

THE TECHNICAL DIRECTION AND ENGINEERING PROVIDED FOR THE 49TH SEASON
OF PORTHOUSE THEATRE IN CONJUNCTION WITH KENT STATE UNIVERSITY
COLLEGE OF THE ARTS,
SCHOOL OF THEATRE AND DANCE
2017

PRODUCTION OF *9 TO 5*

A culminating project paper submitted to the College of the Arts of Kent State University in
partial fulfillment of the requirements for the degree of Master of Fine Arts

By
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INTRODUCTION

This paper documents the processes of technical direction and engineering in regards to the 2017 Porthouse Theatre production of *9 to 5*, located in Cuyahoga Falls, Ohio. The processes were used to realize the scenic design and directorial concept, while balancing the fiscal, physical, and personnel constraints of the theatre company.

Technical direction and theatrical engineering have specific steps or phases that are applied to nearly every production. In this paper, six steps are introduced and explained. There is an assessment of the challenges and successes of working for the full season of Porthouse Theatre. Additionally, an appraisal of the process and of the finalized production is included along with an evaluation of my personal and professional growth. Figures incorporate construction drafting plates, photographs of the process and realized production, budgets, schedules, and supporting mathematical solutions.

The Production Team:

Director....TERRI J. KENT
 Scenic Designer....TERRY MARTIN
 Technical Director....HEATHER R. SINCLAIR
 Lighting Designer....CYNTHIA STILLINGS
 Costume Designer.....KERRY McCARTHY
 Sound Designer.....NATHAN ROSMARIN
 Production Stage Manager.....JOSHUA BROWN
 Music Director.....JONATHON SWOBODA
 Choreographer.....KELLY MENEER
 Properties Master.....PATRICK ULRICH
 Scene Shop Supervisor.....JASON GATES
 Production Manager.....KARL J. ERDMANN

1 Master Carpenter
 1 Lead Carpenter
 5 Carpenters

CHAPTER 1

INTERPRETATION OF THE SCENIC DESIGN

The Design Concept

The scenic design for this production was straightforward. Little interpretation was needed to fully understand what the Scenic Designer, Terry Martin, required of the realized design. The set was comprised of a repeating shape, a circle, in varying sizes (see Photo 1). The primary need was to research the most cost effective and easiest methods to achieve the desired effects.

Challenges of Realizing the Design

The major challenge did not stem from the design itself, but rather from the training of the carpentry crew. The crew was comprised of carpenters from different schools, regions, and backgrounds. As a summer theatre company, Porthouse hires its staff from across the United States. Working with a crew who have no previous personal connections, posed a training issue for the first production. My only understanding of their carpenter's skills came from their resumes and portfolios. While these documents support the hiring process, they shed little light on their personal work ethics, collaboration skills, or creativity that would help me or the Scene Shop Supervisor Jason Gates, to decide how to properly assign the daily work. One challenge posed by the implementation of the design was the movement of door pieces combined with the choreography, which will be discussed later in this paper.

A major fiscal and logistical challenge came from the Director, Terri Kent. In the play's text, a garage door opener machine is used to hoist the character, Franklin Hart Jr., above a bed (see Photo 2). The director placed a high priority on this bit and it was pivotal to the action of the story. The Production Manager, Karl Erdmann, Jason Gates, and I brainstormed ideas for a few

weeks. Ideas included using a canopy bed with a dead rigged system that the actor could hook himself into, a bed with a false step so it would appear as though he was hovering, and a dead-hung system wherein the bed would be rolled away after the actor was rigged. These ideas posed different issues and concerns. Primarily, the issues were steeped in mastering the aesthetic appeal of the effect and allowing for the ideal choreography. It was eventually decided that Porthouse would rework the budget in order to hire an outside flying company to create the effect. Gates took the lead in the process to find and secure a rigging company. ZFX was used to create the effect and while it was not the least expensive company, it was the company with available time and a good reputation. The overall effect cost \$5,880.00. The funds were not subtracted from the scenery, paints, and properties budget of \$7,500. The additional funds were secured from a separate source.

CHAPTER 2

THE PROCESS

Phase I

Breakdown of the Scenic Package

The technical theatrical engineering and direction did not start with the first design meeting, as I was not yet hired by Porthouse Theatre. I approached the design similarly to how an actor would approach a script. First, I looked at the whole, purely to understand what the overall theme would be. Secondly, I broke it down by the plates, just like scenes in a play. Designer plates are layouts of individual scenic pieces. What did each plate have, why were the notes necessary, and how would I implement the artistic virtue of the design? From there the breakdown continued into the individual drawings on each designer plate. What was the size and shape of the item, why were they designed that way, and how would I build it? The final step of the breakdown was the rough material and hardware order for the whole. What materials were needed, why were certain construction methodologies used, and how could I explain this to the carpenters?

The first step of the breakdown is looking at the scenic design as a cohesive unit. I looked at it as a puzzle that is complete and that I must disassemble to fit back into the box, or in this case a 24'-0" box truck. The initial concerns about the main structure and interdepartmental issues that might arise from it were also thought about during the "first read through". I had to decide whether to use steel or wood construction primarily; in the end, it was a mixture. With the first perusal of the package I developed a few key questions for Terry Martin and Terri J. Kent.

