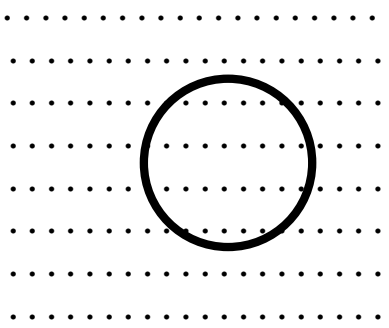
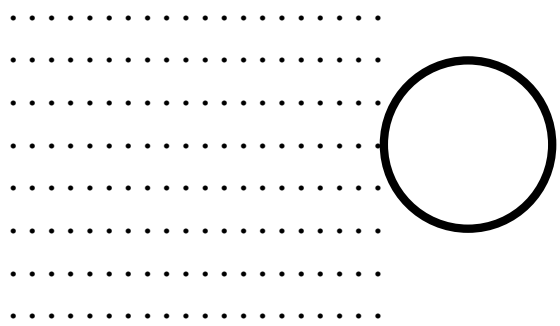
58. Below is a wire loop immersed in a magnetic field. The wire loop is moved to the right to its new position drawn below. What is the direction of the induced current?

**Before**

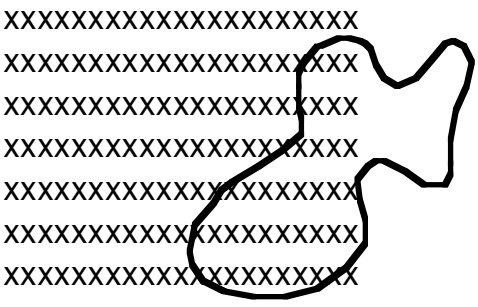


**After**

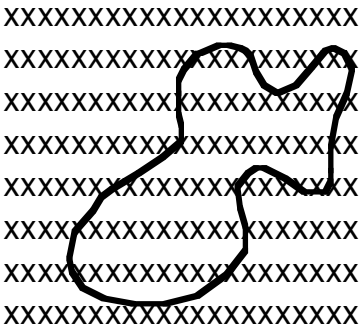


59. Below is a wire loop immersed in a magnetic field. The wire loop is moved to the left to its new position drawn below. What is the direction of the induced current?

**Before**

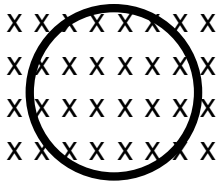


**After**

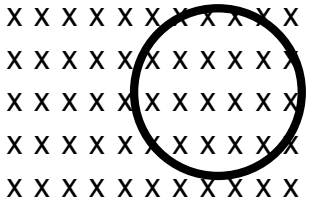


60. Below is a wire loop immersed in a magnetic field. The wire loop is moved to the right to its new position drawn below. What is the direction of the induced current?

**Before**

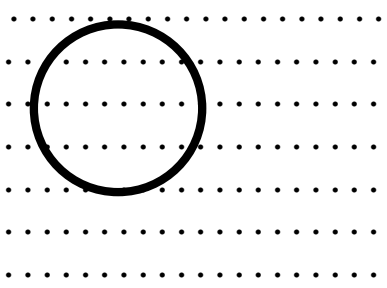


**After**

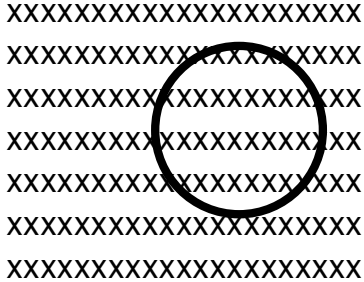


61. Below is a wire loop immersed in a magnetic field. The wire loop is moved to the left to its new position drawn below. What is the direction of the induced current?

**Before**

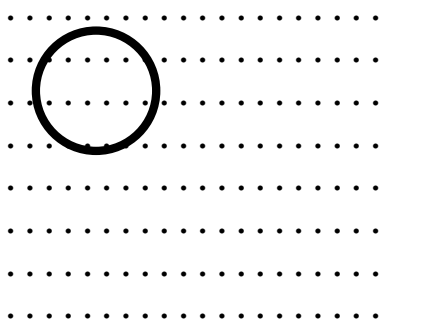


**After**



62. Below is a wire loop immersed in a magnetic field. The wire loop is moved to the left to its new position drawn below. What is the direction of the induced current?

**Before**



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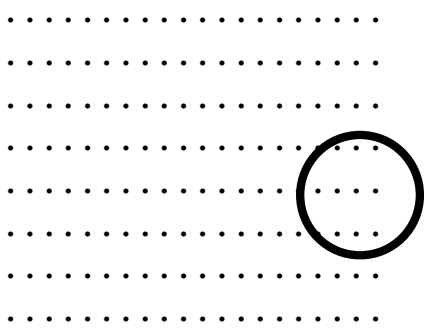
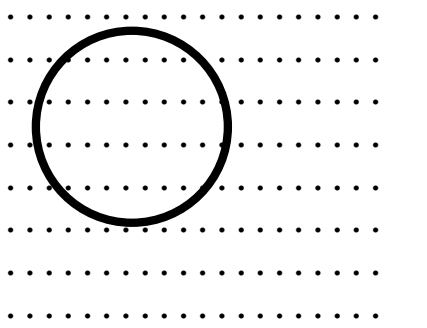


63. Below is a wire loop immersed in a magnetic field. The wire loop is moved to the left to its new position drawn below. What is the direction of the induced current?

**Before**



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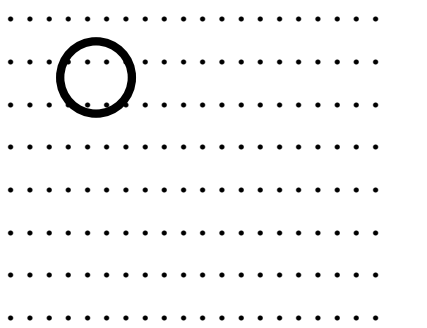
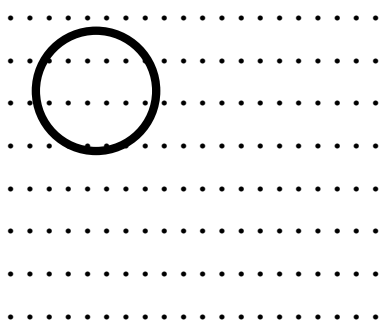
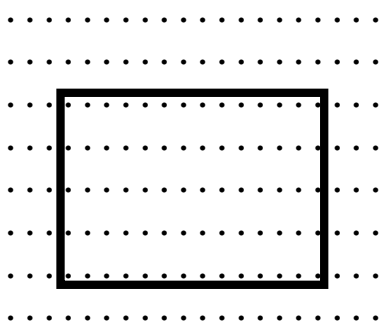


64. Below is a wire loop immersed in a magnetic field. The wire loop is moved to the left to its new position drawn below. What is the direction of the induced current?

**Before**

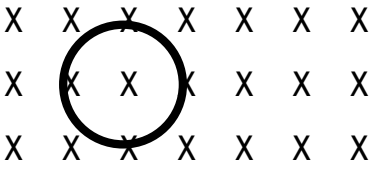


**After**

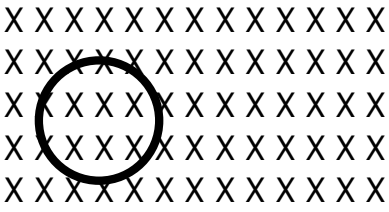


65. Below is a wire loop immersed in a magnetic field. The wire loop is moved to the left to its new position drawn below. What is the direction of the induced current?

**Before**



**After**



66. Electrons flow from north to south. The flow feels a force to the west. What is the direction of the b-field?

67. Current flows east to west. The current is in a magnetic field whose north pole is located at the north. What is the direction of the force?

**68.** The plus pole of a battery is located up and the negative pole of the battery is located down. The wire connected to the battery feels a force to the west. Where is the north pole of the magnetic field that the wire is in?

# Objectives

## Light: the Nature of the Electromagnetic Spectrum

**Students will be able to:**

1. Describe Newton's theory of light
2. Describe evidence of Newton's theory
3. Define what a photon is
4. Describe Huygens' theory of light
5. Describe evidence of Huygens' theory
6. Define longitudinal and transverse wave types
7. Give at least one example of each wave type
8. Identify the wavelength of a transverse and longitudinal wave.
9. From a wave's appearance, identify high frequency, low frequency and amplitude.
10. Describe Einstein's light theory
11. List regions of the electromagnetic spectrum from lowest to highest frequency
12. List regions of the electromagnetic spectrum from longest to shortest wavelengths
13. Give an example of an amplification of how each spectrum of light is utilized.
14. Write the speed of light in standard S.I. units from memory.
15. Do calculations utilizing basic velocity relationships.
16. Do calculations utilizing the mathematical relationship between the speed of light, frequency and wavelength.
17. Calculate the energy of light associated with frequency or wavelength.
18. List regions of the electromagnetic spectrum from highest to lowest energy.
19. Utilizes energy relationships to answer questions.
20. List the visible light spectrum (ROY-G-BIV) in order from
21. Longest to shortest wavelength or vice-versa.
22. Lowest to highest frequency or vice-versa.
23. Lowest to highest energy or vice-versa.
24. Explain how a microwave "cooks" food, why the sky is blue, why sunsets are red and what the "color of visible" light represents.
25. Explain the idea behind polarizing light though filters and reflection
26. Memorize and utilize Brewster's Law of Polarization
27. Calculate light intensity though a polarizer and an analyzer.
28. Describe refraction and reflection
29. Define the index of refraction
30. Use the index of refraction to fin the various speeds of light
31. Use the index of refraction in combination with light's energy to find the wavelength of light
32. Write Snell's Law from memory
33. Use Snell's Law to solve problems
34. Describe total internal reflection
35. List some applications of total internal reflection
36. Do calculations based on total internal reflection

# The Nature of the Electromagnetic Spectrum ( Light )

| Indices of Refraction | | | |
|---|---|---|---|
| **SUBSTANCE** | **-n-** | **SUBSTANCE** | **-n-** |
| CUBIC ZIRCONIA | 2.200 | BENZENE | 1.501 |
| DIAMOND (C) | 2.416 | CARBON DISULFIDE | 1.628 |
| FLUORITE (CAF2) | 1.434 | CARBON TETRACHLORID | 1.461 |
| FUSED QUARTZ | 1.458 | ETHYL ALCOHOL | 1.361 |
| GLASS, CROWN | 1.520 | GLYCERINE | 1.473 |
| GLASS, FLINT | 1.660 | WATER | 1.333 |
| ICE WATER | 1.309 | | |
| POLYSTYRENE | 1.490 | AIR | 1.000 |
| SODIUM CHLORIDE | 1.544 | | |
| ZIRCON | 1.923 | | |

Planck's Constant is $h = 6.63 \times 10^{-34}$ J•s

1. Mercury is $69.7 \times 10^{6}$ km from the sun. How much time does to take for a light ray to travel from the Sun to Mercury?

2. A radio signal takes 2 minutes and 18 seconds to travel from the Earth to Venus. How away is Venus from the Earth in meters and Miles.

