Lights up

A little arithmetic can illuminate your artistic vision

BY JESSICA GREENBERG

Theatre teachers are often expected to have fluency in all aspects of putting on a show: casting, directing, and rehearsing, as well as sound design, scenery, costuming, and lights. It's a tall order, so professional lighting designer Jessica Greenberg breaks down the fundamental technical aspects of lighting design by offering some simple mathematical strategies that can improve your illumination.

Lighting designers have a lot of decisions to make, based on the effects they want and the specific lights they have on hand. Any good lighting designer should also know how to calculate the amount of light a specific instrument provides. Knowing the size of the pool of light cast is important not only to gauge how an instrument works in isolation but also to determine how many lights you need to cover the stage without any gaps or dark spots.

Here's the little mathematical formula that will simplify your life: T × MF = D.

This formula determines the size of the pool of light by the time it hits your actor onstage. Throw distance (T) is the distance from the instrument to the lighting area. The multiplying factor (MF) is a ratio provided by the manufacturer. The diameter (D) is the resulting width of the pool of light.

But let's begin by talking through an example from the lighting design for *Phantasmagoria*, by Chana Porter, which premiered last year at New York's La MaMa Experimental Theatre Club. The lighting grid in the Ellen Stewart Theatre is 24 feet high. Say I want a pool of light coming from directly above that is roughly 8 feet wide at head height for the actor onstage. Given these parameters, what is the best light in my inventory to help achieve this?

First, I need to know what the throw distance is between the light and the actor's head. For simplicity's sake, let's say our sample actor is 6 feet tall. I can quickly subtract the actor's height (6 feet) from the grid's height (24 feet) and know that I'll have about 18 feet of throw distance between where the lighting instrument will hang in the grid and the actor being lit (Figure 1, next page).

Next, let's take a look at the inventory. Say I have a selection of Source Four ellipsoidal lighting instruments of various sizes. I've taken a look at the manufacturer data sheets and gathered the multiplying factors for each one: Source Four 50° MF = 0.93; Source Four 36° MF = 0.61; Source Four 26°

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From left, Equiano and Demetrius Stewart shine in the La MaMa Experimental Theatre Club's production of *Phantasmagoria*, designed by Jessica Greenberg.