The second step of the breakdown was dissecting each plate and creating a rough estimate of the materials used and their cost for the production. It is important to note that the labor costs were taken from a separate personnel budget and not tied to the show carpentry budget. Using typical theatrical construction methods, I envisioned building each unit and calculated an approximate amount of lumber or steel. This process took just over two hours to complete, as the set was not intricate or overly complicated. The estimates were written on the plates of the design packet. This allowed me to keep my work in one place and would also allow easier collaboration between myself, the scenic designer, and the scene shop supervisor; as they could see directly how the budget and materials would be broken up. The plate breakdown also revealed more specific questions and concerns. The notes provided answers to the most obvious questions but they were not enough for others. An example of a question that remained unanswered was “What was on the back side of the upper structure?”. The drawings designated that there was nothing, however knowing that this would cause severe sightlines and potential lighting issues, it needed to be addressed. Through conversations with Martin, it was decided to use a clear, ribbed plastic material called Polygal with a matte film applied to the upstage side.

The last step of the scenic design package breakdown was completed by looking closely at each unit as a separate entity. This step is crucial in formalizing a construction plan and predicting any issues that may arise during construction. By building each unit separately, in my mind, I could see where a carpenter might get stuck and have a solution ready. This pre-planning allows for effective drafting. As I had already mentally built the units, all that needed to be done in the drawing phase is placing my mind’s eye in the computer or on paper.

Phase II

Drafting and Engineering

The second phase, and arguably, the most important is developing the technical drawings of the scenery. I used the computer program AutoCAD 2016 to create the draftings. This process starts with bringing in the designer files. Martin used the program Vectorworks, so I had to convert the file to a .dwg. After the file was brought in, I created two copies of the full designer package. This allows me to modify or adjust one copy, while keeping one unadulterated and easy to access. Directly below the designer drawings, there is a copy that is stripped of any notes, multileaders, or extraneous information or lines. This bare bones version is used as the jumping off point for engineering the unit. From there, I could create working drawings for the shop carpenters.

A major concern from an engineering standpoint was the weight of the center upper structure. This structure was engineered to be built of steel (See Plate 918). The structure was made of 1x1, 1x3, and 2x2 rectangular mechanical tube, commonly called box tube. Due to the size and weight of the units, the center base structure had to be built out of steel (See Plate 909). However, a compounding issue of the construction method, was the fact that the base structure was comprised of six doors. Four of these doors also had to pivot on a center fulcrum so that they could swing from stage right to stage left on the downstage side of the structure. The other two doors were hinged typically and placed on the upstage side of the structure. A solution that was discovered was extending four points of the upper unit and using cheseboroughs to attach to the grid of the theatre. An additional solution used 1/8" air craft cable attached to the upstage side of the upper steel structure and pulling it upstage in a vertical diagonal. This solution was uncovered through discussions with Jason Gates and the master carpenter during the first week of building. This kept

the upper structure secure and allowed me to design the base structure without a reasonable fear of catastrophic failure.

The stage right (SR) and stage left (SL) upper steel structure was built in the same style as the center upper structure. However, the base SR and SL structure was engineered to be constructed of wood. The decision to use wood was made to have work for carpenters who did not yet have the skills or knowledge to build with steel. The base units were mirror images and had large French doors that opened upstage (see Plate 925). The base units were built with plywood and 2x4 nominal number 2 Southern Pine. The engineering was derived from hogs-troughs and compression legs (see Plate 907). To ensure that the base structure could support such a large steel frame, a calculation of the structural integrity was needed (see p. 19). The top of the frame for doors A and C was constructed with lamination of 23/32" BC plywood to the face of 2x4. Therefore, only the stresses of the built-up shape of the 2x4 frame were examined for structural stability. The sides of the frame had one vertical 2x4 and a 6" wide vertical cut of 23/32" BC plywood. Although, the 2x4 on its own is structurally strong enough to withstand the stresses of the unit, I still felt as though an examination of the stresses on the plywood was needed (see p. 22). The other units were engineered with industry standard construction methodology.

Phase III

Selected Research of Materials and Scenic Function

In March, I attended several workshops at the 2017 USITT Conference (United States Institute of Theatre Technology). One of the workshops was about the designations of certain types of woods and plywoods. The speaker mentioned that he used plywood exclusively for flat construction, citing cost savings and durability. So, I decided to test his theory for this production.

I used 23/32" BC plywood in place of 1x4 nominal number 2 pine for all of the flats. This small change allowed the carpenters to have, overall, less wood waste during the construction process, and keep the shop fiscally responsible. One full sheet of 3/4" Plywood can create 13 sticks of wood at the dimensions of a 1x4 (3/4"x3 1/2"). The sheet lumber is \$33.09 each, however when ripped down, one stick of 1x4 came to \$2.54. The price of 1x4x8 nominal number 2 Southern Pine is \$5.79; a cost savings of \$3.25. Additionally, as the plywood purchased is rated for outdoor use it was a perfect fit for Porthouse. The theatre has a covered roof, although the sides and front are open to the elements (see Photo 1). 1x4 would warp with the change in temperature, moisture, and wind, where exterior grade plywood withstands these conditions better. The plywood framed flats did not warp and also did not dry out or split during the run.