3. How many FEET does light travel in 1 nanosecond ($1.0 \times 10^{-9}$ s).

4. The average radius of the sun is $6.96 \times 10^{5}$ km. If light could bend around the sun, how many times could a ray of light travel around the sun in 1.0 second?

5. How many miles does light travel in one year's time?

6. The wavelength of red light is about $650 \times 10^{-9}$ m.
   a. What is the frequency of the light?
   b. What is the energy of a photon of light?

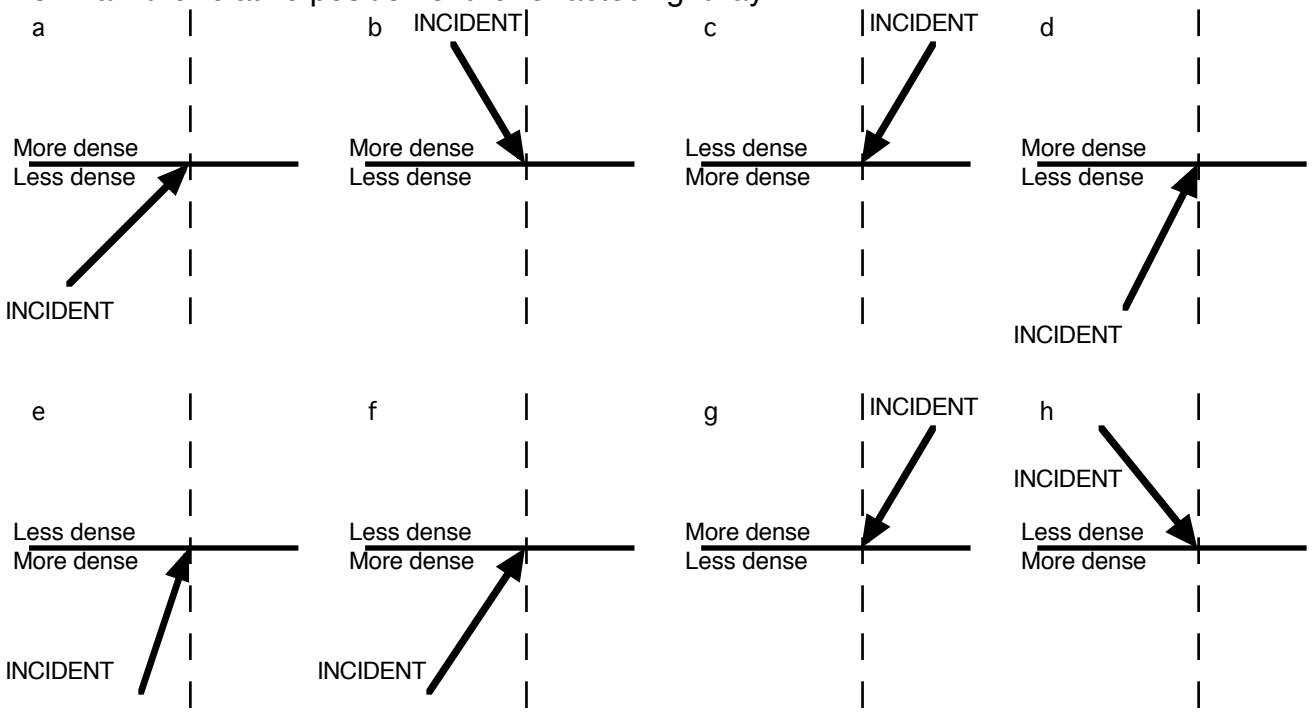
7. What is the wavelength of a radio wave whose frequency is 97.5 MHz?

8. What is the wavelength of a radio wave whose frequency is 1040 kHz?

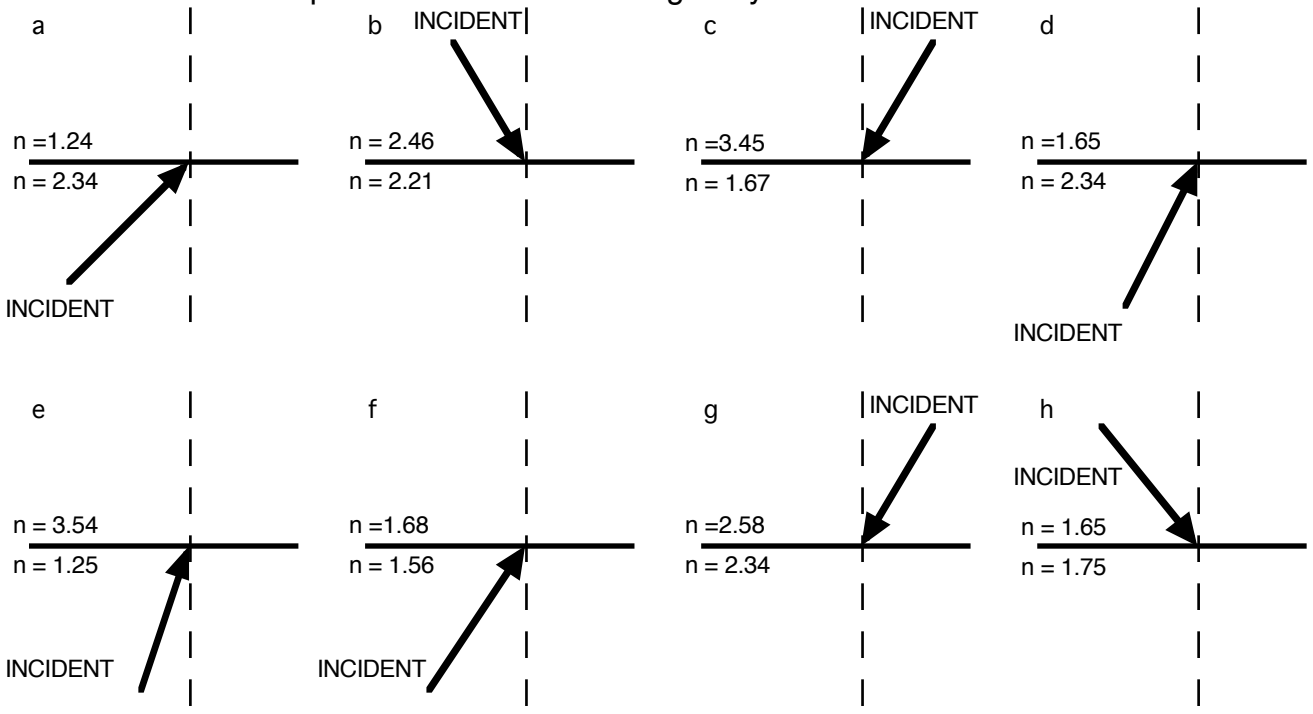
9. What is the frequency of a green light whose wavelength is $741 \times 10^{-9}$ m?

**Problems:**

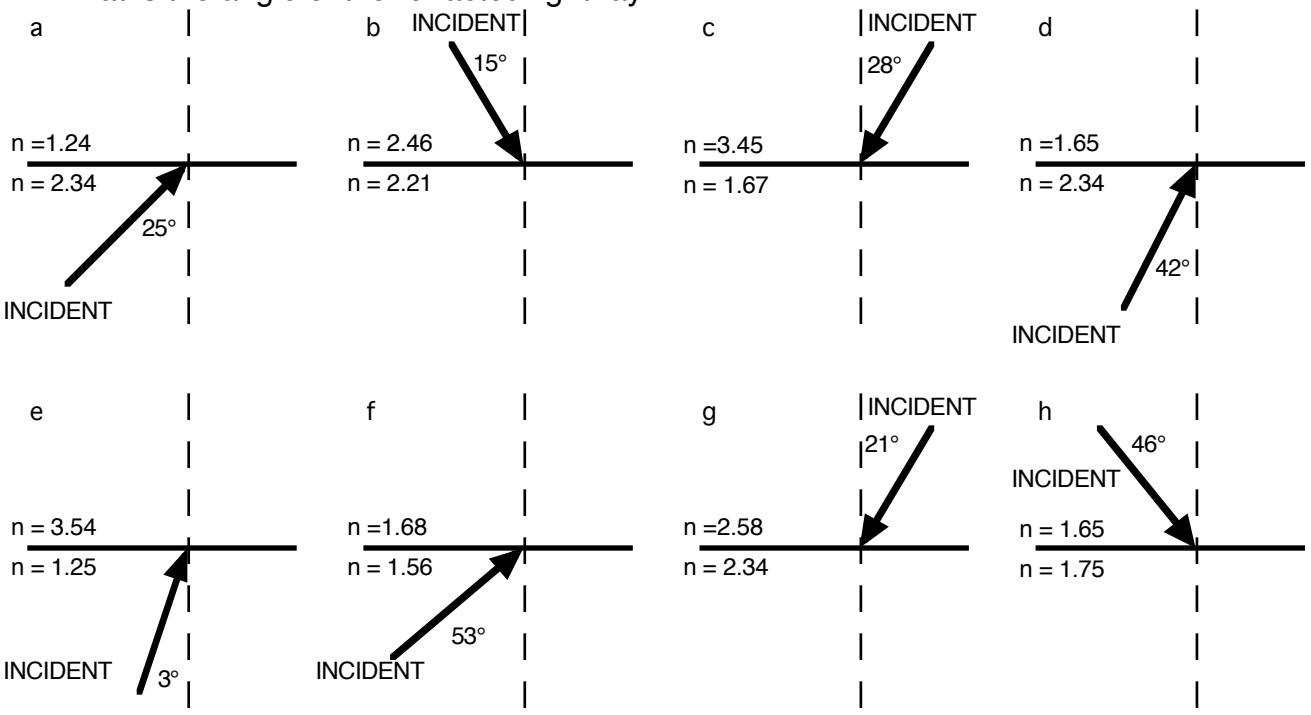
**10.** Draw the relative position of the refracted light ray.




