Tiny Spaceships

Learning Objective

Students will learn about and apply the concepts of dilation, scale factor, and forced perspective using miniatures. They will apply it on their own by making a miniature and photographing it.

Common Core Connections

- CCSS.MATH.CONTENT.7.RP. A.1-3 Recognize and represent proportional relationships between quantities.
- CCSS.MATH. CONTENT.7. G.A.1 Solve problems involving scale drawings of geometric figures.
- VA: Cr1.2.7 - Cr2.3.7 Demonstrate persistence in developing skills with various materials, methods, and approaches in creating works of art or design.
- VA: Pr4.1.7 Compare and contrast how technologies have changed the way artwork is preserved, presented, and experienced.

Key terms

Term	Definition
Practical effects	Filmmaking visual effects created using three-dimensional models or figures. Practical effects are recorded directly by a camera rather than created digitally by CGI (computer-generated imagery).
Miniature	Models used to represent things that are too expensive or difficult to film in reality.
Scale	The relationship or ratio between the measurements of an object and a model of the object.
Similarity	Figures having the same shape; having corresponding sides proportional and corresponding angles equal.
Dilation	A transformation that produces an image that is the same shape as the original but is a different size.
Proportional	Corresponding in size or shape to something else.
Forced Perspective	A technique which employs optical illusion to make an object appear farther away, closer, larger, or smaller than it actually is.
Composition	The placement or arrangement of visual elements in a picture.

Materials You Will Need

A ruler or measuring tape, compass, calculator, pencil, paper, camera, paper, scissors or x-acto knife, and colored pencils, paint, or markers.

Introduction

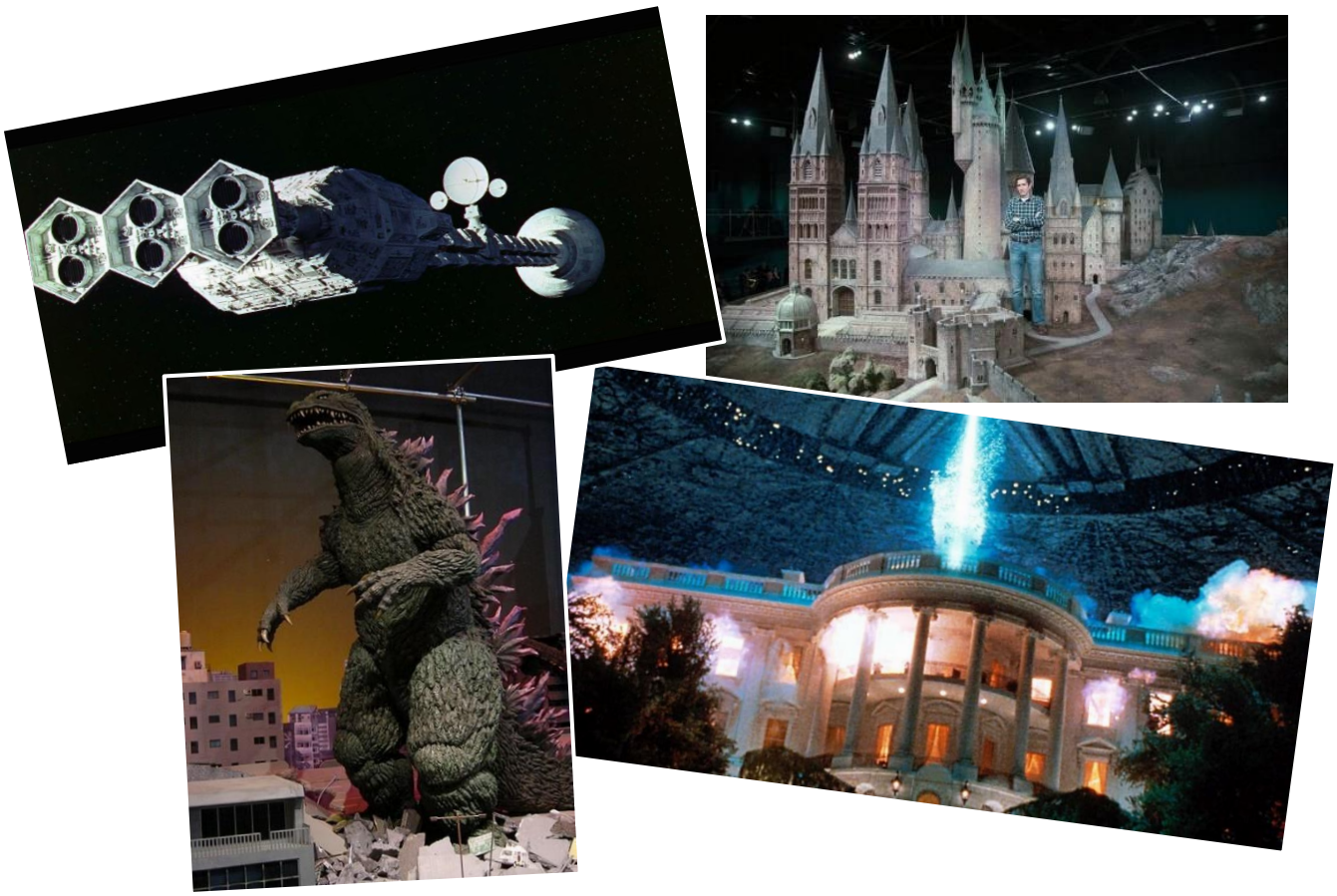
Have you ever watched a movie with special effects and wondered “how did they do that?!” There are many ways filmmakers make movie magic. Today we will explore a few of those methods!