The scene changes were fast and were blocked to be seamless and fluid. The six doors of the center structure posed a difficulty. They were designed to be hinged on the center and rotate 180°. Additionally, they had to be able to be moved by actors, who would open the doors by pushing rolling desks against them. My first thought had been to use pillow blocks and a pipe that ran the total height of the doors. However, this would involve precise drilling of the toggles within the door and specific placement of the pillow blocks. Generally, placement of hardware is easy, however, the stage floor of Porthouse varies in height and texture. This meant that each door would have custom pipe lengths and would not allow easy adjustment. From this realization, my thoughts bounced to piano hinges, inset door hinges, ball bearings, and Lazy Susans. However, these ideas would add extra weight to the doors, limit flexibility, and hinder the build time. In the end, my solution came from the bathroom stall doors at KSU. The hinges were manufactured as a rod and sleeve with one fulcrum at the top and one at the bottom. After arriving at the solution, I spent 45 minutes online to find the correct hardware (see YouTube 2). The hardware is called a Left-Hand

Pivot Hinge with Holes, Surface Mounting with an Aluminum Finish sold by Grainger (see Photo 4). Once it arrived, it had to be modified to work for the doors within the constraints of the steel structure. The right-angle support was cut off and a piece of 1"x4" steel bar was welded to the pivot housing. The 1"x4" steel bar was used to screw the wooden door to the pivot. The hardware created an ease of function, minimal sound disturbance, and flexibility.

However, there were flaws in this particular type of hinge. The housing was molded aluminum with bored holes which did not have a soft edge. The issue did not present itself until the Wednesday of technical rehearsals (tech). Just as Joshua Brown, the Production Stage Manager, called for lunch, an actor shut door number six and it fell. Luckily, no one was injured and the fix was quick. The issue was that one of the three 2" drywall screws that had been used to attach the bottom fulcrum to the deck had sheared, causing the hinge to move and the door to fall. To ensure that no other screw would shear from use, the drywall screws were exchanged with star head deck screws.

Phase IV

Building and On-Floor Modifications

The fourth phase of my TD process involves on-the-floor building as well as modifications due to material constraints, construction errors, and directorial/actor needs. Throughout a theatrical construction process, particularly with a crew made entirely of collegiate students, questions and mistakes are expected. The bulk of the mishaps with the set occurred with the trim of the four large doors. These doors were 3'-0" x 8'-11" and had applied detail (see Picture 6). The crew had a difficult time adhering the trim square. Part of the issue was that the carpenters were using two different tape measures and two different people measuring. In addition, they were not using a framing square, which resulted in the removal of the glued and stapled lauan being reapplied four

times. To help mitigate the problem the master carpenter was assigned to do measuring checks whenever a new piece of trim was attached.

An in the space modification occurred during tech week. The bathroom stall unit was built as drawn. However, when we entered the performance space, the unit looked as though it was a large green box. To rectify this, Terry Martin and Terri Kent, decided to have two large rectangles cut out of the sides (see Photo 7). This allowed the audience to see that there was, in fact, a toilet on stage and increased the sightlines of the actress who was hiding in the stall.

Phase V

Installation in Stump Theatre

Porthouse Theatre is unique. The production shops, storage, and materials are not housed at the theatre. They are kept at the theatre building of the Kent State University main campus and shipped to the space. This show had a lot of moving parts that were difficult for the actors to fully understand. To minimize the confusion around the functionality of the set, I decided to temporarily build the main structure, complete with doors, and allow the actors and choreographer to work with it, in the rehearsal space. In addition to the clarification for the performers, the temporary set allowed the carpenters to see all their work come together. We also tested the method of placing the upper structure on the lower portion of the set. This was vital as we learned that the best process was to use a chain hoist in place of a block-and-fall or a 1 to 1 pulley system.

Phase VI

Installation at Porthouse Theatre

The first step of the installation of the scenery at Porthouse was loading the truck at Kent State University main campus. The scene shop rented two 24'-0" box trucks. These are used to

ship the scenery, props, costumes, and electrics to Porthouse. Loading the trucks takes a lot of forethought. Each piece of scenery must get on to the truck, but the location and placement is important. For example, the large upper section steel frames were loaded in the front of the truck near the cab while the stage floor is loaded at the back. This allows the stage floor to be unloaded first because it is the first thing that is installed in the space.

The first show for Porthouse, unlike the other two, has one week of load in. This means that the carpenters, electricians, painters, and the props department has a full week to work on the set in the space without the encumbrance of rehearsals. While this time is invaluable to finish the details of a set, it also comes with its own problems. The main issue of a full week at Porthouse is that the location is far from the scene shop. For the carpentry crew to fully realize the scenic design, a scene shop with all its tools is needed. So, we bring a scene shop with us. Porthouse rents a trailer that houses the tools, materials, hardware, and soft masking that might be needed to complete the set or to take care of any performance notes. Additionally, there is a room that is a designated scene shop however, it is also prop storage for the run of the show.