26°
PRIMA MATERIA

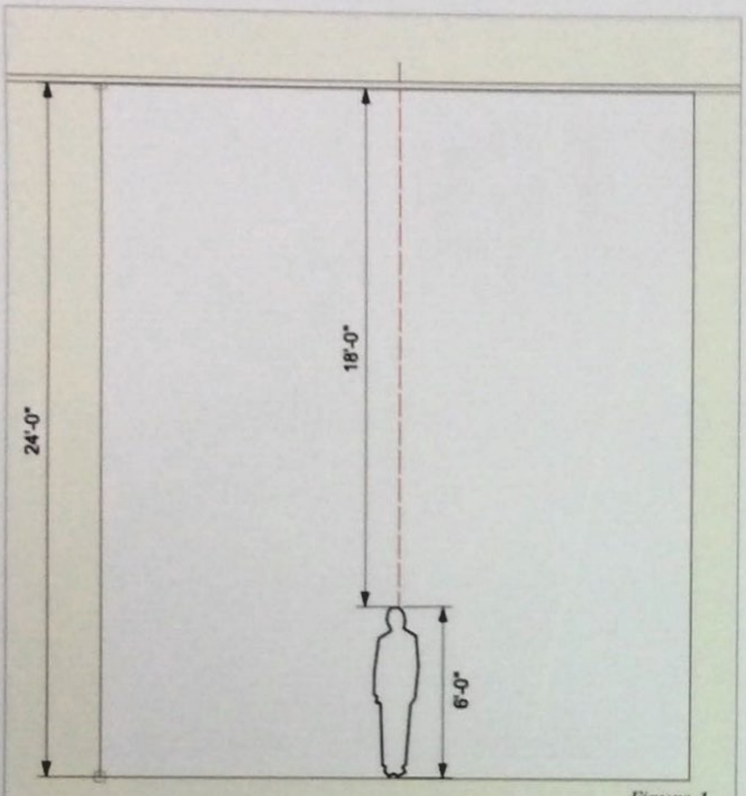

Figure 1

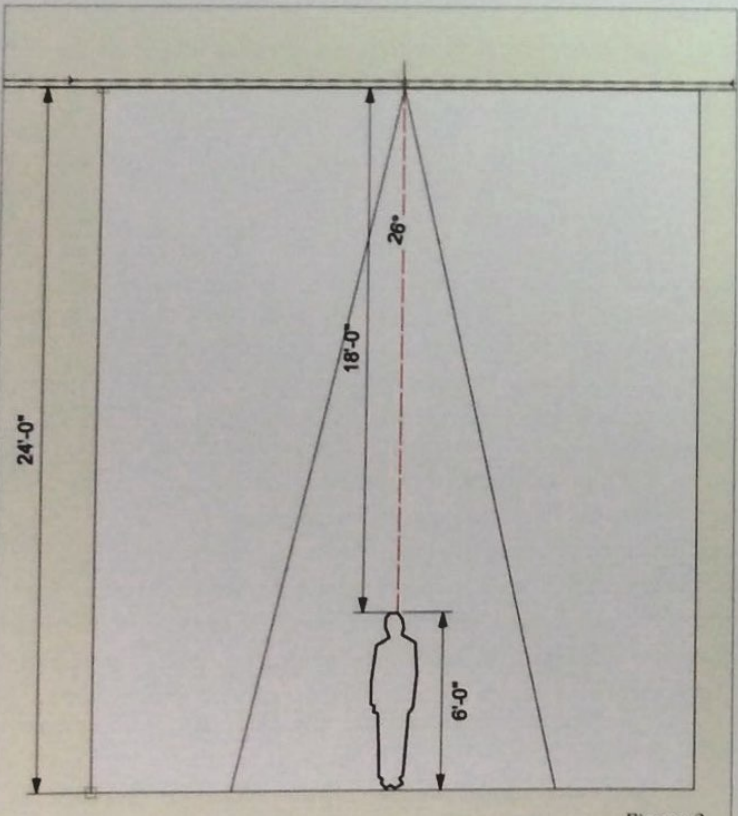

Figure 2

MF = 0.45; and Source Four 19° MF = 0.32. Let's see which one of these lights will be the best choice for this job.

What size pool of light would a Source Four 50° provide? Using T × MF = D, we get 18 feet × 0.93 = 16.74 feet. That is a bit too large. How about the Source Four 36°? Using T × MF = D, we get 18 feet × 0.61 = 10.98 feet. That's closer but

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still a little too much. Let's take a look at the Source Four 26°. Using T × MF = D, we get 18 feet × 0.45 = 8.1 feet.

Perfect. I now know that I can hang a Source Four 26° directly above my actor, and it will provide the field of light that I want to achieve (Figure 2).

D / T = MF

You can also accomplish this task by using this variation: D / T = MF. If you know the desired diameter of the pool of light and where you'd like to hang the instrument, divide the diameter by the throw distance to get your ideal MF. Compare this number with the multiplying factors of the lights in your inventory and choose the one that comes closest to meeting your needs.

If you need to know how far away to hang a light from an actor — often the case when determining how high to place onstage electrics positions — the formula can be altered to determine the distance the instrument should hang from the actor's head in a given area.

D / MF = T

Using D / MF = T, designers can calculate:

1. which lighting instrument to use;
2. where to hang the lighting instrument; and
3. the correct size of pool of light onstage.

Eliminating guesswork will save time and make for a better result onstage.

Pythagorean theorem

As we've learned, if we know the height of the lighting grid, then we can learn the throw distance of a down light. With front light, back light, or side light, one way to figure the throw distance is using the trusty Pythagorean theorem. In any right-angle triangle, the sum of the squares of the lengths of the triangle's legs is equal to the square of the length of the triangle's hypotenuse (or the triangle's longest side). This theorem is represented by the formula: $A^2 + B^2 = C^2$.

Using the vertical distance between the actor and the lighting grid and the horizontal distance between the actor and the hanging position of the light, we can use the Pythagorean theorem to get the throw distance of a side light (Figure 3). The throw distance of the side light is equal to the square root of 724 (or 26 feet and 10 3/4 inches): $18^2 + 20^2 = 724$.