In this activity you will:

- Learn about two **practical effect** techniques used in filmmaking, **miniatures** and **forced perspective**.
- Practice calculating scale
- Apply what you have learned by creating a miniature spaceship overlaid with life sized elements to create a forced perspective photograph!

What is a practical effect?

A practical effect is a special effect produced physically without CGI (computer-generated imagery) or post-production techniques (editing of visual and audio content after filming has been completed). Many of our favorite movie effects are produced this way! Spaceships, explosions, monsters, and castles are brought to you through the magic of the two key practical techniques you will be learning about today: **miniatures** and **forced perspective**.



How does it work?

Filmmakers apply these methods in many ways. Using small things in place of big things is a classic movie magic trick. Miniatures often stand-in for props that would be too expensive and difficult to make full-size. The starship Enterprise from the *Star Trek* series is an example of this. Obviously, filmmakers couldn't build a full-size spaceship, rather they used miniatures.

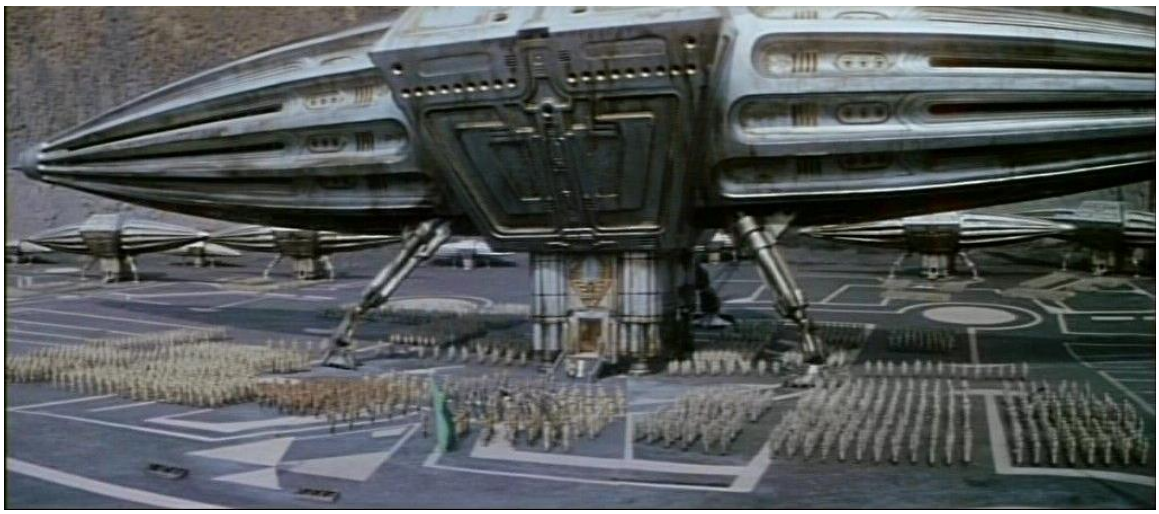
Filmmakers often face the problem of how to make small things look big. *The Lord of the Rings* films were innovative for their extensive use of forced perspective techniques to conquer this problem. The filmmakers built clever sets that altered the distance of the actors while in the same shot. By carefully manipulating the distance of objects and actors to the camera, our eyes are fooled into thinking that it is the sizes of things not the distance that is different. In the example below we can see this in action.

Put It Together

When used together, miniatures and forced perspective can bring the incredible to life! One example of these two techniques used together is from the 1984 film *Dune*. Miniature maker Emilio Ruiz del Rio overlapped a real-life set in the background with miniatures in the foreground. By carefully arranging the two sets he was able to make it look like the actors were walking out of a huge spaceship which was in fact a miniature with a hole cut into it! He achieved this by placing the miniature close to the camera with the actors on a life size set far in the background.

Real-life set

Miniature set



End result

Now that you know the basics of how these techniques are used, it's time to dive into learning more about miniatures and forced perspective!