**11.** Draw the relative position of the refracted light ray.

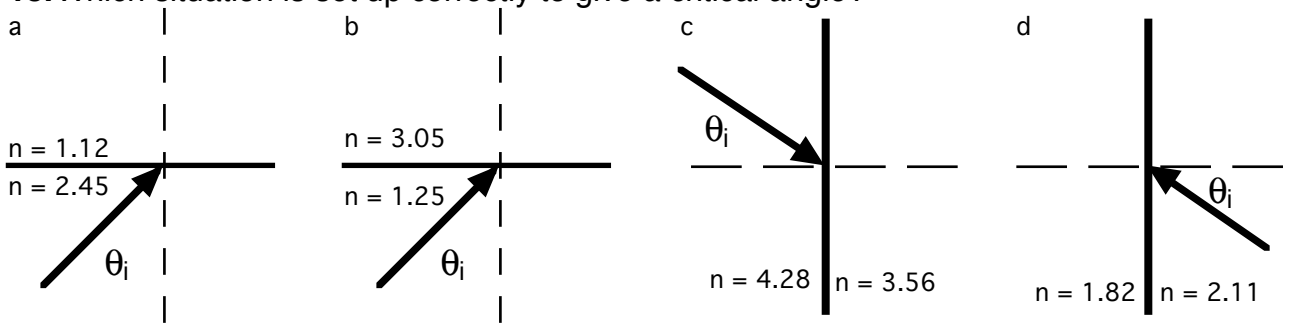


**12.** What is the angle of the refracted light ray?

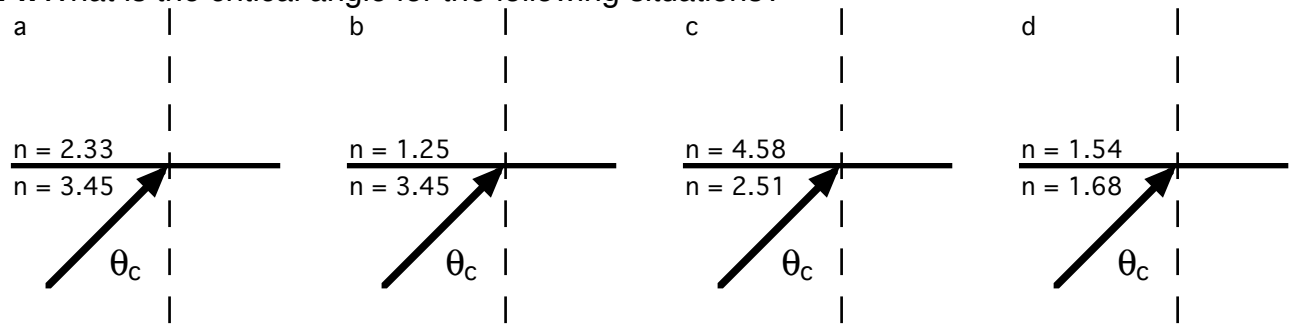



## CRITICAL ANGLE

**13.** Which situation is set up correctly to give a critical angle?

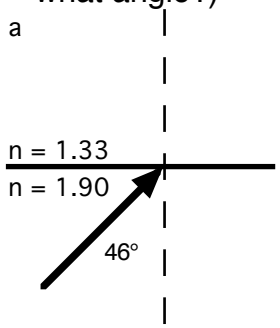



**14.** What is the critical angle for the following situations?



**15.** What will happen to the light ray? (Is it reflected and at what angle? Is it refracted and at what angle?)

a

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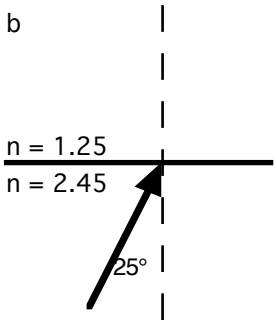


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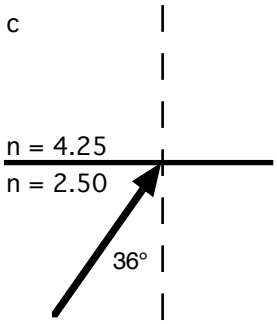


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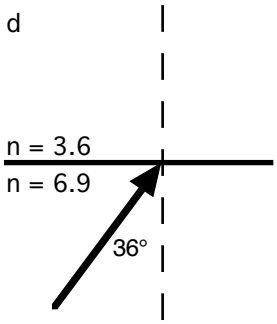
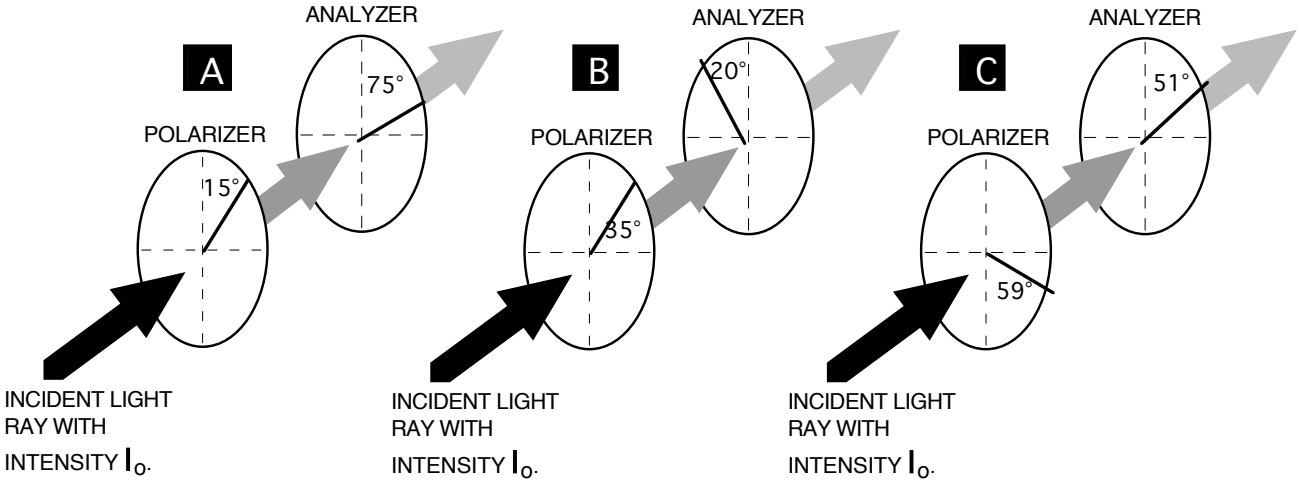
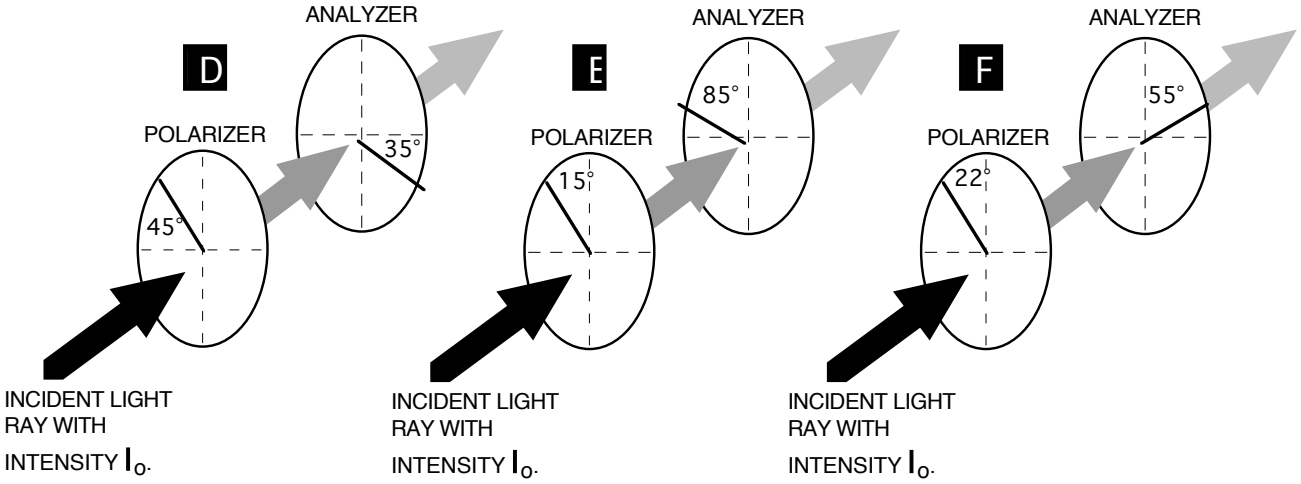
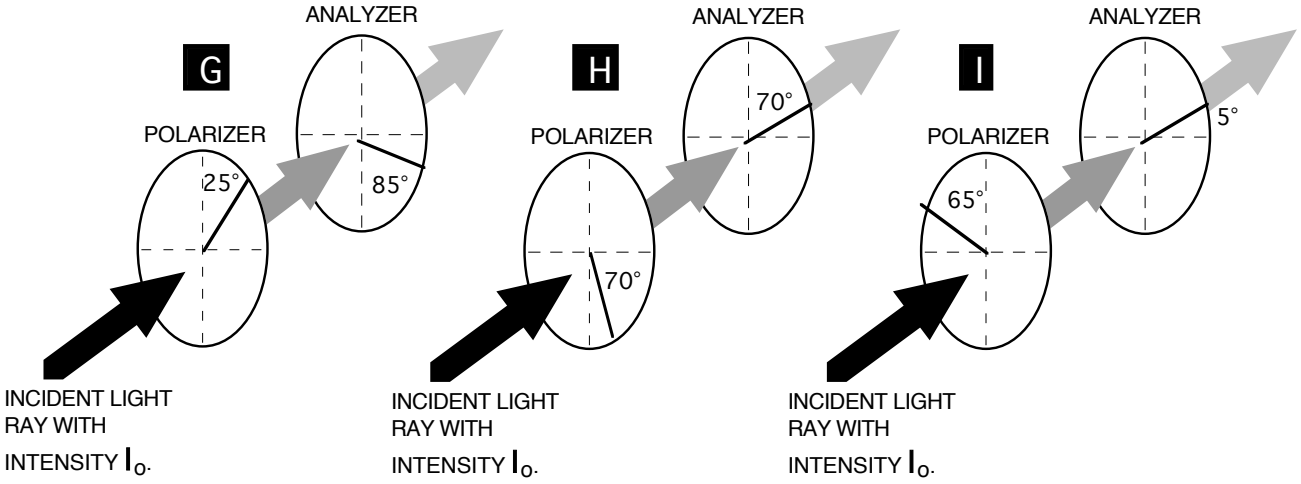


## POLARIZATION

**16.** FIND THE LIGHT INTENSITY AS THE RAY PASSES TO THE END POLARIZER. EXPRESS YOUR ANSWER AS A PERCENTAGE.



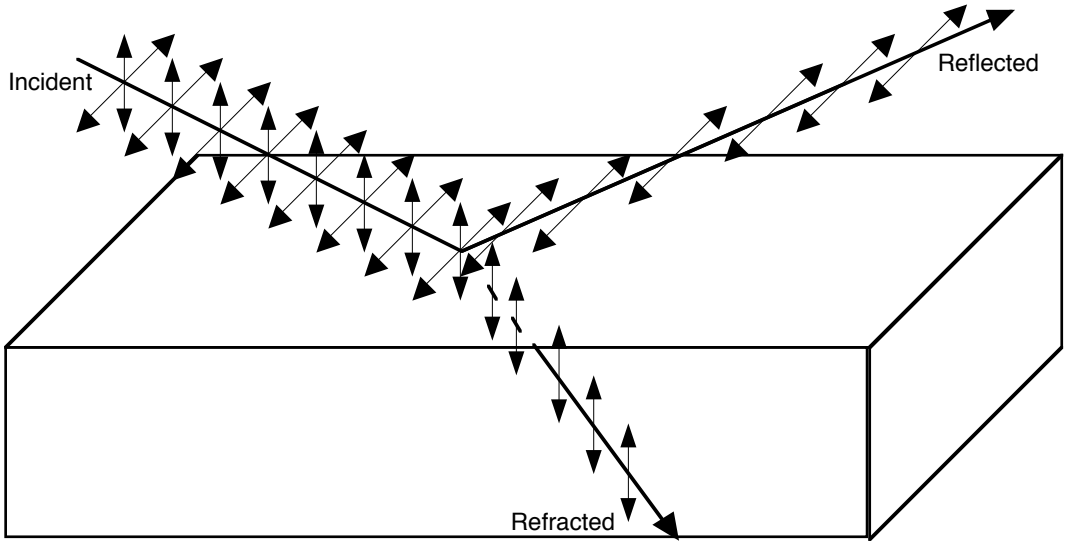



**17.** Two pairs of polarized sunglasses are held at 90° and 50° from the horizontal. By what factor has the intensity of the transmitted light been changed?