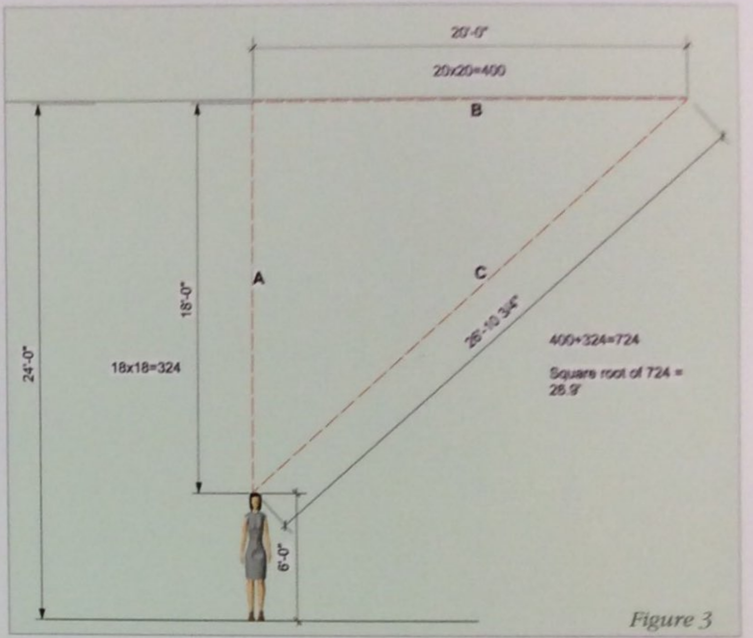

Figure 3

Systems of light

Now that you understand how to calculate the appearance of one light onstage, let's create a full system of lights that will properly cover the entire stage space.

Start with a scale ground plan of your scenic design. If that's not available, know the dimensions of your stage space. The first step is to look at your stage space or ground plan and identify how much of it the actors will be using. We will break down the stage space into individual acting areas, each of which will be assigned its own light.

If we continue with the example from *Phantasmagoria*, let's say I would like to have a system of down lights that, working together, can cover the entire stage space. Try not to think of an acting area as a two-dimensional circle on the floor. Instead, think of it as a three-dimensional cylindrical space in which your actor will move (Figures 4 and 5).

One choice we have to make is how large or small we'd like our individual pools of light to be. As a general guideline, I recommend a range of 8 to 12 feet. Our goal is to make sure that wherever our actor roams, he will be covered evenly in this lighting system. To accomplish this, our pools of light must overlap (Figure 6).

In this example, I have nine areas, each 8 feet in diameter. If I apply what I learned in my earlier calculations, I know I can accomplish a nice, even system of light with nine Source Four 26° lights. With a down light system, I know that these lights will be best hung directly above the center of each acting area, and I can look at my lighting grid positions and choose the best placements. Without too much effort, I can determine how many lights I'll need and exactly where they need to be hung to do what I need. I'll have no surprises when I get into the theatre.

