Investigation 21C: Image formation for a convex lens

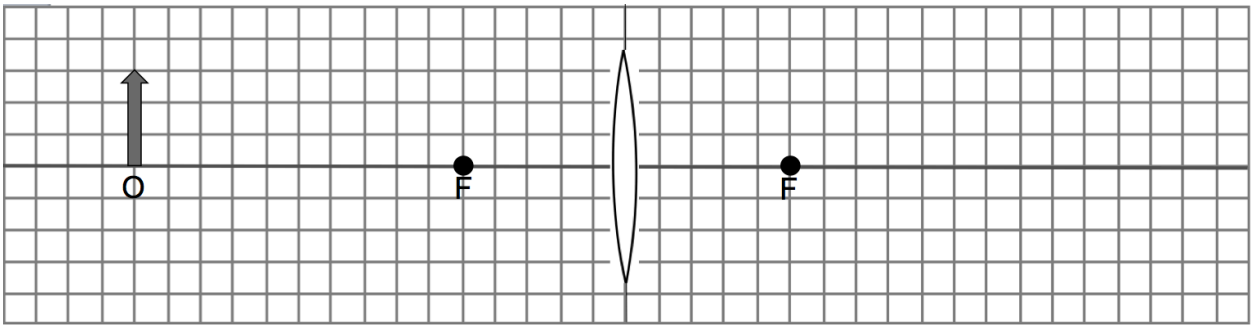
Essential questions: How does a convex lens form an image?
How do you measure the focal length of a lens?

Part 1: Converging lens – rules for ray tracing with converging lens:

1. Incident rays parallel to the optical axis refract through the *far* focal point.
2. Incident rays passing through the center of the lens pass straight through the lens *undeflected*.
3. Incident rays passing through the *near* focal point refract parallel to the optical axis.

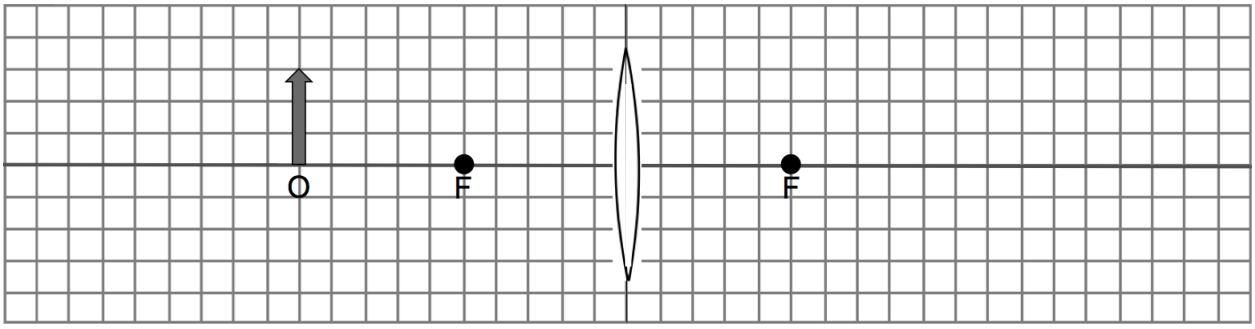
For each case shown below, sketch the ray diagram and complete the table describing the image.

Converging lens case #1: Object at 3F = 60 cm (scale: 4 cm per square)



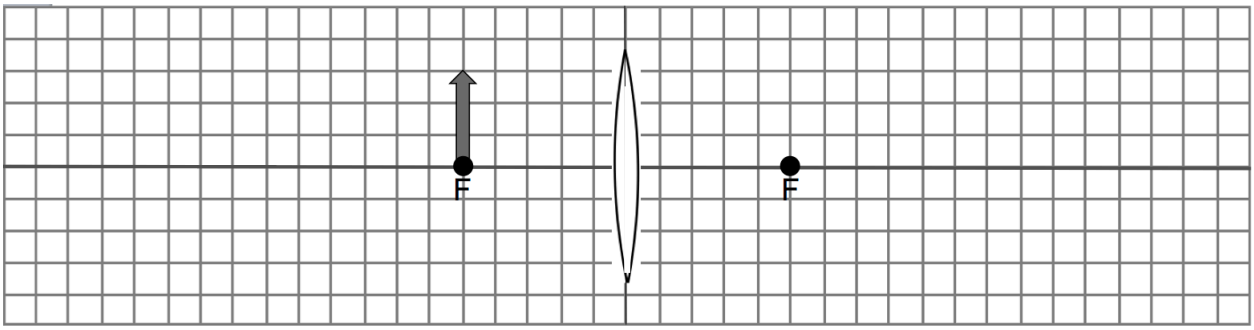
Focal length	Object distance	Image distance	Reduced or enlarged?	Inverted or upright?	Real or virtual?
20 cm	60 cm				