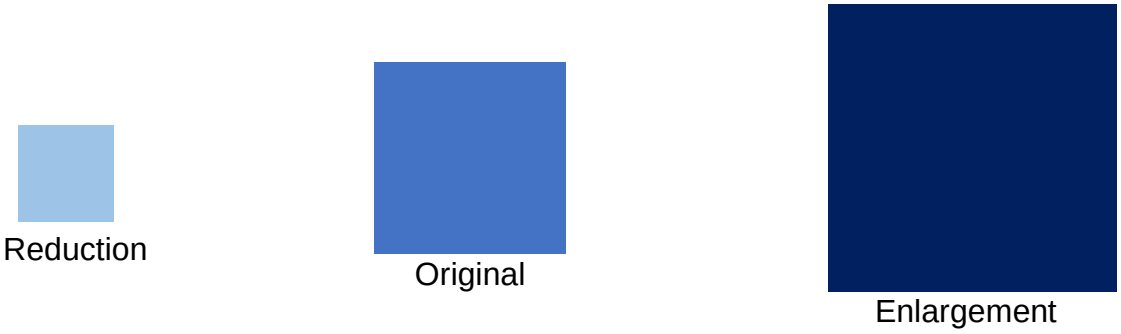
Section I - Miniatures

Miniature effects work because they fool our brains into thinking that we must be looking at a real thing and not a miniature. It requires a little bit of math; a poorly planned miniature won't accurately depict the creator's vision to the audience. If the math is off, the miniature can look too big or small or even be spotted as obviously small, like this plane below from *Goldeneye*. Let's learn how to do it right through **proportion**, **dilation**, and **scale.**

Miniature Math – How to Scale Objects

Proportion - Miniatures should be **proportional** to the original object. Meaning that the angles and basic shape of the objects are the same. Proportionality can also refer to the relation of the object and the rest of the scene.

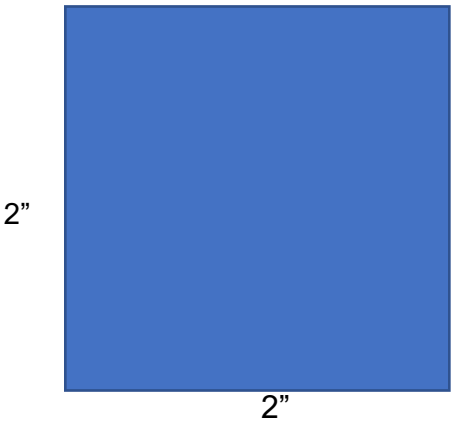
Dilation - Successful miniatures require careful planning to keep the relative length, width, height, and angles of each of the original object when you change their size. Transforming or changing the size of an object while keeping the proportions the same is called **dilation**. Making an object bigger is called an enlargement and making is smaller is called a reduction.



Scale Factor – This is a more precise way of talking about dilation. **Scale** is how much larger or smaller an object is compared to the original. You can measure the change in scale with something called a **scale factor**, this is the numerical description of how big or small the object is compared to the original.

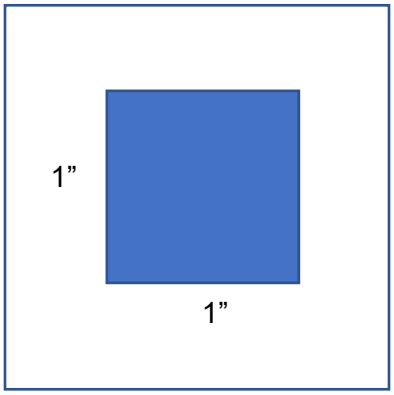
Application

Now it's time for you to practice what you've learned. First, we need to find our starting measurements and then **scale** the dimensions by a consistent number so that it will be proportional. For example, this square is 2 inches tall and 2 inches wide. To make a new square with a **scale factor** of 1/2 we would multiply each measurement by 1/2.



Height - 2” x 1/2 = 1”

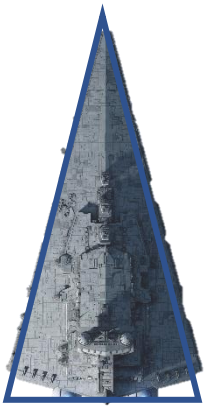
Length - 2” x 1/2 = 1”



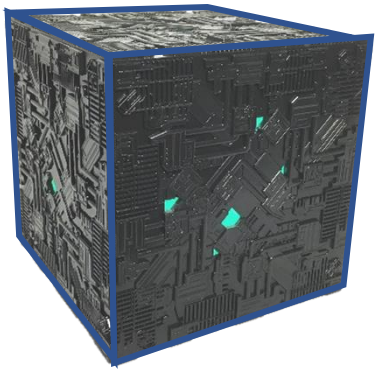
We now have a square that has a scale factor of 1/2 or is half the size of the original!

On Your Own

Practice on your own with these spaceships from pop culture. First multiply the dimensions by the scale factor. Then draw the object at scale size and write the new measurements. Check your answers on page 17.



Scale Factor: ½	Scaled Drawing	New Measurements
Height: 2”		Height: _____
Length: 1”		Length: _____



Scale Factor: ¼	Scaled Drawing	New Measurements
Height: 2”		Height: _____
Length: 2”		Length: _____
Depth: 2”		Depth: _____

Scale Factor: 2	Scaled Drawing	New Measurements
Height: 1 1/2”		Height: _____
Length: 1 1/2”		Length: _____

Determine the **scale factor** between these two objects by dividing the measurements of the enlargement by the original. Check your answers on page 18.