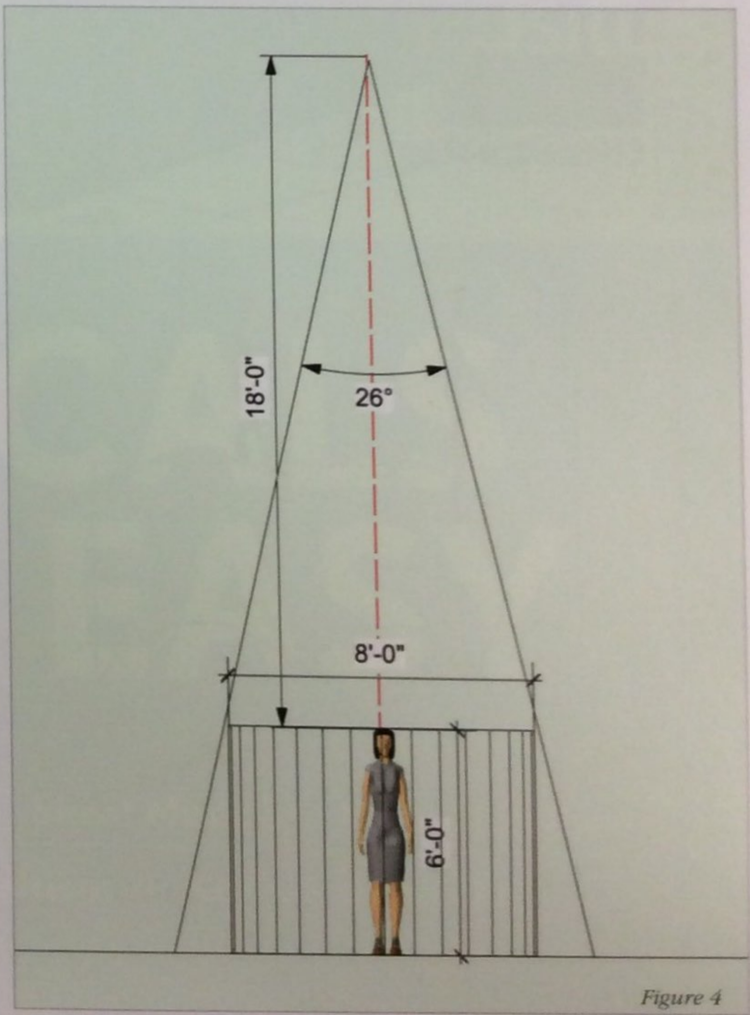

Figure 4

Field angles for Fresnels and PARs

Ellipsoidal instruments like Source Fours produce a sharp, round beam of light. They each have a single, fixed field angle and multiplying factor. Other types of instruments, like the Fresnel and the PAR, have different qualities of light and more than one field angle and multiplying factor.

Light comes out of theatrical lighting instruments in a conical shape, which means that the beam of light is smaller when it is closer to the instrument and larger when it is farther away from the instrument. The angle of that beam of light is called the "field angle." All theatrical lighting instruments will have a known field angle, sometimes labeled on the body of the instrument.

A Fresnel produces a round pool of light with a soft edge that can be adjusted in size. The different Fresnels are named by the diameter of their lens, which typically range from 3 to 6 inches up to 12 inches and higher. If you take a look at a manufacturer's data sheet for each one, you'll often see two possible field angles: a "spot" field angle (the smallest) and a "flood" field angle (the largest).

For example, the Source Four version of a 6-inch Fresnel has a wide range of field angles, fully adjustable anywhere between 20 (with a 0.42 MF) and 65 (with a 1.262 MF) degrees. This will give you a lot of options when focusing the light, but the MF calculations we learned earlier work the same way. If we hang a 6-inch Fresnel instead of a Source Four 26° in that same position for my sample actor, I could calculate the following options.

For a 6-inch Fresnel spot focus, the formula T × MF = D yields 18 feet × 0.42 = 7.56 feet. For a 6-inch Fresnel flood focus, the formula T × MF = D yields 18 feet × 1.26 = 22.68 feet.

A PAR (parabolic aluminized reflector) produces a pool of light with a soft edge. Some PARs are round, but others are oval. When the light is oval, you need to calculate the size of the length of the light as well as the width. PAR sizing comes in two forms: One is the diameter of the lens, and the other is the actual spread of the lens. The lens diameter is measured in 1/8 of an inch, ranging from PAR 16 (2 inches wide) to PAR 64 (8 inches wide).

In each PAR size, we can choose the spread of the lens as well. The most common are wide flood, medium flood, narrow spot, and very narrow spot. Let's say we hang a wide flood lens 18 feet above an actor and see what size light it would produce.

The field angles for a Source Four PAR wide-flood lens are 37 degrees vertical, with a 0.66 MF, and 51 degrees horizontal, with a 0.95 MF. For a wide-flood lens vertical size, the formula T × MF = D yields 18 feet × 0.66 = 11.88 feet. For a wide-flood lens horizontal size, the formula T × MF = D yields 18 feet × 0.95 = 17.1 feet. At an 18-foot throw distance, I would have an oval that is 11.88 feet tall and 17.1 feet wide.