The weather also affects the build and the production at the space. As I stated before the theatre is covered but the sides are open and exposed to the elements. One of the most difficult challenges to deal with is the wind. The stage floor is sunken into the ground and the seating rises on three sides to become level with the grounds of Porthouse. When the back doors to the theatre are open a particular wind pattern is created. The four center doors were my primary concern, as the wind would push the doors open or closed. To counteract this movement, paint brushes were screwed to the bottom of the doors and would brush against the stage floor creating friction and reducing movement by the wind but did not hinder the movement by the performers. Another weather challenge was the rain. The rain would come in and flow down the steps of the house and

pool in the moat of the stage. The moat prevented the rain water from reaching the stage floor and ruining the deck. While the roof was extremely useful, there were a few leaks. Luckily, for the set, the leaks were in the house and only impacted a small area. Another factor about the weather, that impacts the crew is the humidity. Heat can be dealt with by drinking water and staying in the shade. Humidity follows one around and can trick a person into believing that they are not dehydrated. The crew was instructed to drink water regularly throughout the day and were required to take a 15-minute break every 2 hours.

The final portion of the installation at Porthouse is the strike of the set after the production closes. There were no notes, other than the typical wear and tear of a musical, and so I will not speak on the run of the show. Strike is interesting at Porthouse. The entire set is thrown out, except for a few select pieces. The strike must take place in one night as the load in for the next show is the day following closing night. The only items saved from 9 to 5 were the black upstage masking and full sheets of Masonite that covered the deck. This is, in my opinion, an extravagant waste of materials and money. One solution to help counteract the waste, is to mandate standard door sizes. The 10 doors of the show that were designed did not fit the typical door size and so they had to be custom. Using doors from scenery stock would have saved the show about \$500.00. Additionally, the Masonite that covers the deck for the first show could be used for the third show. While the deck is sealed many times to protect it from the action on stage, the back is only painted once. If Porthouse was to use the back of the Masonite it would save \$832.00 a season.

CHAPTER 3

Assessment of *9 to 5*

Collaboration

During the pre-production process I made strides to keep the lines of communication and collaboration open. I believe that the more a person knows, the better they will be. It is vital for all the departments and performers to know as much as they can about the other areas and the production to create the best art they can. I have been on productions where the departments are segregated severely; I wouldn't let that happen at Porthouse if I could help it. For example, when I emailed the scenic designer, I would cc the shop foreman, the director, and any department heads that could be affected in any way.

Besides the scenic designer, I collaborated with the Master Electrician, Sophia Phillips, most often. The main focus of our conversations centered around the five large lightboxes (see Photo 8). These had lamps inside the unit and LED tape that wrapped around the exterior and was hidden by a lauau ring (see Photo 9). Without our discussions in the weeks leading to the building of these units, the install would not have gone as smoothly.

Personal Reflection

There are many factors to be taken into consideration while forming a thoughtful and honest personal assessment of my work on *9 to 5*. The first was that I was performing on a professional level and did not have the safety net of an educational production. Though, I earned course credit for the season, I was the full season Technical Director for the 49th Season of Porthouse Theatre. This meant that I was being paid as a professional and treated as one. This season was my first full-season professional TD position. The level of detail and planning had to

exceed any work that I would do in the academic setting of KSU. I had to be assertive and direct with issues that would normally be left to the academic advisor. My first real test with stepping further into professional theatre was my fee and position for the summer. I earned the full season position by expressing my willingness to do more, learn, and drive to move up the vertical management ladder to Steve Pauna, KSU School of Theatre and Dance Technical Director. Typically, Porthouse will split the shows between three technical directors or Pauna would act as the full season TD. He helped me to gain the position by supporting my request with the Artistic Directors and the Production Manager of Porthouse. With the position secured I had to look at the salary which would reflect my experience. The first offer that was presented was not enough to support the work and responsibility required. I had worked as a TD for one show at Porthouse the season prior and the offer that was presented was \$1500.00 more than I had earned before. I countered the offer by stating that I would be responsible for two more shows and that the initial offer was adequate for two shows of the season, not three. We negotiated to a fee that was supported by the budget of the theatre and reflected the skills and time required of the position. Two conditions of my employment, beyond the pay, was that Porthouse would pay for my admission to the Southeastern Theatre Conference (SETC) and allow me to interview prospective carpenters and painters and the other was that I would attend the First Aid/CPR/AED summer seminar.

I was engineering and working on three shows at once. The drafting for *9 to 5* was nearly finished by the time the crew arrived on the first day. While that show as being built, the second and third shows were in pre-production. This meant that three vastly different designs were bouncing around in my head. In the past, I had some practice at this. I have worked as an ATD-Draftsperson for another Summer Stock company and would engineer four shows at once. Without

three years of that type of work, the full season of Porthouse would have been extremely difficult and stressful. I believe that if a future graduate student of KSU wishes to be hired as the full season TD, they should have previous professional experience of working on multiple shows at once.

The final factor that influenced my performance was the knowledge that I was the first full season female technical director in Porthouse history. There is this feeling and understanding between women in the carpentry field that we must be better, that we are held to a different standard than our male counterparts. A memory kept returning to my mind from my first Summer Stock. I was the properties intern. There was a female ATD-Draftsman in the scene shop. I remember walking past a few of the carpenters, both men and women, and they were talking about how underqualified the ATD was. One of the women commented how it only takes one bad female carpenter to bring doubt upon the whole sex in that position. That's the thought that was constantly in my head and what pushed me to be better than I had been before and to create the best season as possible. In my professional experiences I have seen a poor season with a female TD place doubt on future women in that position. Overall, I think I fine-tuned my diplomatic assertiveness and my skills dealing with mistakes that are repeated by the carpentry crew.