**18.** Thee pairs of polarized sunglasses are held up in front of one another. The first pair the light hits is held at 20° from the vertical. The second pair is held at 70° from the vertical. The third pair is held at 90° from the vertical. By what factor has the intensity of the transmitted light been changed?

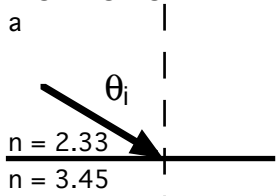
**19.** Thee pairs of polarized sunglasses are held up in front of one another. The first pair the light hits is held at 70° from the vertical. The second pair is held at 90° from the vertical. The third pair is held at 20° from the vertical. By what factor has the intensity of the transmitted light been changed?

## BREWSTER'S LAW




20. Identify if the conditions are right for maximum polarization of the out going light ray in each problem below

a

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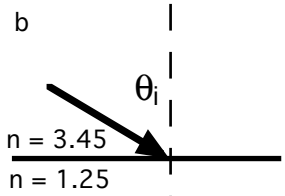


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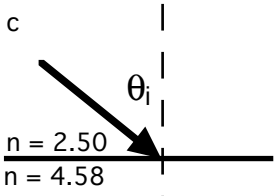


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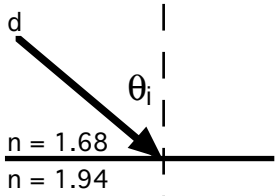


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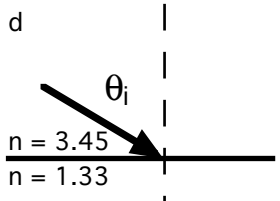


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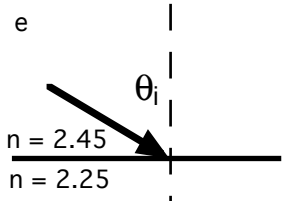


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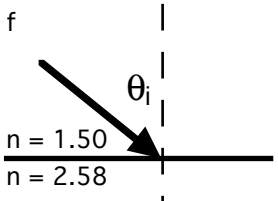


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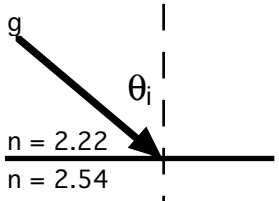
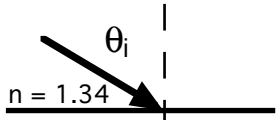


**21.** For the problems below, calculate the angle of maximum polarization.

a

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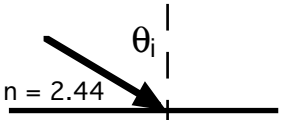


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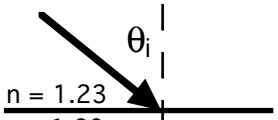


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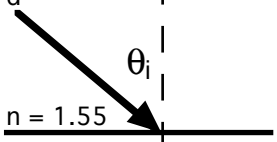


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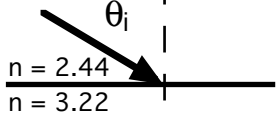


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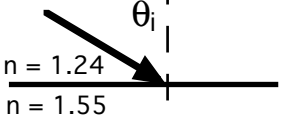


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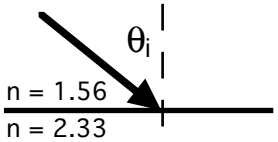


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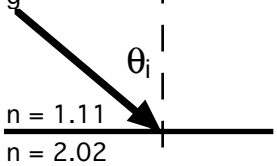



**22.** What is the angle of maximum polarization for the reflected ray of light that bounces off of a diamond?

**23.** What is the angle of maximum polarization as a light ray bounces off a piece of glass under the water?

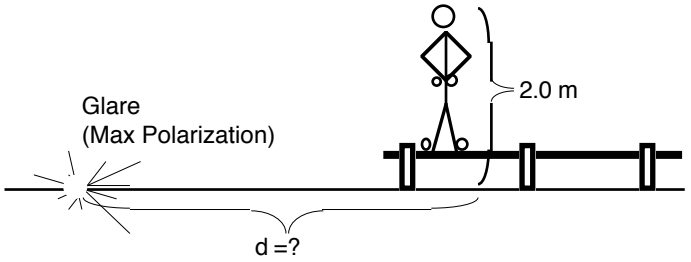
**24.** What is the angle of maximum polarization as a light ray bounces off a piece of glass that is lying in the air next to the water?

**25.** What is the refracted angle of a light ray that bounces off a piece off plastic whose index of refraction is 1.41 if the reflected angle is at its maximum polarization?

**26.** A light ray is refracted at a 30° angle from the normal. The reflected light ray is maximally polarized. What is the angle of the incident light ray?

**27.** A piece of material in the air reflects a light ray at 35°. The reflected ray is maximally polarized. What is the index of refraction of this material?

**28.** If you are standing such that your eyes are 2.0 meters vertically from the waters smooth surface, then how far away from you is the glare on the water if the glare is at the angle of maximum polarization?



**29** Locally, the radio station WWWV broadcasts at 97.5 MHz ($97.5 \times 10^6$ Hz). Radio waves are electromagnetic waves like light. The waves travel at the speed of light. What is the wavelength of WWWV's wave length?

**30** X-Rays have a wavelength of $1.00 \times 10^{-10}$ m. What is the x-rays frequency?

**31** Microwave ovens have a frequency of $2.457 \times 10^{10}$ Hz. What is the wavelength of this microwave?

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**32** What is the energy of 12 photons from a microwave oven?

**33** Visible red light has a wavelength of 0.680 mm. What is the energy of a photon from this light?

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**34** A beam of light travels though a piece of plastic at $2.97 \times 10^8$ m/s. What is the index of refraction of this plastic?

**35** A beam of light with a frequency of $624 \times 10^9$ Hz travels though a fluid with an index of refraction of 1.44. How fast is the light traveling though the fluid?

**36** A beam of light travels though a dense sodium vapor at 260.00 m/s. What is the index of refraction of the sodium vapor?

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**37** A beam of light travels though a piece of plastic with an index of refraction of 1.85. What is the wavelength of this light in the plastic if its frequency in a vacuum is 760 nm?

**38** A beam of light has a wavelength of 0.950 mm while in a diamond (n=2.48). What is the energy of a single photon in the diamond?

**39** A photon travels though a piece of plastic with $6.63 \times 10^{-23}$ J of energy. What is the wavelength of light if the index of refraction is 1.49?

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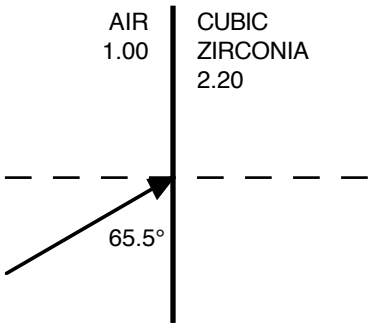
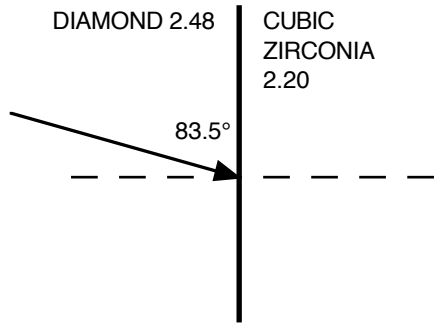
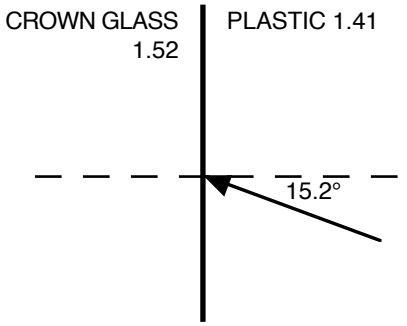
**40** A beam of light is incident on cubic zirconia. Draw the refracted ray and calculate its refraction angle.



**41** A beam of light is incident on cubic zirconia. Draw the refracted ray and calculate its refraction angle.




**42** A beam of light is incident on crown glass as shown. Draw the refracted ray and calculate its refraction angle.

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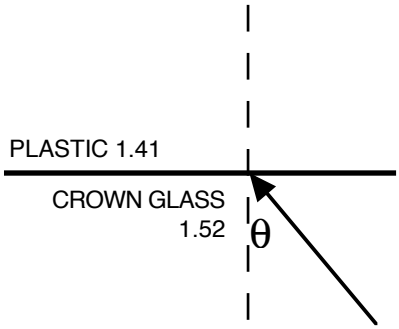
**43** What is the condition(s) for total internal reflection?