Scale Factor: _____

Original

½”

1”

Enlargement

1 ½”

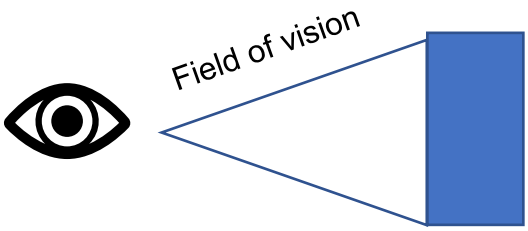
3”

Challenge: Find the measurements of the full-sized spaceship from *Dune*. This miniature version of the ship is 10 feet tall and 30 feet long. If the miniature has a **scale factor** of 1/15, what are the dimensions of the full-sized ship? Check your answers on page 18

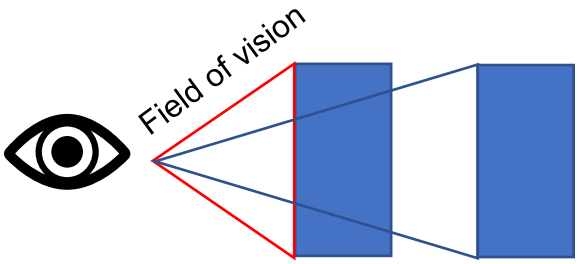
Section II - Forced Perspective

Now that you've mastered miniature math, it's time to learn how to make them look big! **Forced perspective** is a technique filmmakers use to make an object appear larger or smaller than it really is. It is an optical illusion that manipulates our visual perception.

So how does it work? An object that is closer to us takes up more space in our field of vision and appears larger. Move the same object further away, and it will appear smaller. Let's explore this visually! The diagrams below illustrate this principle. Notice how the distance of the object impacts the field of vision.

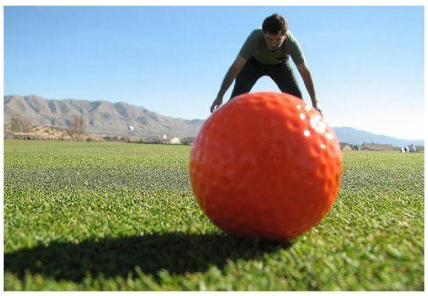


Object at a further distance



Object at a closer distance

These example photos show the same thing. By manipulating the distance of the objects to the camera the objects appear to be different sizes than they are in real life.



Let's look at another example of forced perspective in *The Lord of the Rings*. In this scene the filmmakers needed to make some actors look much smaller than the others. In the context of the film hobbits like Frodo (Elijah Wood) are supposed to be about 3 ½' tall versus Gandalf (Ian McKellan) who is supposed to be the height of an average man. To make Frodo look the right height they built specially designed sets that would put Gandalf closer to the camera and Frodo farther from the camera. Our eyes do the rest, tricking us into thinking that one person is smaller than the other because they are farther away.

Application

Practice taking some forced perspective photographs!

1. Find two small objects in your house. You will take three photos of your objects. Keep your camera in roughly the same place for each photograph.
2. First place the objects next to each other and take a photo.
3. For the next photo move one object farther from the camera.
4. For the last photo, move the object closer to the camera.

1st Photo

2nd Photo

3rd Photo

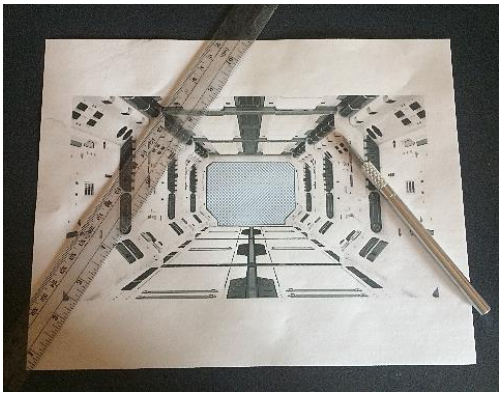
Activity

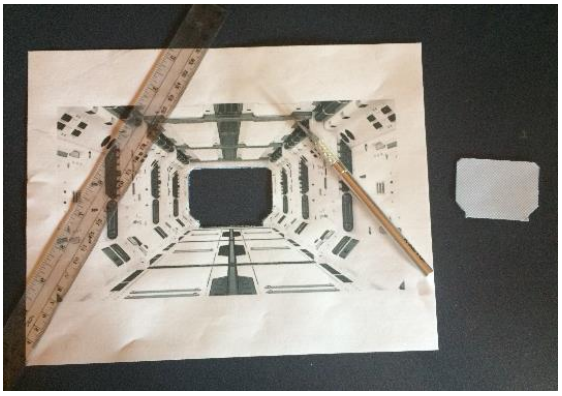
Time to put what you've learned together! In this activity, you will use **forced perspective** to combine a sci-fi template and your own real-life set to create your own miniature shot. Once you've finished your shot, you'll identify the **scale factor** you used. You may want to ask an adult for help. Also look at the example *in italics* by our educational staff for help.