Doorway A and C Structural Analysis

2x4 Number 2 Southern Pine

A	5.25in ²	F _b	1.5	F _b	1050 psi	BUS	0.75
S_{x-x}	3.063in ³	F _t	1.5	F _t	650 psi	Dead Load	317 lbs. (53 ftlb UDL)
I_{x-x}	5.359in ⁴	F _c	1.15	F _v	175 psi	A (1.5x2.75)	4.125in ²
S_{y-y}	1.313in ³	C _D	1.15	F _{c⊥}	565 psi		
I_{y-y}	0.984in ⁴	E	1.4 x 10 ⁶	F _c	1100 psi		

Built up structure (The Header):

$$\text{Moment of Inertia}^1 \rightarrow I = \frac{bd^3}{12} = \frac{1.5in \times 2.75in^3}{12} = 2.599in^4$$

$$\text{Elastic Section Modulus}^2 \rightarrow S = \frac{bd^2}{6} = \frac{1.5in \times 2.75in^2}{6} = 1.8906in^3$$

$$\text{Plastic Section Modulus}^3 \rightarrow Z = \frac{bd^2}{4} = \frac{1.5in \times 2.75in^2}{4} = 2.835in^3$$

$$\text{Extreme Fiber Distance}^4 \rightarrow c = \frac{d}{2} = 1.375in$$

$$\text{Radius of Gyration}^5 \rightarrow r = \frac{d}{\sqrt{12}} = 0.289d(2.75in) = 0.794in$$

Weight of the beam:

$$w_t = 2 \left(\frac{1.276 plf}{12 in/ft} \right) = 0.212 pli$$

Bending Test:

Find c_{x-x} :

$$d_{NA} = \frac{1.375in(4.125in^2) + 0.75in(5.25in^2)}{4.125in^2 + 5.25in^2} = 1.0249in \rightarrow c_{x-x} = 4.25 - 1.0249 = 3.225in$$

Find I_{tot} :

¹ Quantifies a beam's resistance to deflection

² Predicts the capacity of a beam to resist bending forces

³ Predicts the capacity of a beam to resist permanent deformation

⁴ Perpendicular distance from the neutral axis (center) to the furthest point

⁵ Quantifies the resistance of a beam to buckling

$$I_A = I_{X-X} + A_A Z_A^2 = 0.984in^4 + 5.25in^2(3.5 - 1.024)^2 = 33.168 in^4$$

$$I_B = I_{Y-Y} + A_B Z_B^2 = 2.599in^4 + 4.125in^2(3.225 - 1.375)^2 = 16.716in^4$$

$$I_{tot} = I_A + I_B = 49.88in^4$$

Find S_{x-x} :

$$\frac{I_{tot}}{c_{x-x}} = \frac{49.88in^4}{3.225 in} = 15.46 in^3$$

Find M_{all} (Flexure Formula):

$$S_{x-x} F'_b = 15.46in^3(905.6 psi) = 14000.576 inlbs$$

Find w_{all} (Maximum Allowable Load):

$$\frac{8M_{all}}{l^2} = \frac{8(14000.576inlbs)}{[6(12in/ft)]^2} = 21.605 pli$$

Find the working load:

$$21.605 pli - 0.212 pli = 21.393 pli = \mathbf{256.71 plf}$$

Shear Test:

Find F'_v (Adjusted Horizontal Design Value):

$$F'_v = C_D(BUS)F_V = 1.15(0.75)175psi = \mathbf{150.93 psi}$$

Find Q (Statical Moment above or below the Sheer Plane):

$$Q = d_{TOP} A_{TOP} = \left(\frac{3.225in}{2} \right) 3.225in(1.5in) = \mathbf{7.8004in^3}$$

Find V_{all} (Maximum Allowable Horizontal Sheer Stress):

$$V_{all} = \frac{F'_v I b}{Q} = \frac{150.93psi(49.88in^4)(1.5in)}{7.8004in^3} = \mathbf{1447.69 lbs}$$

Find w_{all} (Maximum Allowable Load for Sheer):

$$w_{all} = \frac{2V_{all}}{l} = \frac{2(1447.69lbs)}{72in} = 40.213pli = \mathbf{482.56 plf}$$

Find the Working Load:

$$w_{all} = 40.213pli - 0.212pli = 40pli = \mathbf{490 plf}$$

Deflection Test:

Find Δ_{all} (Maximum Allowable Deflection):

$$\Delta_{all} = \frac{l}{240} = \frac{6ft \left(\frac{12in}{ft} \right)}{240} = \mathbf{0.3in}$$

Find w_{all} (Maximum Allowable Load):

$$w_{all} = \frac{384EI\Delta_{all}}{5l^4} = \frac{384(1.4 \times 10^6)(49.88in^4)0.3in}{5(72in)^4} = \mathbf{59.86pli}$$

Find the Working Load:

$$59.86pli - 0.212pli = \mathbf{715.89plf}$$

Allowable Limits:

Bending	14007lbs	> 317 lbs.	Structurally Sound
Sheer	1448 lbs./in	> 317 lbs.	Structurally Sound
Deflection	715 lbs./ft.	> 317 lbs.	Structurally Sound

Columns (Vertical Door Framing, 2x4):

Euler's Equation (Ultimate Failure Load due to first mode of Buckling):

$$P_{cr} = \frac{n^2\pi^2EI}{l^2} = \frac{1^2\pi^2(1.4 \times 10^6)(0.984in^4)}{113in^2} = \mathbf{1064.79 lbs}$$

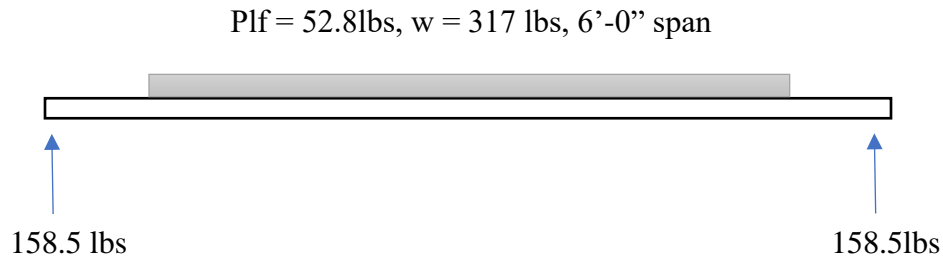
Find r (Radius of Gyration):

$$r = \sqrt{\frac{I}{A}} = \sqrt{\frac{0.984in^4}{5.25in^2}} = \mathbf{0.4329}$$

Find F_{cr} (Maximum Allowable Compressive Stress):

$$F_{cr} = \frac{\pi^2 E r^2}{l^2} = \frac{\pi^2 (1.4 \times 10^6) (0.4329^2)}{113 \text{ in}^2} = \mathbf{202.78 \text{ psi}}$$

Free Body Diagram:



Allowable Limits:

Buckling **203lbs** **> 159 lbs.** **Structurally Sound**

Columns (Vertical Door Framing, Plywood):

23/32 BC Ext Plywood. Group 1

E	1.8x10 ⁶	A	4.5in ²
I	0.197in ⁴ /ft	Dead Load	159 lbs.

Euler's Equation (Ultimate Failure Load due to first mode of Buckling):

$$P_{cr} = \frac{n^2 \pi^2 E I}{l^2} = \frac{1^2 \pi^2 (1.8 \times 10^6) (0.197 \text{ in}^4)}{113 \text{ in}^2} = \mathbf{274.08 \text{ lbs}}$$

Find r (Radius of Gyration):

$$r = \sqrt{\frac{I}{A}} = \sqrt{\frac{0.195 \text{ in}^4}{4.5 \text{ in}^2}} = \mathbf{0.208}$$

Find F_{cr} (Maximum Allowable Compressive Stress):

$$F_{cr} = \frac{\pi^2 E r^2}{l^2} = \frac{\pi^2 (1.8 \times 10^6) (0.208^2)}{113 \text{ in}^2} = \mathbf{60.19 \text{ psi}}$$

Allowable Limits:

Buckling **274lbs** **> 159 lbs.** **Structurally Sound**

Material Pricing and Vendors

Porthouse Theatre 2017

Company Name	Item	Size	Pricing each	Weight
Arlo Steel Corporation	1-1/2 sq x 16 Ga wall tubing ASTM A-513	24'-0"	\$60.81	30 lbs
	2 sq x (.83) 14 ga tubing ASTM A-500 Grade B	24'-0"	\$68.90	52 lbs
	2-1/2 Sq x 12 ga wall tubing ASTM A-513	24'-0"	\$99.63	85 lbs
	3 x 1 x 16 ga wall tubing ASTM A-513	24'-0"	\$69.55	41 lbs
	2 x 1 x 14 ga Wall tubing ASTM A-513	24'-0"	\$69.40	38 lbs
	1 sq x 16 ga Wall tubing ASTM A-513	24'-0"	\$72.50	20 lbs
	2 X 2 X 1/4 A-36 ANGLE	20'-0"	\$52.50	64 lbs
	1/4" x 5" A-36 HR Steel	20'-0"	\$53.90	85 lbs
	1/8" x 3" HR Strip CQ	20'-0"	\$19.31	
	1/8" x 4" HR Strip CQ	20'-0"	\$25.18	34 lbs
	1/4 X 2 A-36 HR STEEL	20'-0"	\$56.81	34 lbs
Carter Lumber	CDX Plywood	48" x 96"	\$24.59	
	3/4" Plywood BC Ext YP Sanded	48" x 96"	\$33.09	
	1/4 Masonite	48" x 96"	\$16.99	
	Sureply Lauan	48" x 96"	\$24.59	
	3/4" MDF	48" x 96"	\$38.00	
	1x4 No2 Pine	12'-0"	\$5.79	
	2 x 4 No 2 Pine	12'-0"	\$4.59	
	2 x 8 No 2 Pine	12'-0"	\$10.59	
	1 5/8" #6 Drywall Screws	25 lbs	\$50.19	
	2" #7 Drywall Screws	25 lbs	\$50.19	
McMaster Carr	3" #8 Drywall Screws	5 lbs	\$13.69	
	Cut to Size Lift Off Panel Hanging Brackets 1201A38	72" x 1 7/8"	\$14.04	
	Oval Head Drilling Screws for Metal	100/pack 1.25"	\$8.40	
	Soapstone	Sq 5"x.5x.5	\$58.04	
	Disposable Latex Gloves, L, M, XL	100/pack	\$57.54	
	Push-to-Hold Wall-Mount Door Holder		\$27.67	
	Strap hanger		\$15.31	
	Chalk, Dustless Board White	12/pack	\$4.24	
	Carbide Tip Panel Pilot Router Bit for Wood		\$14.32	
	Roller-Arm Storm Door and Gate Closer		\$14.85	150 lb capacity
Grainger	Ready-to-Use Mop Head with Handle	24oz	\$10.64	
	Magnetic Latch		\$4.64	22lbs max pull
	Right Hand Pivot Hinge with Holes, 40JK93		\$32.85	25lb load limit