Converging lens case #2: Object at 2F = 40 cm (scale: 4 cm per square)



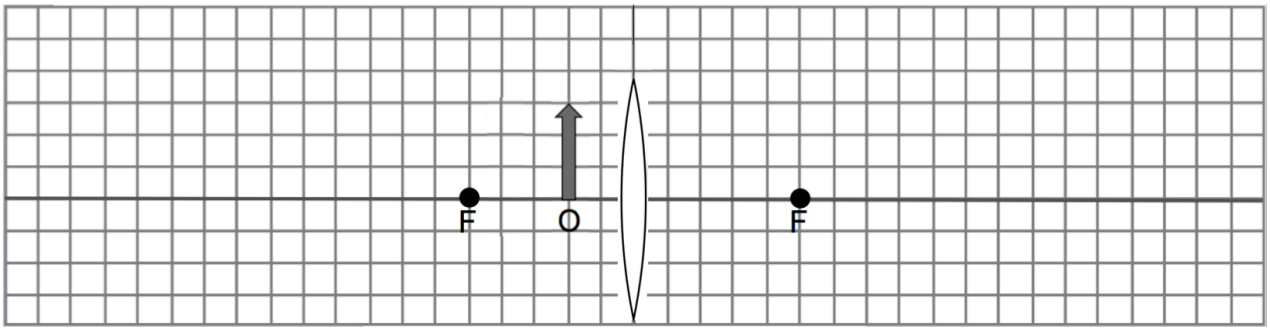
Focal length	Object distance	Image distance	Reduced or enlarged?	Inverted or upright?	Real or virtual?
20 cm	40 cm				

Converging lens case #3: Object at F = 20 cm (scale: 4 cm per square)



Focal length	Object distance	Image distance	Reduced or enlarged?	Inverted or upright?	Real or virtual?
20 cm	20 cm				

Converging lens case #4: Object between F and lens, at 8 cm (scale: 4 cm per square)



Focal length	Object distance	Image distance	Reduced or enlarged?	Inverted or upright?	Real or virtual?
20 cm	8 cm				

Questions

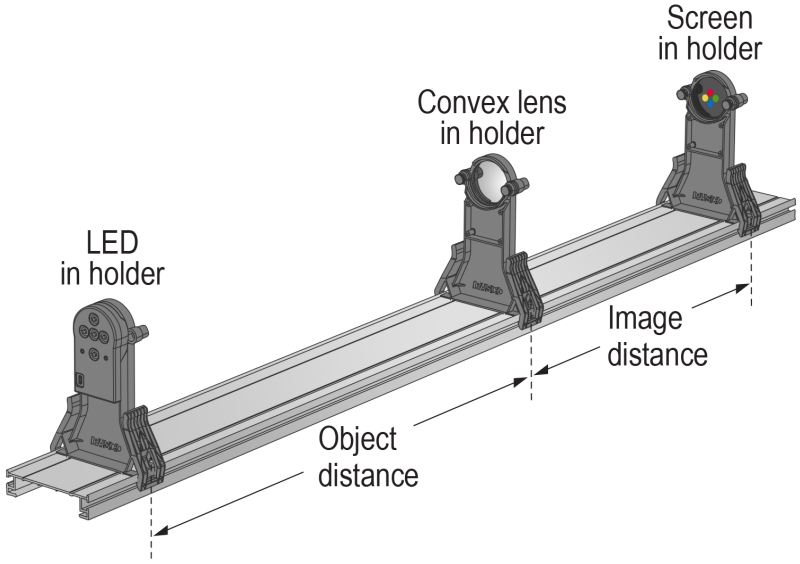
a. What type of image is produced when the object distance is greater than the focal length?

equal to the focal length?

less than the focal length?

Test the predicted image locations

1. Set up the optics equipment as shown. Place the LED light source (the "object") at an object distance of 60 cm from a convex lens with a 20-cm focal length.
2. Slide the screen along the track on the far side of the lens until the sharpest possible image is projected onto the screen.
3. Measure the image distance and compare it to your prediction.
4. Repeat for object distances of 40 cm and 20 cm.