1. Brainstorm what you would like to make. You can use one of the provided templates (pages 10-12 below) or make your own unique miniature spaceship!

2. Print your miniature template and cut out the blue shaded sections. If you are making your own template, sketch your spaceship and cut out a space for your real-life set.

I decided to use this template.

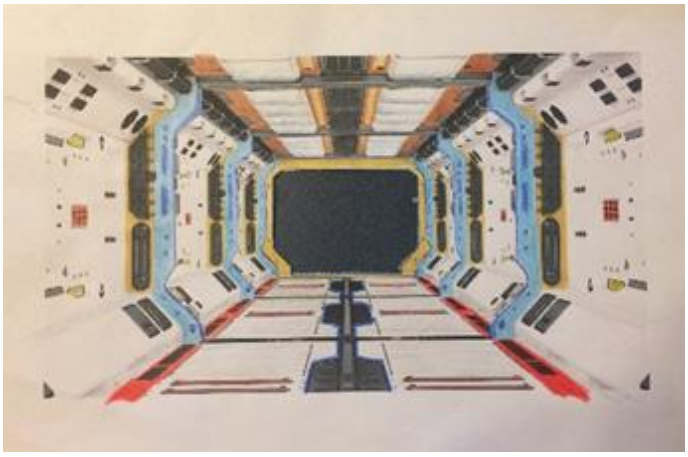




3. Scout your real-life set location. Choose something that you have easy access to. This will be the background that will overlap with the miniature.

I choose some doors that roughly match the shape of my template.

4. Finish your miniature. Use colors that match your real-life set.

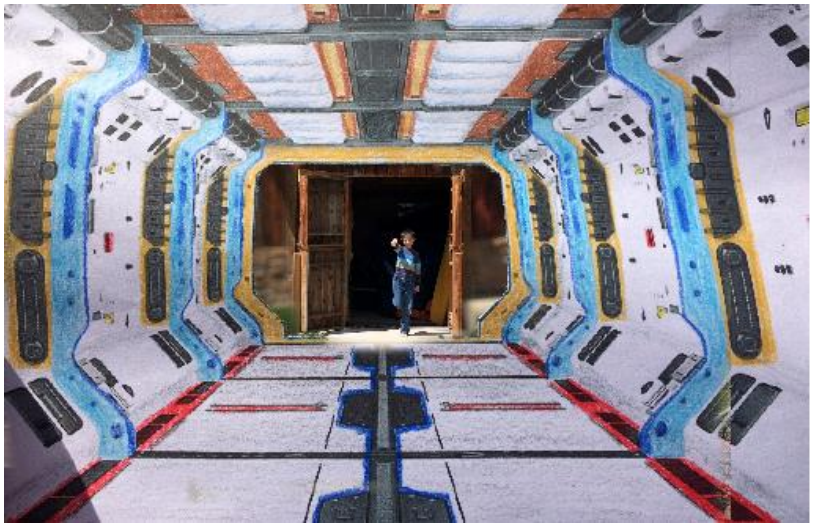


5. Establish how far away you need your miniature to be from your real-life set to achieve the proportion you want by holding up your miniature template with the hole showing your real-life set at different distances.

I had to try a several different distances until I was far enough away.

6. Mark the distance that you need to stand to take your photo. You may want to put a piece of tape on the ground or use something else to mark your spot.

7. Take your photograph. Set up your shot with the miniature closer to the camera and the real-life set in the background through the cut out. Trial and error is key! Practice taking the photo several times.



If you want a person in the photograph, ask someone to help you.

In my photo, I asked my nephew to pose in the shot while I took the photo.

8. Measure your real-life set. Write down the measurements.

Height:	Length:

Height:	*Length:*
81”	*62”*

The doorway I used in my real-life set is 81” tall and 62” wide.

9. Based on the measurements you took of the set, estimate what the measurements of your spaceship would be in real life. Remember to keep the proportion of the real life set to the spaceship in mind.

The cut out in my spaceship is wider than the real doorway, so I’m estimating that the door in my spaceship would be 81” tall and 116” inches wide.

10. Measure the cut-out in your miniature. Feel free to round your numbers so that they are easier to work with.

The cut out in my miniature is 1.625” tall and 2.25” wide. I’m rounding those numbers to 1.6” x 2.3”

11. Using the measurements of your miniature and the estimated measurements of the real-life spaceship, identify the scale factor of your miniature compared to the real-life set.

*My estimated height for my spaceship was 81 inches tall and my miniature was 1.6” inches tall. 81/1.6 = **50.6**. The estimated length was 110” the miniature was 2.3. 116/2.3 = **50.4**.*

The numbers aren’t exact because I’m estimating, but I can conclude that my miniature is a scale factor of about 1/50. Wow!