Hartville Hardware	2x4x10		\$4.37
	3/8" Bending Luan 4x8		\$47.99
	3/4" CDX Plywood	48"x96"	\$23.88
	1/2" BC Yellow Pine Plywood	48"x96"	\$22.75
	1x4x8 Foam R-10 25 PSI	48"x96"	\$18.61
	2x4x8 Foam R-10 25 PSI	48"x96"	\$33.32
	1x4x12 White Pine #2	12'	\$5.36
E & T Plastics	Twin Wall Polycarbonate Sheet Clear General Purpose	48" x 96"	\$67.5
Lowes	2x4 No 2 Pine	10'-0"	\$3.97
	23/32 Plywood	48x96	\$23.78
	23/32 BC Plywood	48x96	\$27.88
	Lenox 6" Sawzall Blade Pack	6"	\$13.98
	2x10x12 Top Choice #2 SYP	Pine	\$14.3
	Lenox 8" Sawzall Blade Pack	8"	\$13.58
	Gallon Elmer's Glue-All White	Gallon	\$14.98
	Irwin 1/2" Trim bit x 1/2" H	1/2" blade	\$19.98
	NYW 48"x25' Brite Aluminum Screen		\$27.98
	24 Pack Red Shop Towels		\$5.98
	Painter's Terry Cloth 12 pack		\$7.38
	128 fl oz Simple Green LE		\$9.98
	3M safe Release Tape Pack		\$31.98
	25 lb 1 1/4" CRS Drywall Screws	25lbs	\$39.96
	Dewalt 4.5" Angle Grinder		\$59
	Dewalt 4.5" T29 80 Grit Flap Disk		\$8.98
	Solid Braid Poly Rope 1/2"x75'		\$20.98
	Bolt Snap with Key Ring, 5/8"x3.75"		\$2.48
	Stanley 1/4"x4" eye bolt		\$0.52
	Irwin 1/4"x3/4" socket adapter		\$3.98
Sherwin Williams	5 Gallon A86W1151 SPR Int Fl extra	5 gallons	\$13.46
	5 Gallon B30B4600 PM 400 0 FL Black	5 gallons	\$12.38
	Gallon A6W151 A100 Ex FL Extra	1 Gallon	\$39.47
	Gallon A6W151 A100 Ex FL Extra	1 Gallon	\$39.47
	Gallon A6W151 A100 Ex FL Extra	1 Gallon	\$39.47
Rose Brand	Paint Artists Choice Gallon Silver #7725	1 Gallon	\$98
Home Depot	Minwax Polycrylic Satin Gallon	1 gallon	\$47.96
	Minwax Polycrylic Gloss Gallon	1 Gallon	\$47.96
	2" Utility Brush, Flat Basic Brush	2"	\$2.97
	1.88" Scotch blue Tape		\$6.25
	Specialty Metallic Gold Spray Paint		\$3.76

	Stops Rust Satin Black Spray Paint		\$3.76	
	Minwax Polycrylic Gloss 12oz	12 oz	\$8.68	
	Minwax Polycrylic Sat 12oz	12 oz	\$8.68	
	Stops Rust Satin White Spray Paint		\$3.76	
	Goo Gone Spray Gel	12 oz	\$4.46	
	1" Black Pipe	10'-0"	\$19.76	
Amazon	Saint-Gobain ADFORS BRIGHT ALUMINUM SCREEN	36"x100'	\$75.2	
	Bead Smith Super-Lon Cord, Size 18 Twisted Nylon	77 yd	\$4.51	Black
	Yeuton Pendants-teardrop Chandelier Crystal Pendants	12/pack	\$9.99	Clear
Vincent Lighting	Rosco OB Yellow Ochre Gallon	1 Gallon	\$34.1	
	Rosco OB Orange Gallon	1 Gallon	\$46.95	
	Rosco OB Burnt Umber Gallon	1 Gallon	\$37.1	