**44** What is the critical angle for the situation shown below?



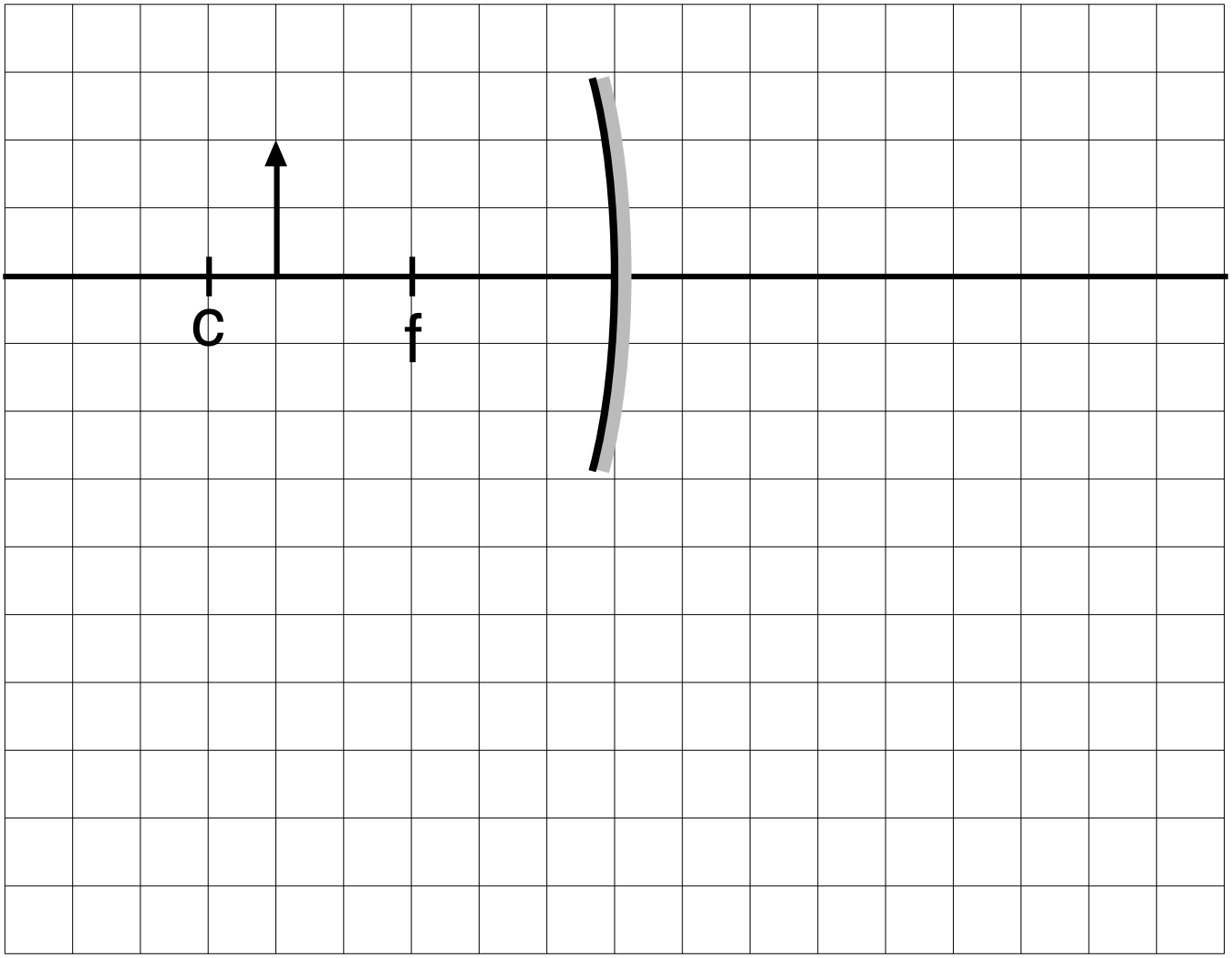
# Objectives

## Geometrical Optics: Spherical Mirrors

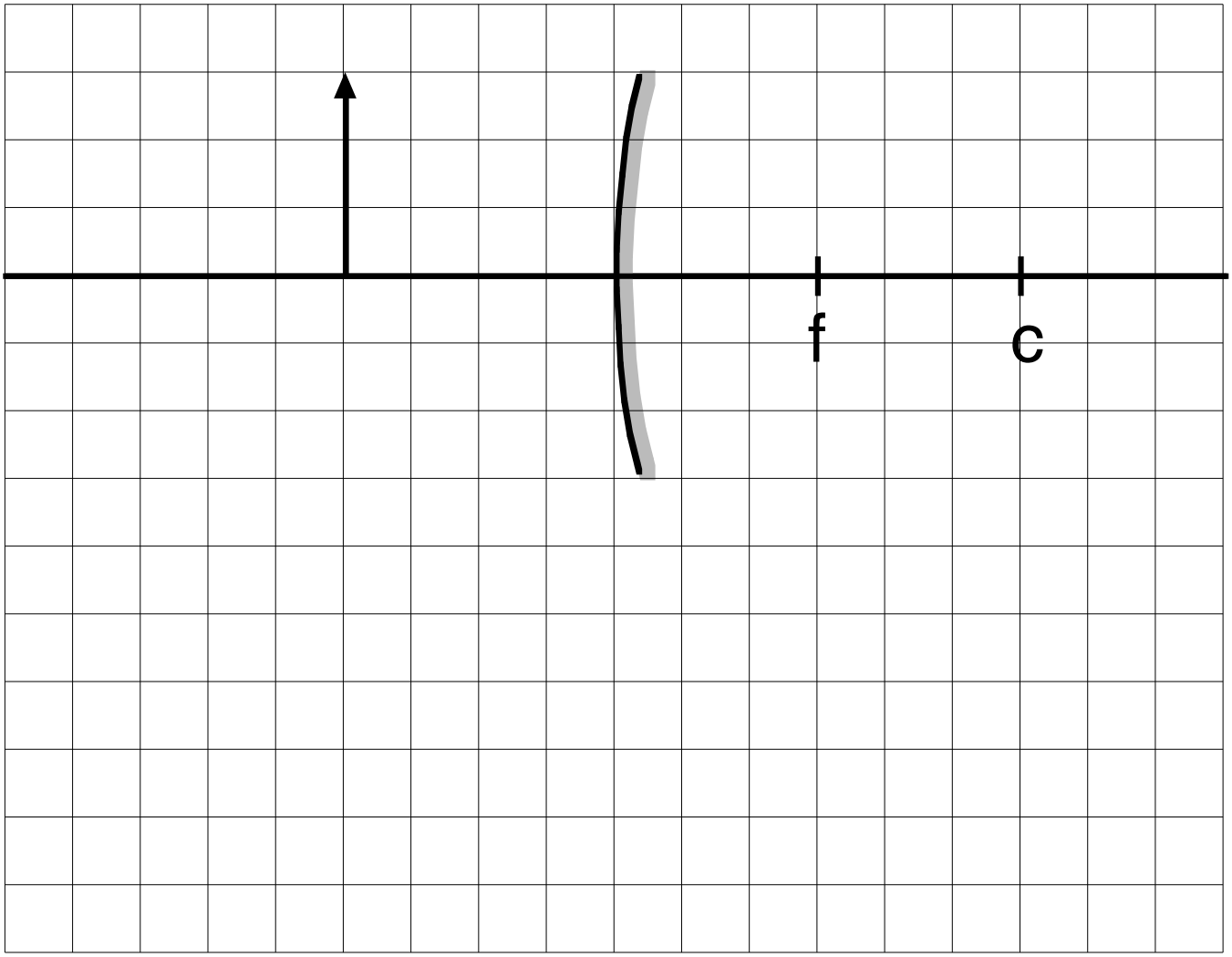
**Students will be able to:**

1. Draw the incident and reflection rays for plane, or spherical mirror.
2. Find the image in plane or spherical mirror.
3. Describe an image's magnification for a plane or spherical mirror.
4. Calculate an image's position for a plane or spherical mirror.
5. Draw all for possible incident/reflection rays for spherical mirror to visually locate an object's image.
6. Describe concave and convex mirrors' characteristics regarding image properties based on an object's location.