Tips and tricks

Here are other things to consider that help create magical effects!

Composition – this is the framing of the objects in the shot. One of the simplest things you can do to make your subject feel large is to shoot it from a low angle, pointed slightly upward at the subject. You can also convey the supposed size of something by deliberately keeping some the subject out of the frame, you can give the impression that it is simply too big to be seen all at once.

Independence Day 1996

Details – By adding smaller parts to an object you can make it appear larger. The smaller details give a reference point for scale, unlike a smooth, bland surface.

Atmosphere – Another way to exaggerate scale is by incorporating the effects of environment into your scene. This tactic works best for showing something large from far away. For instance, you might obscure the large object in comparison to objects in the foreground like rocks, trees, or fog.

Star Wars: The Force Awakens 2015

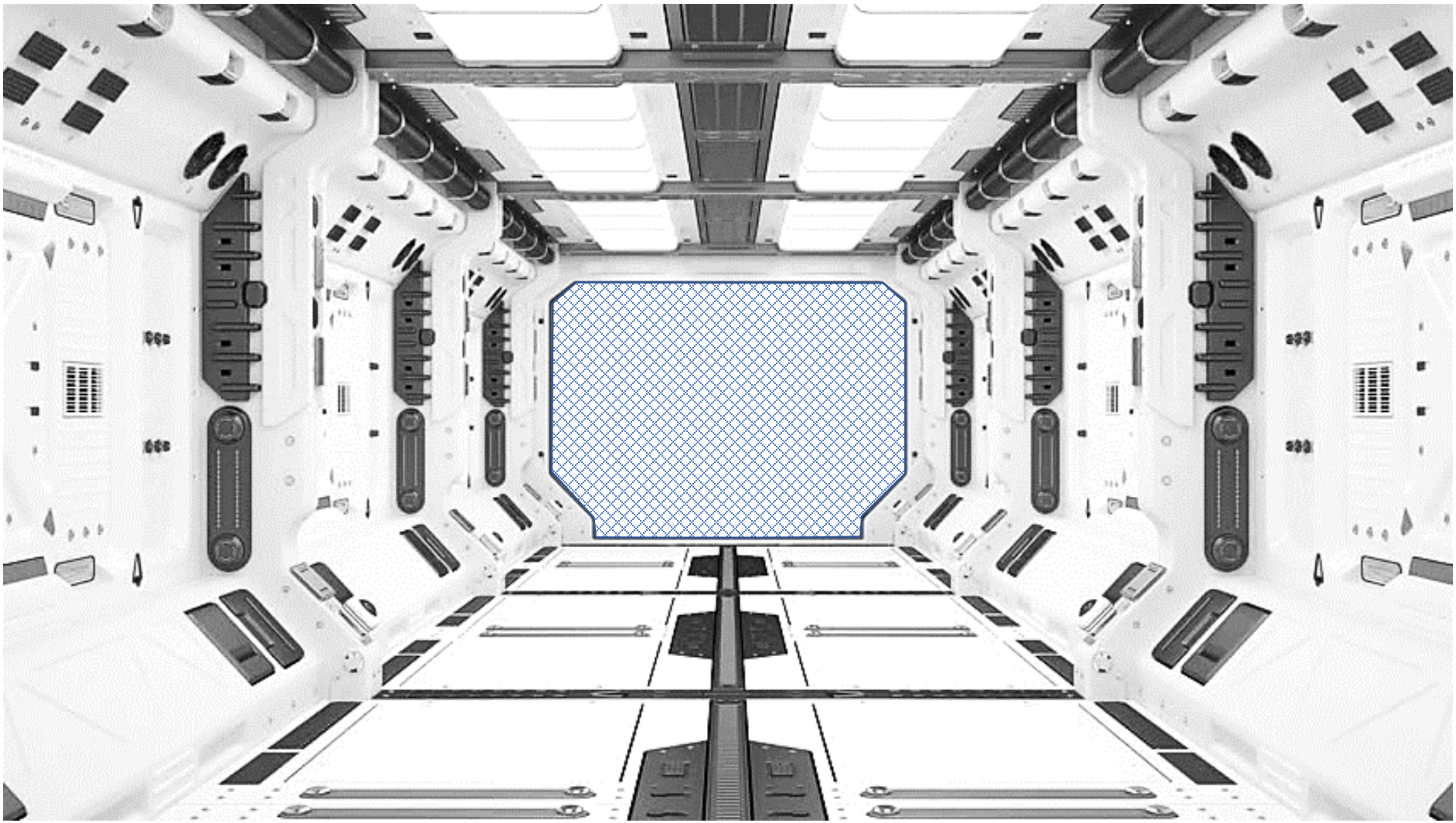
Lighting – This is key. The lighting needs to match as closely as possible in order for the background and foreground to look like they occupy the same space.