Photo 1



Production Photo

Technical Rehearsal

Porthouse Theatre 2017, Cuyahoga Falls, Ohio

9 to 5

Photo 2



Production Photo

Flying Effect

Porthouse Theatre 2017, Cuyahoga Falls, Ohio

9 to 5

Photo 3



Preshow

Production Photo

Porthouse Theatre 2017, Cuyahoga Falls, Ohio

9 to 5

Photo 4

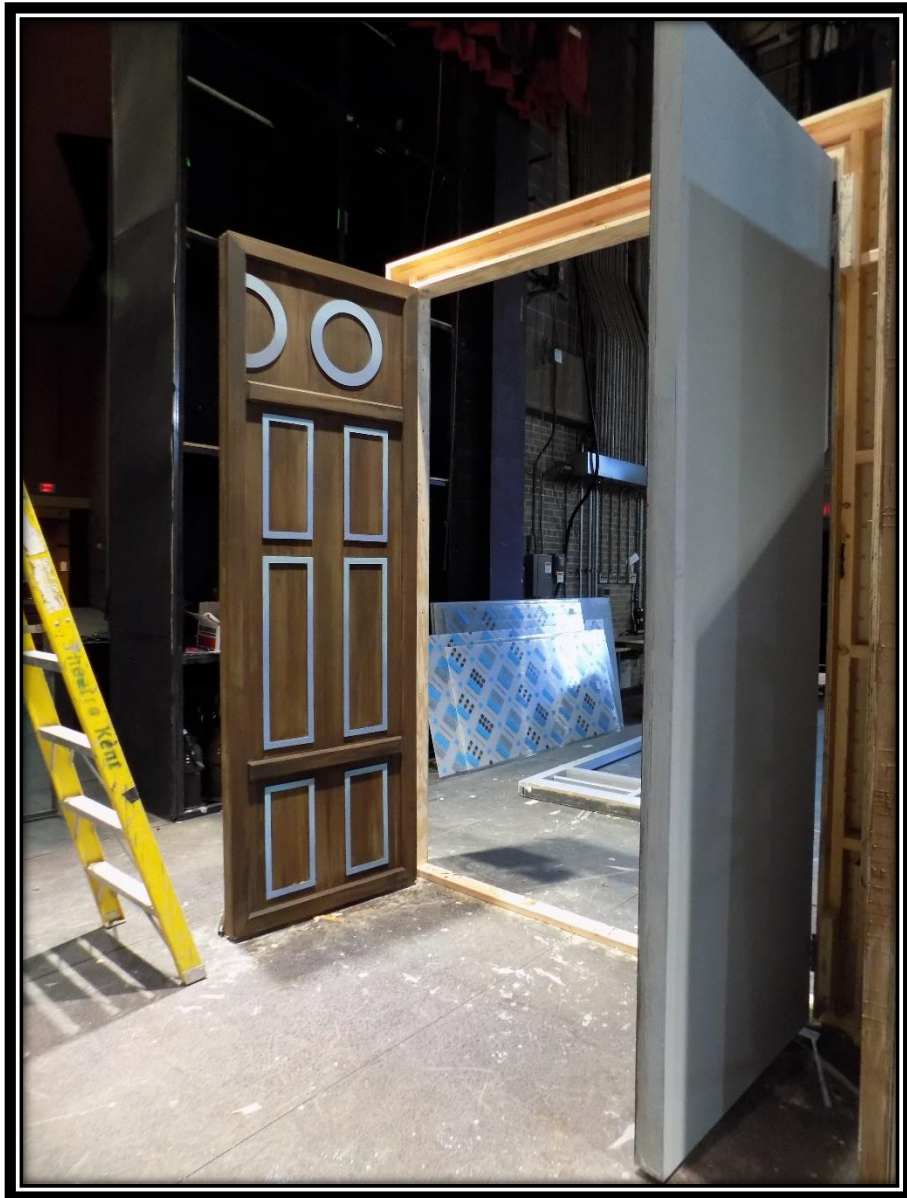


Left Hand Pivot Hinge, Surface Mount with an Aluminum Finish

Porthouse Theatre 2017, Cuyahoga Falls, Ohio

9 to 5

Photo 6



French Doors

3'-0" w x 8'-11" h x 2" d

Process Photo

Porthouse Theatre 2017, Cuyahoga Falls, Ohio

9 to 5

Photo 7



Production Photo

Porthouse Theatre 2017, Cuyahoga Falls, Ohio

9 to 5

Photo 8



Production Photo

Porthouse Theatre 2017, Cuyahoga Falls, Ohio

9 to 5

Photo 9



Production Photo

Porthouse Theatre 2017, Cuyahoga Falls, Ohio

9 to 5

Selected Porthouse Load-In Photos



Selected Porthouse Load-In Photos



Media List

1. Porthouse *9 to 5* Crew Photos

<https://www.youtube.com/watch?v=mQdHrNNXexY>

2. Porthouse *9 to 5* Technical Drafting Timelapse 1 of 4

<https://www.youtube.com/watch?v=ApWWub7te1E&t=2s>

3. Porthouse *9 to 5* Technical Drafting Timelapse 2 of 4

https://www.youtube.com/watch?v=x0lgMAuOg_4&t=2s

4. Porthouse *9 to 5* Technical Drafting Timelapse 3 of 4

<https://www.youtube.com/watch?v=qEf4BLdA3P8>

5. Porthouse *9 to 5* Technical Drafting Timelapse 4 of 4

<https://www.youtube.com/watch?v=pXlwPYiGHYU>

6. Porthouse *9 to 5* Scene by Scene

Contact for a copy

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