

Twens

[13: Projection](#)

Two View

[4.1.2: Visualization](#)

U

Unbalanced cable

[14: Sound Design and Production](#)

Upstage

[2.1: Theatre Spaces](#)

[2.2: Navigating the Stage](#)

V

value

[9: Color](#)

Vehicle

[10: Painting](#)

Video Playback

[13: Projection](#)

Video projections

[13: Projection](#)

Volts

[11.2: Electrical Fundamentals](#)

W

Wagon

[5.2: Construction Materials](#)

Wardrobe Crew

[1.2: Organizational Structures](#)

Washes

[10: Painting](#)

Watchout

[13: Projection](#)

Water effects

[3: Equipment Through History](#)

Watts

[11.2: Electrical Fundamentals](#)

Weapons

[7.2: Props and Effects](#)

Wet tech

[15.2: Stage Management](#)

Wetblend

[10: Painting](#)

Wings

[2.2: Navigating the Stage](#)

[3: Equipment Through History](#)

Wireless lavalier/body microphone

[14: Sound Design and Production](#)

Wood grain

[5.2: Construction Materials](#)

Wrenches

[5.1.4: Threaded Fasteners, Drivers, Pliers and Wrenches](#)

X

XLR

[14: Sound Design and Production](#)

Z

Zoom

[3: Equipment Through History](#)

Glossary

8K videos | Nearly 8,000 pixels wide, 8K native resolution is 7680 x 4320 pixels, which equates to 33,177,600 total pixels. By comparison, 4K, also called ultra HD or UHD for short, is approximately 4,000 pixels wide with 8.3 million total pixels.

Amphitheater | An open circular or oval building with a central space surrounded by tiers of seats for spectators, for the presentation of dramatic or sporting events.

Artificial intelligence | Intelligence—perceiving, synthesizing, and inferring information—demonstrated by machines, as opposed to intelligence displayed by non-human animals and humans.

Audio playback | Using pre-recorded media to play music or sound effects to the audience.

Blackouts | Turning off all light onstage, creating darkness.

Blended | When multiple images or videos are layered on top of each other but both can be seen at the same time.

Cable drum | A metal cylinder, usually attached to a motorized winch that is used to spool cable.

Deep learning | A type of machine learning method based on artificial neural networks. Teaching computers to learn for themselves.

Duvelyn | A soft matte theatrical fabric, most frequently in black. It is used to mask areas of the stage or backstage to control sightliness.

False proscenium | An additional, usually smaller, proscenium constructed for one production. It is installed in front of the theatre's existing proscenium to further control how the audience views the production.

Fly gallery | The area above the stage where battens holding scenery and drapes can be stored overhead out of the view of the audience.

Forced perspective | A design style that creates the visual illusion that a hallway continues farther than it does in actuality.

Gas Lighting | Controlled gas flame used as an illumination source.

Gobos | A thin metal template cut into a shape placed between a light and lens to cast a pattern of light. Gobo, is short for "go between."

Head-blocks | A pulley attached to the ceiling or grid of a theatre, usually placed directly above a lift line.

High contrast | If your image consists of extremely bright and dark areas, then it's considered high contrast.

Holographic projection | A media projection technique that provides either a two-dimensional or three-dimensional projection which can be seen without any additional hardware or viewing devices.

Intensity changes | Increasing or decreasing the brightness of the stage lights.

Keyframes (tweens) | The start and end points of an animation, such as scaling or dissolving a video.

LED Video Wall | A large screen made of small light-emitting diodes (LED's) that display visual content like videos, images, text, and other forms of graphics, similar to a television.

Live video feeds | A video source from a live camera or camcorder displayed to a projector or screen.

Masked | When multiple images or videos are layered on top of each other but one obscures the other, or creates a frame or pattern of opacity.

Modeling (with light) | *When a light used to create a three dimensional effect achieved through the perception of form and depth.*

Motorized winch | An electric device used to pull or hoist a load attached to a rope or wire rope.

Moving lights | Theatrical lighting fixtures that can move autonomously to change where their light of focused.

Pageant Wagons | A medieval mobile performance stage built on top of a wagon.

Performer flying | The act of hoisting performers above the stage on ropes or wire ropes to give the illusion that they are flying.

Pixels | A minute area of illumination on a display screen, one of many from which an image is composed.

Pyrotechnics | Flame effects used for the stage.

Quick changes | When an actor needs to change costumes quickly and requires assistance backstage to do so.

Raked stage (or seating) | A stage or seating area that is placed on an angled platform or ramp.

Rounds | A permeant Medieval circular venue used for carnival-like performance events.

Shadow puppetry | Flat articulated cut-out figures (shadow puppets) which are held between a source of light and a translucent screen.

Sight lines | The view the audience has of the stage and surrounding area. If the audience can see something from where they are seated, that item is considered within the audience's sight line.

Slide projector | A 20th century device used to project light through a film slide, allowing the slide to be enlarged and viewed on a screen.

Trap lift | A motorized platform installed in a theatre's trap, used to lift performers or scenery up to the stage level.

Word-clock | In digital audio electronics, a word clock or wordclock is a clock signal used to synchronize other devices, such as digital audio, effects, and other playback equipment.

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