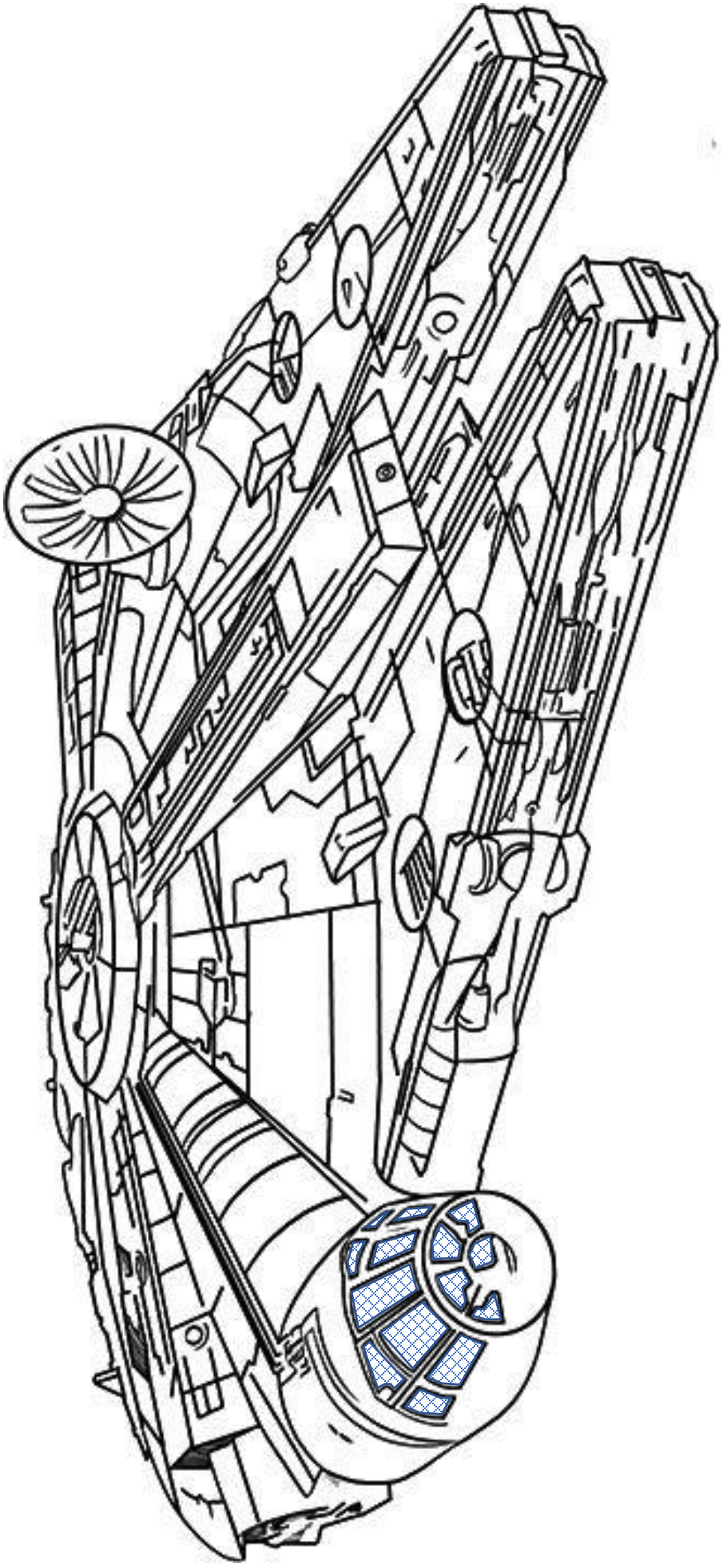
Congratulations! You successfully used forced perspective and a scaled paper miniature to create an epic sci-fi image. **Scale factor**, **forced perspective**, and **miniatures** are all practical effects tools that filmmakers use to create memorable science-fiction and fantasy films. Now that you've learned the basics, explore what else you can do with your newfound skills!