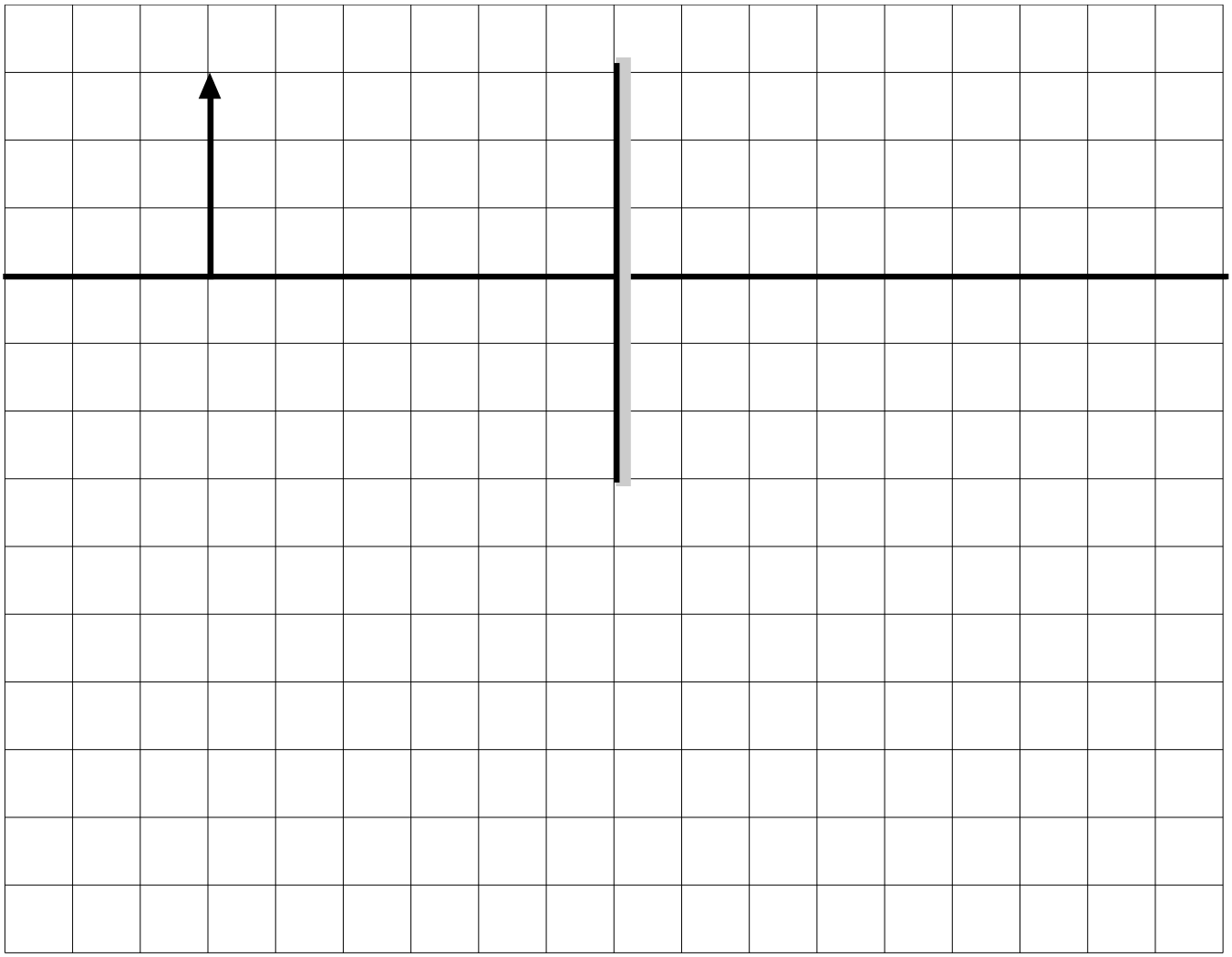
Concave Mirror



Convex Mirror



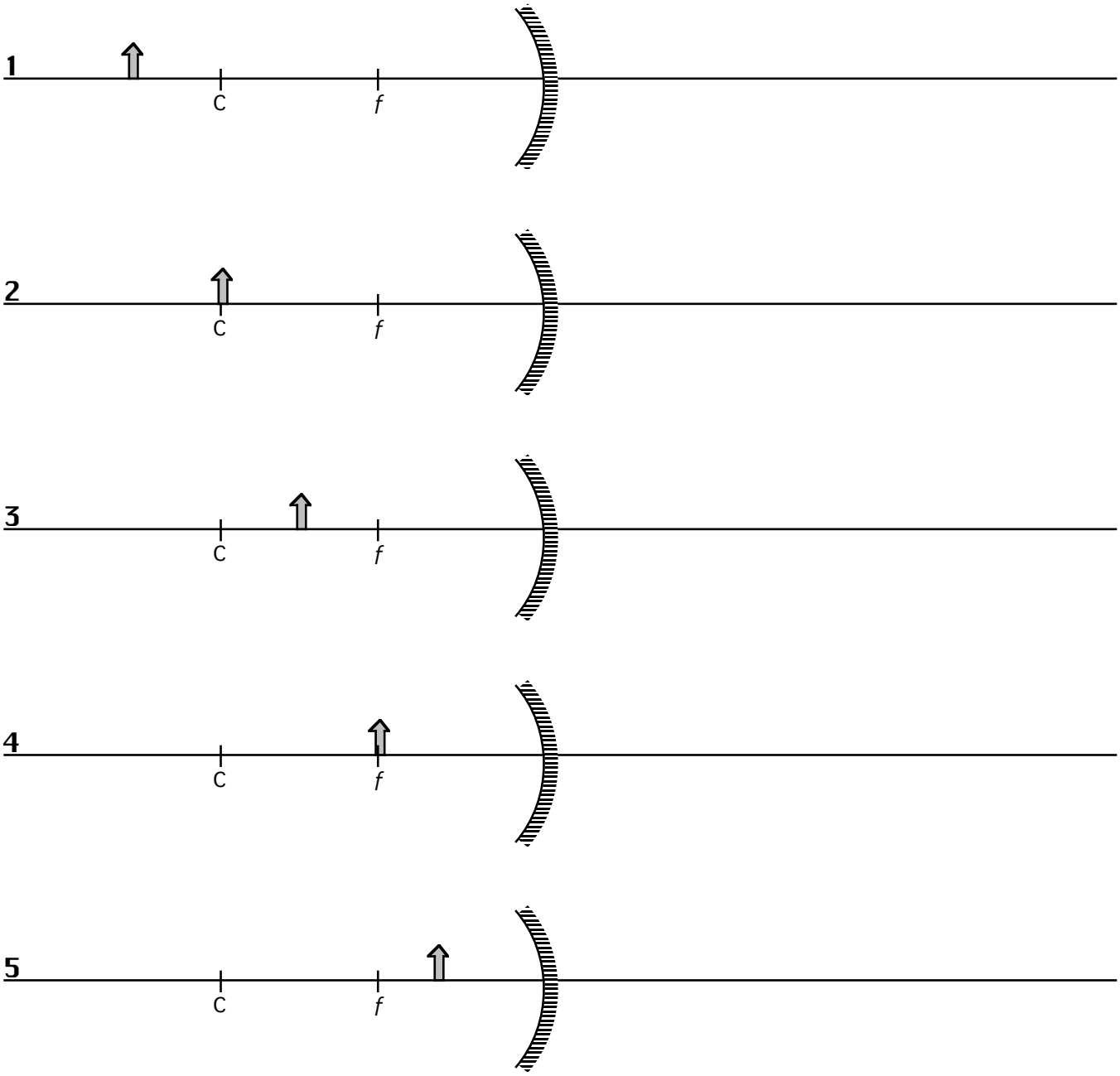
Plane mirror



# Geometrical Optics: Spherical Mirrors

For each object below, draw the position of its image as formed by the mirror using all thee rays when possible.

## CONCAVE MIRRORS

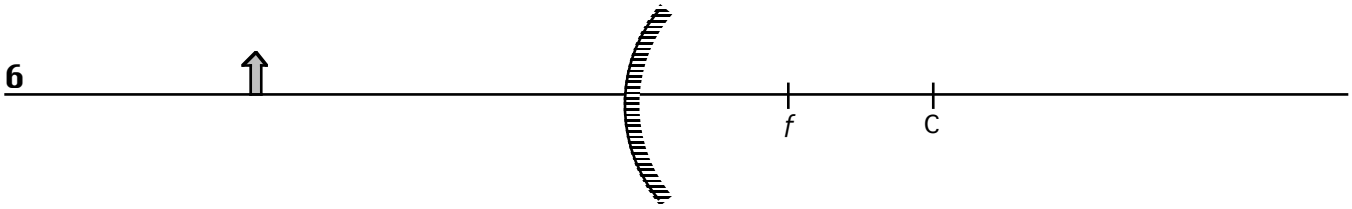


## Geometrical Optics: Spherical Mirrors

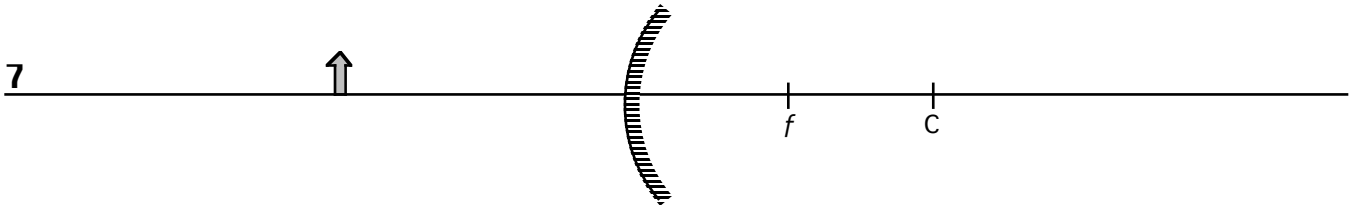
For each object below, draw the position of its image as formed by the mirror using all thee rays when possible.