Focal length	Object distance	Measured image distance	Predicted image distance
20 cm	60 cm		
20 cm	40 cm		
20 cm	20 cm		

Questions

a. Do your actual measured image distances match your predictions?

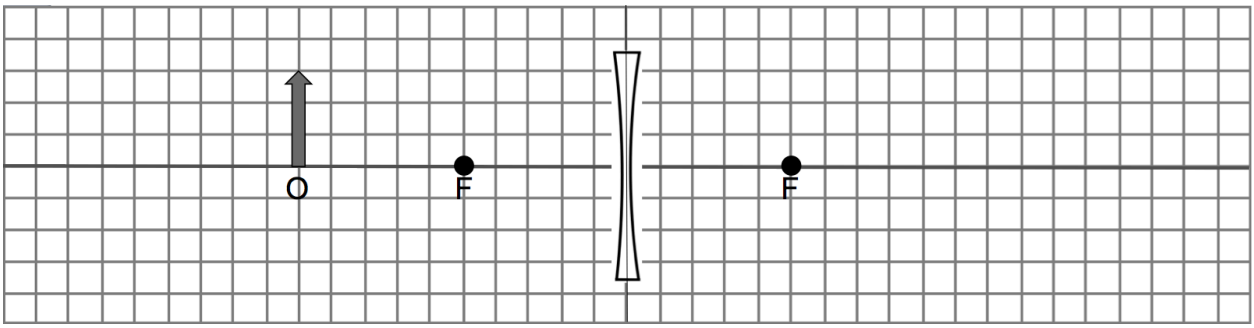
b. What will the image distance be if you place the LED light source far away (such as several meters)? Check your prediction by making the measurement.

c. Why can't you use an object distance of 10 cm with this technique?

Part2: Diverging lens – rules for ray tracing with diverging lens:

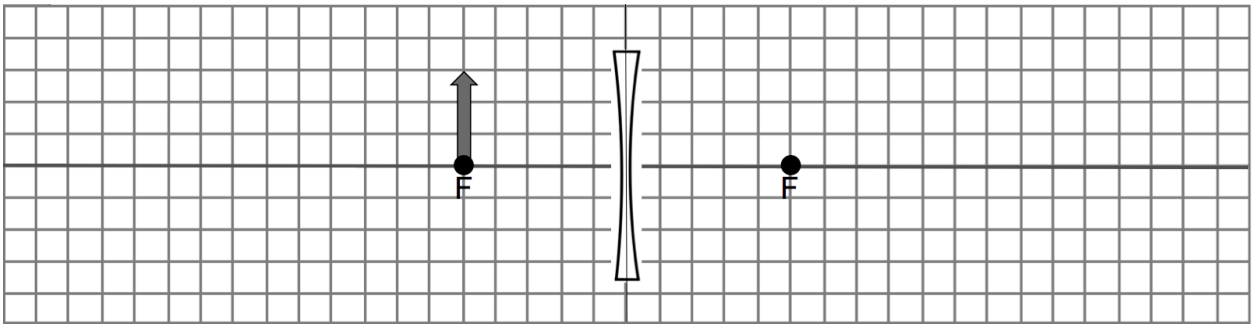
1. Incident rays parallel to the optical axis refract along a line passing through the *near* focal point.
2. Incident rays passing through the center of the lens refract straight through the lens *undeflected*.
3. Incident rays directed towards the *far* focal point refract parallel to the optical axis.

Diverging lens example #1: Object at 2F



Focal length	Object distance	Image distance	Reduced or enlarged?	Inverted or upright?	Real or virtual?
-50 cm	1.0 m				

Diverging lens example #2: Object at F



Focal length	Object distance	Image distance	Reduced or enlarged?	Inverted or upright?	Real or virtual?
-50 cm	50 cm				

Applying new knowledge

1. An object is placed 150 cm in front of a convex lens with focal length of 60 cm. What is the resulting image distance? Draw the ray diagram and sketch the image.

2. Draw the ray diagram for an object placed 50 cm from a thin convex lens with a focal length of 70 cm. What are the image properties?

3. Draw a ray diagram for a thin convex lens with a focal length of 50 cm and an object distance of 80 cm. What are the image properties?