Using these formulas and knowing where your lights will be focused at the beginning of the production process can simplify some of the more technical aspects of lighting design and help you more easily create beautiful, dramatic moments onstage. ■

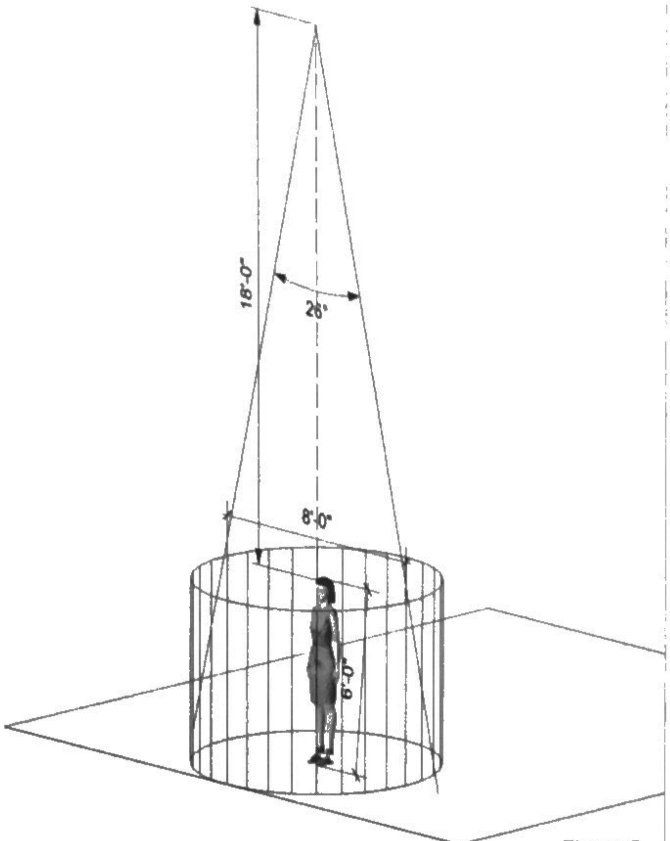

Figure 5

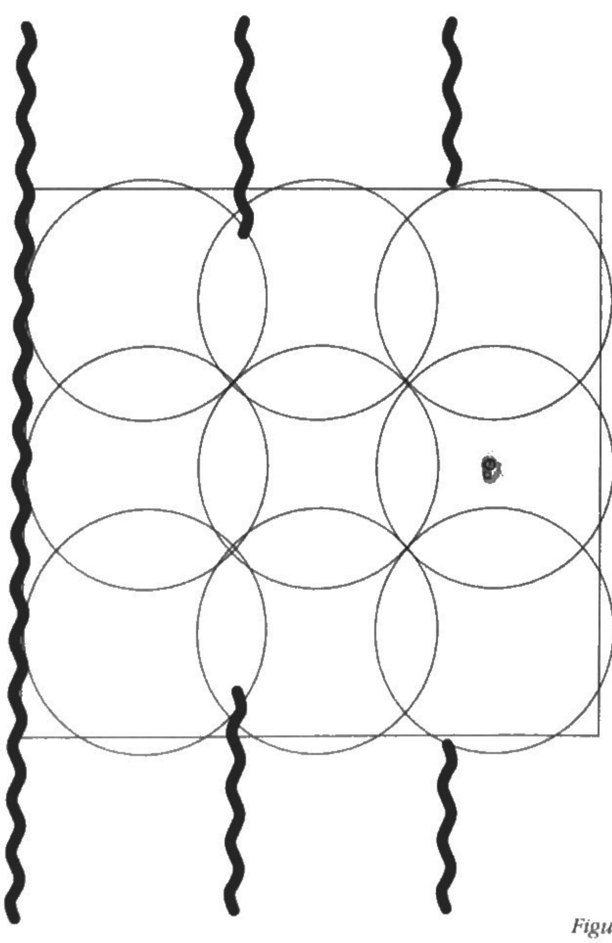
Figure 6

Recommended resources for further information

www.stagelightingprimer.com
www.etcconnect.com
Smartphone apps: Light Calc or Show Tool LD