**CONCAVE MIRRORS**

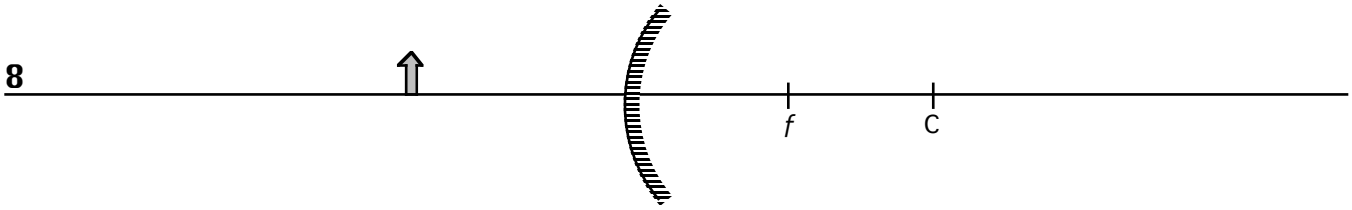
**6**



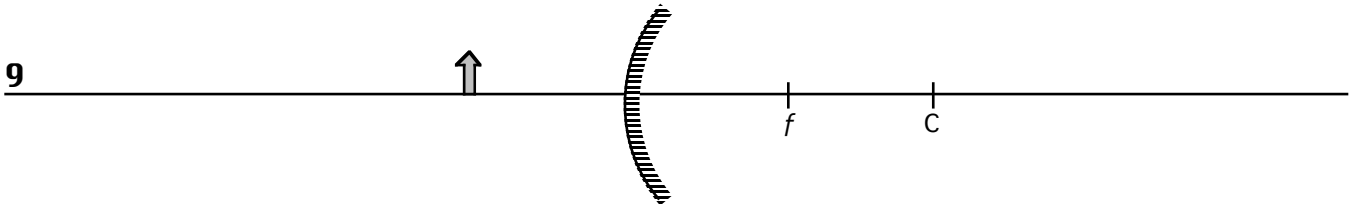

**7**



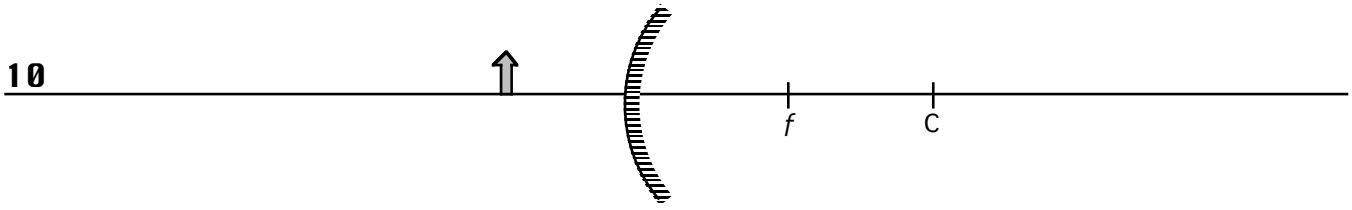

**8**



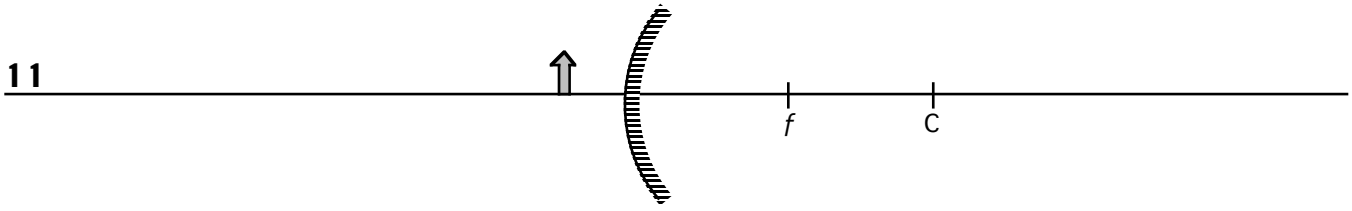

**9**




**10**

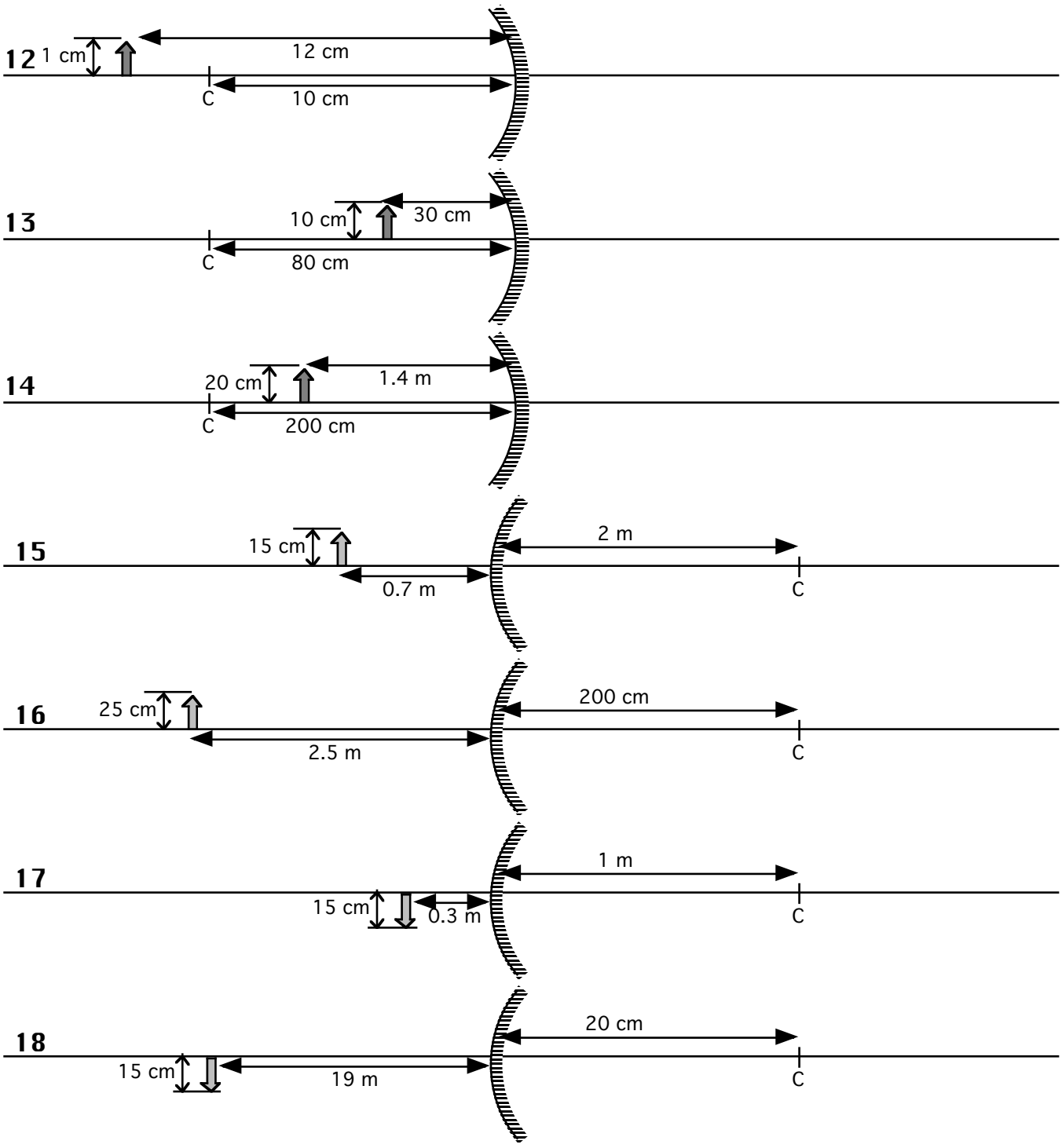



**11**



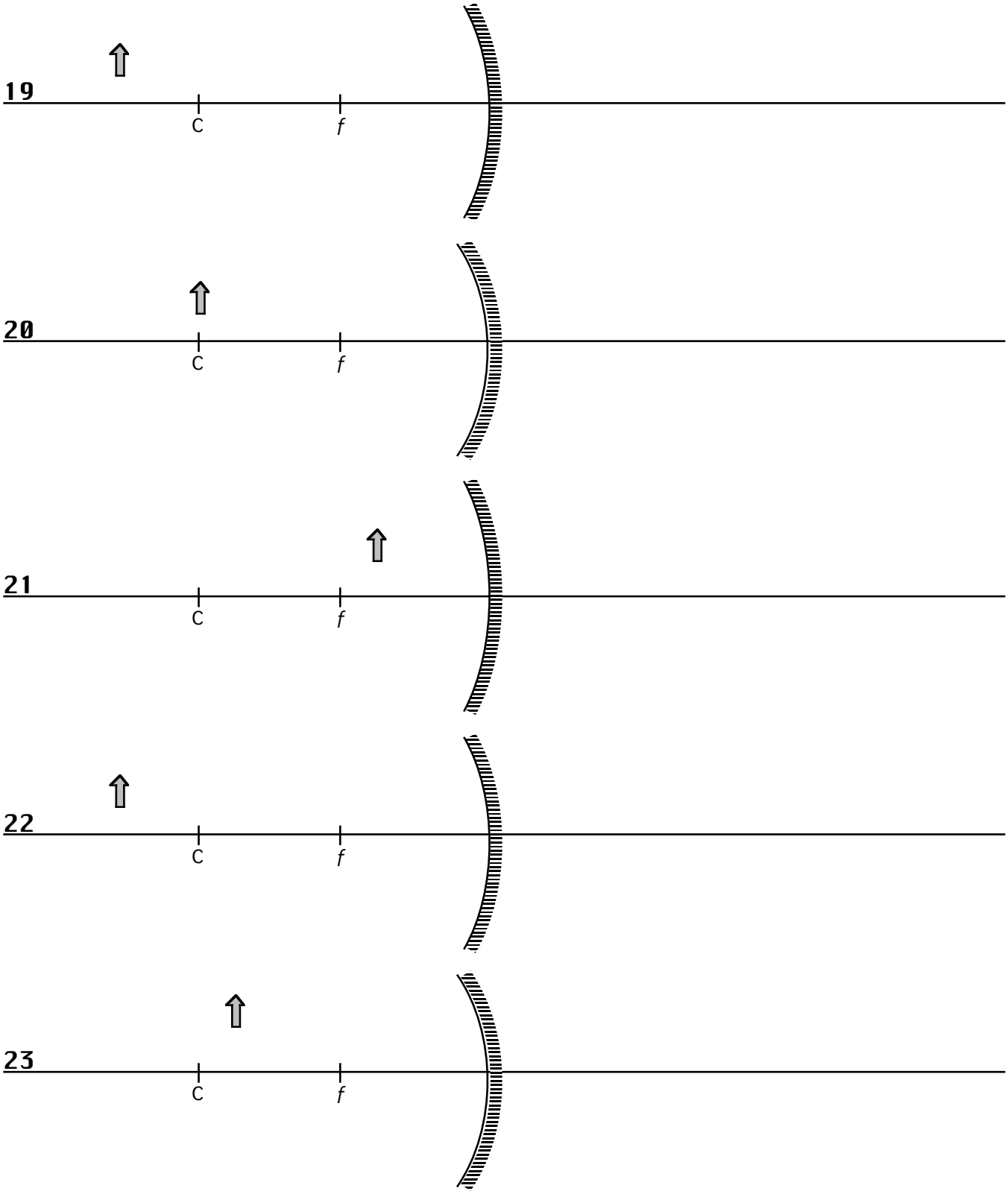
## Geometrical Optics: Spherical Mirrors

For the problems listed below. Calculate the image's distance, image height, (real or virtual) and its "invertedness."



## Geometrical Optics: Spherical Mirrors

Draw the location of the floating objects top and bottom. You do NOT need to use all 3 rays.



Use the "**Virtual Optics Bench**" at http://webphysics.davidson.edu/physlet_resources/dav_optics/Examples/optics_bench.html to help answer these questions. All the answers will not be found on this web page.

**24.** When is an image real?
**25.** When is an image virtual?
**26.** Where is an image placed when it is real?
**27.** Where is an image placed when it is virtual?
**28.** What is the minimum number of rays to draw to find an image?
**29.** What is a "virtual ray?"
**30.** Where on a diagram is the image located when "q" is negative?
**31.** Where on a diagram is the object located when "p" is positive?
**32.** What shape is a concave mirror?
**33.** What is the relationship between the center, radius and focus?
**34.** What is the sign of the focus when a mirror is a concave mirror?
**35.** What is the sign of the focus when a mirror is a convex mirror?
**36.** Which variable indicates a virtual image? How does it indicate a virtual image?
**37.** Which variable indicates a real image? How does it indicate a real image?
**38.** What is the minimum number of rays to draw to find an image?
**39.** Mathematically, when are "p" and "q" negative?
**40.** What are the four rules for drawing rays?
**41.** Which type of spherical mirror only has virtual images?
**42.** Which type of spherical mirror can produce an enlarged image?
**43.** Which type of mirror can produce an real image?
**44.** Where is an object located to produce a real image?
**45.** Where is an object located to produce an inverted image in a concave mirror?

**A "characteristic" is described by**

- **the magnification as being positive or negative**
- **the magnification as being less than, equal to, or greater than 1.**
- **p or q, as being positive or negative**
- **real or virtual**

**46.** What are the characteristics of an image when the object is at the center of a concave mirror?
**47.** What are the characteristics of an image when the object is between the center and focus of a concave mirror?
**48.** What are the characteristics of an image when the object is at the focus of a concave mirror?
**49.** What are the characteristics of an image when the object is at the inside of the focus of a concave mirror?
**50.** What are the characteristics of an image when the object is at the center of a convex mirror?
**51.** What are the characteristics of an image when the object is between the center and focus of a convex mirror?
**52.** What are the characteristics of an image when the object is at the focus of a convex mirror?
**53.** What are the characteristics of an image when the object is at the inside of the focus of a convex mirror?

**54.** A shiny glass Chistmas ornament in the shape of a ball is 10.0 cm in diameter. What is the magnification of an object placed 15 cm from the surface of the ball? Is the image upside-down or right-side up. Justify your answer?

**55.** A makeup mirror is labeled as 5X magnification. The image is upright like the object. How far away from your eye (1.5 cm in height) does the mirror need to be held so the image is 7.5 cm tall?

**56.** When driving a car around a sharp 90° blind corner, sometimes you will see a round mirror that shows you the traffic on the other road. The image appears upright and on the other side of the mirror. What is the focal length of this mirror if the your car's image appears to be 5 m away then your car is 7.5 meters away from the mirror?

**57.** The focal length of a concave mirror is 17 cm. An object is located 38 cm in front of this mirror. Where is the image located?

**58.** A clown is using a concave makeup mirror to get ready for a show and is 27 cm in front of the mirror. A virtual image is formed 65 cm from the mirror. Find (a) the focal length of the mirror and (b) its magnification. (c) Is this a convex or concave mirror?

**59.** The image behind a convex mirror (radius of curvature = 68 cm) is located 22 cm from the mirror. (a) Where is the object located arid (b) what is the magnification of the mirror? Determine whether the image is (c) upright or inverted and (d) larger or smaller than the object.

**60.** Convex minors are being used to monitor the aisles in a store. The mirrors have a radius of curvature of 4.0 m. (a) What is the image distance if a customer is 15 m in front of the mirror? (b) Is the image real or virtual? (c) If a customer is 1.6 m tall, how tall is the image?

**61.** A dentist's mirror is placed 2.3 cm from a tooth. The enlarged virtual image is located 5.1 cm from the mirror. (a) What kind of mirror (plane, concave, or convex) is being used? (b) Determine the focal length of the mirror. (c) What is the magnification? (d) How is the image oriented relative to the object?

**62.** A small postage stamp is placed in front of a concave mirror (radius = R), such that the image distance equals the object distance. (a) In terms of R, what is the object distance? (b) What is the magnification of the mirror? (c) State whether the image is upright or inverted relative to the object.

**63.** A concave shaving mirror is designed so the virtual image is twice the size of the object, when the distance between the object and the mirror is 20 cm. Determine the radius of curvature of the mirror.