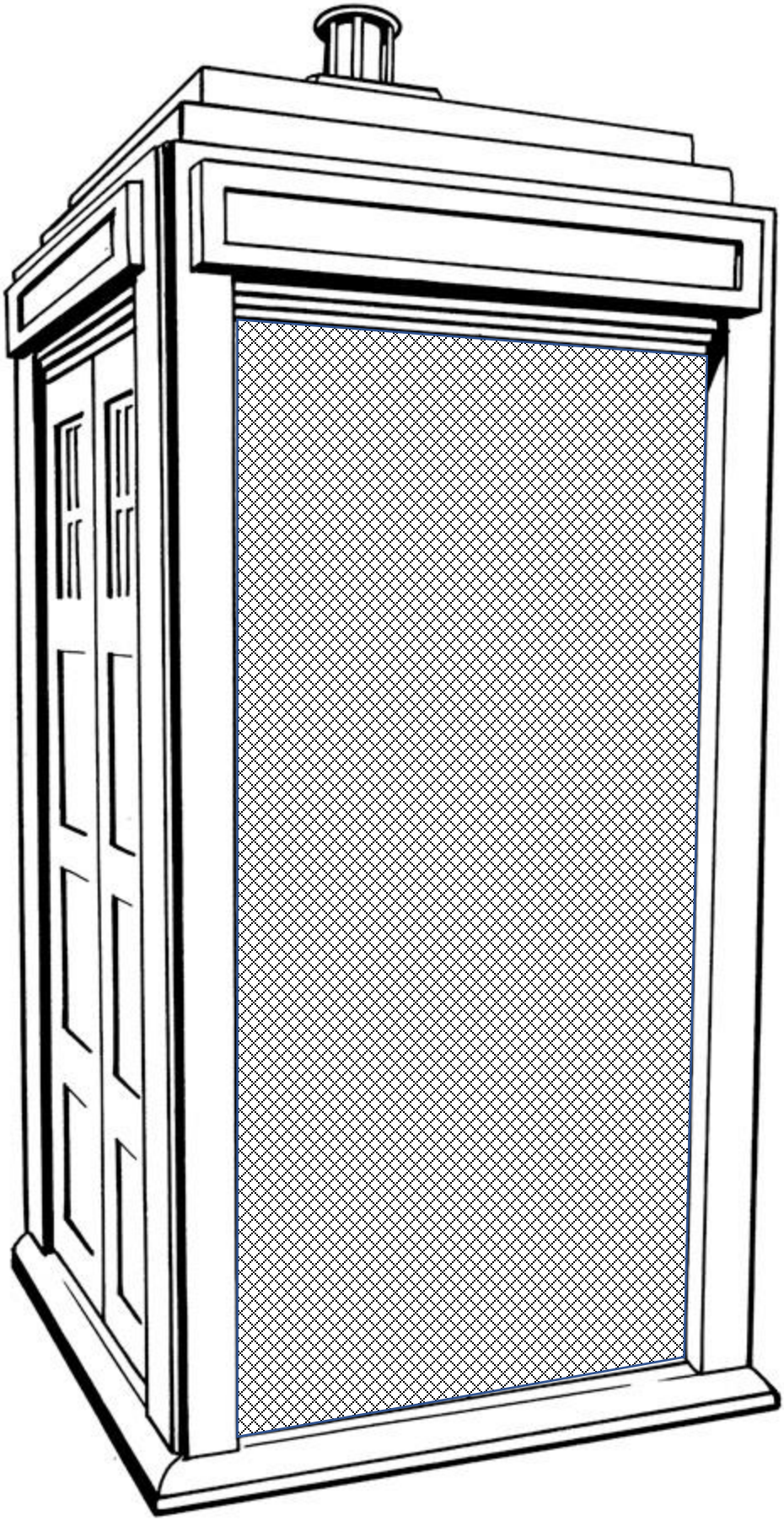
- Keep practicing! Take more forced perspective photographs and grow your skills.
- Make a 3-D miniature and use it in a photo.
- Film your own sci-fi or fantasy story using your miniatures shots.

Share what you've created!

Please send us your pictures at education@mopop.org.

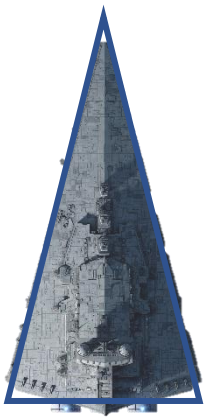






ANSWER SHEET

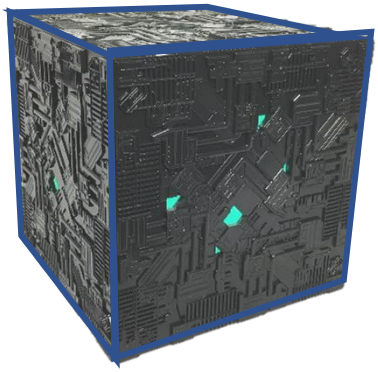
Practice on your own with these spaceships. First multiply the dimensions by the scale factor. Then draw the object at scale size and write the new measurements.



Scale Factor: ½ **Scaled Drawing** **New Measurements**

Height: 2” Height: 1”

Length: 1” Length: ½”

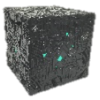


Scale Factor: ¼ **Scaled Drawing** **New Measurements**

Height: 2” Height: ½”

Length: 2” Length: ½”

Depth: 2” Depth: ½”



Scale Factor: 2 **Scaled Drawing** **New Measurements**

Height: 1 1/2” Height: 3”

Length: 1 1/2” Length: 3”

Determine the **scale factor** between these two objects by dividing the measurements of the enlargement by the original.

Original

½”

1”

Enlargement

1 ½”

3”

Scale Factor: 3

Challenge: Find the measurements of the full-sized spaceship from *Dune*. This miniature version of the ship is 10 feet tall and 30 feet long. If the miniature has a **scale factor** of 1/15, what are the dimensions of the full-sized ship?

150 feet tall

450 feet long