# Mirrors Summary

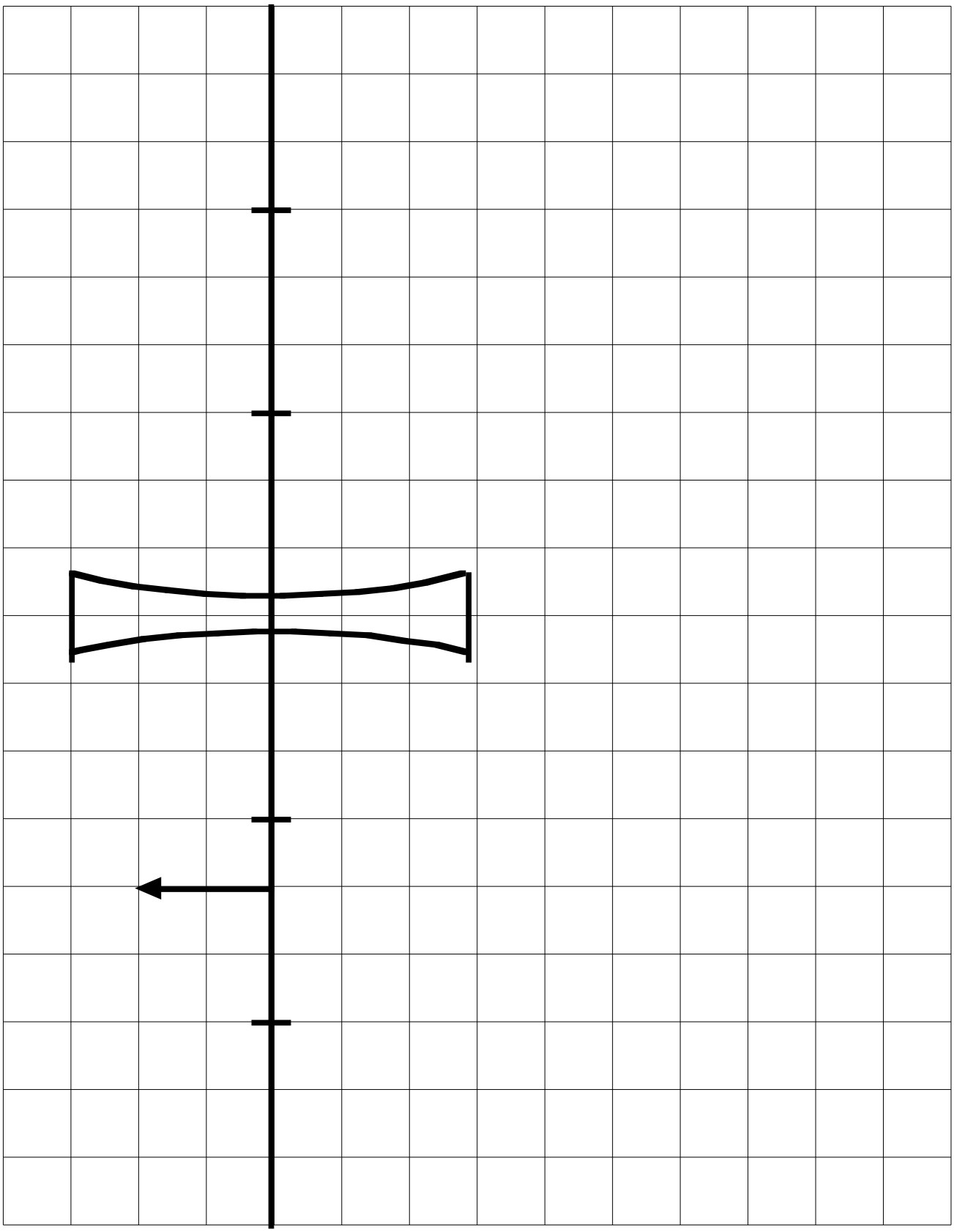
| Converging Mirror | Focal length's sign is … | | |
|---|---|---|---|
| | Image real or virtual | Image upright or inverted | Image magnification |
| For images where p > f | | | |
| For images where p = f | | | |
| For images where p < f | | | |
| **Diverging Mirror** | Focal length's sign is … | | |
| | Image real or virtual | Image upright or inverted | Image magnification |
| For images where p > f | | | |
| For images where p = f | | | |
| For images where p < f | | | |

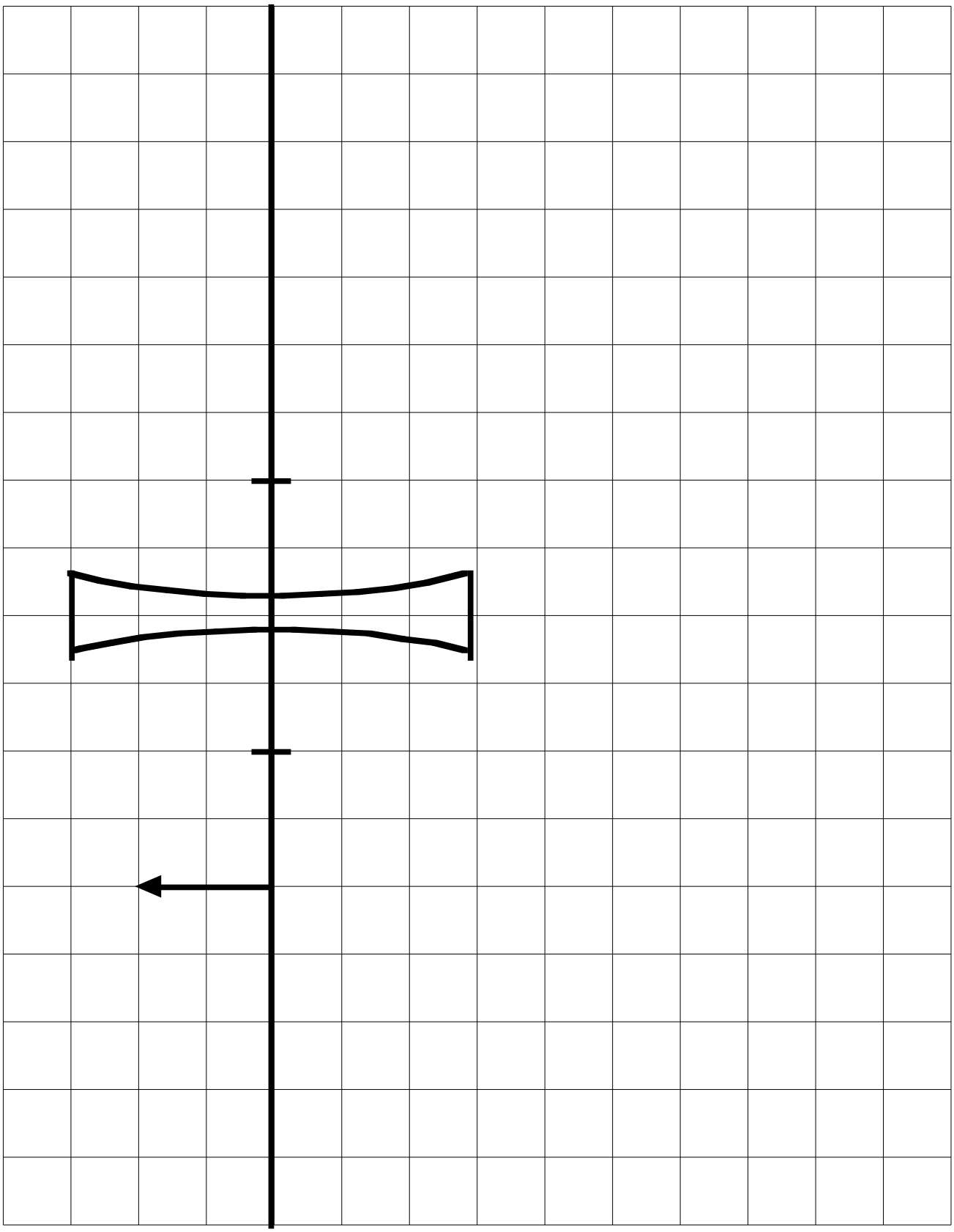
# Objectives

## Geometrical Optics: Spherical Thin Lenses

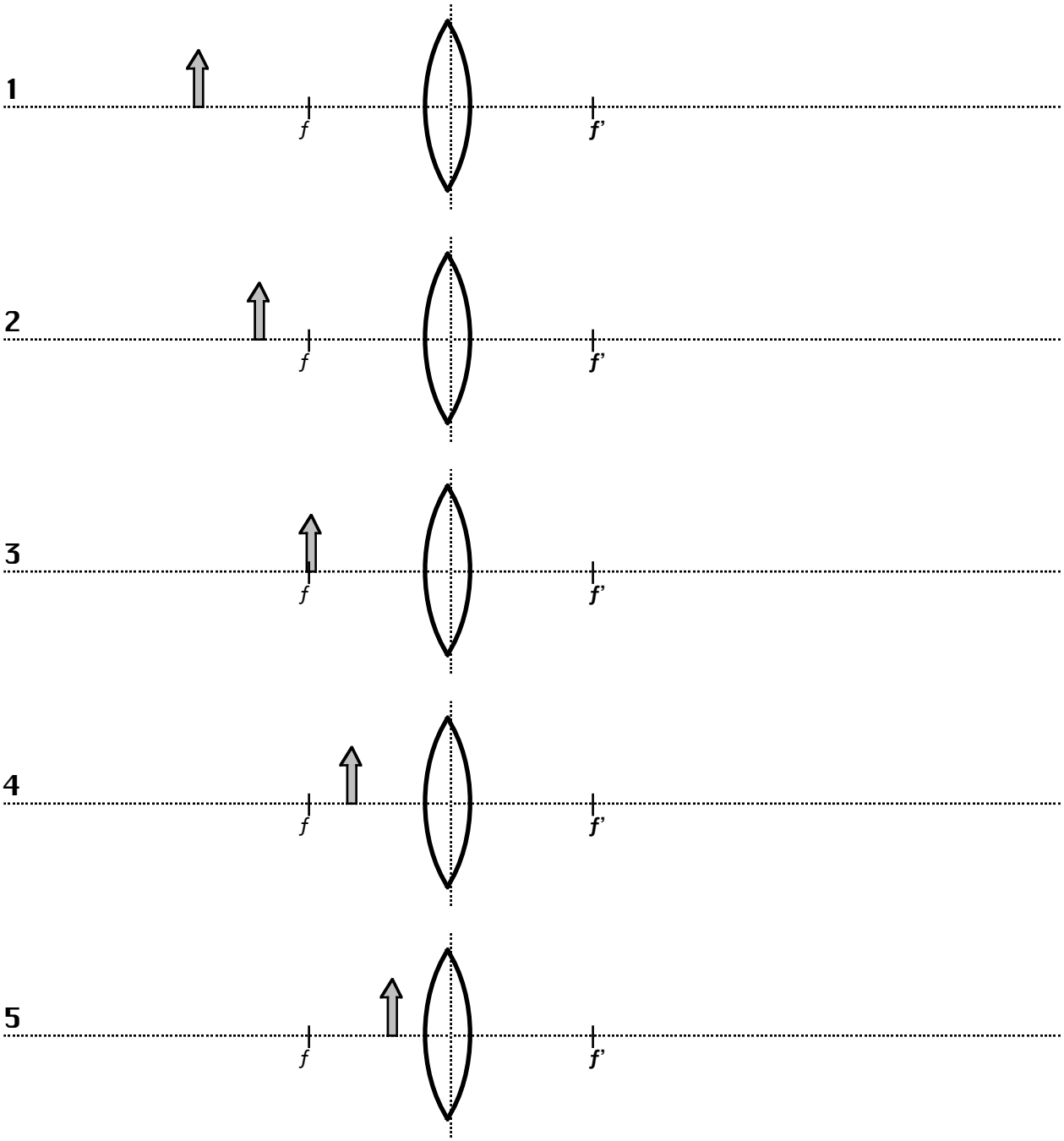
**Students will be able to:**

1. Draw the incident and refraction light rays for converging and diverging lenses.
2. Find the image in a converging or diverging lens.
3. Describe an image's magnification for converging and diverging lenses.
4. Calculate an image's position for converging and diverging lenses.
5. Draw all for possible incident and refraction rays for converging and diverging lenses to visually locate an object's image.
6. Describe converging and diverging lens characteristics regarding image properties based on an object's location.

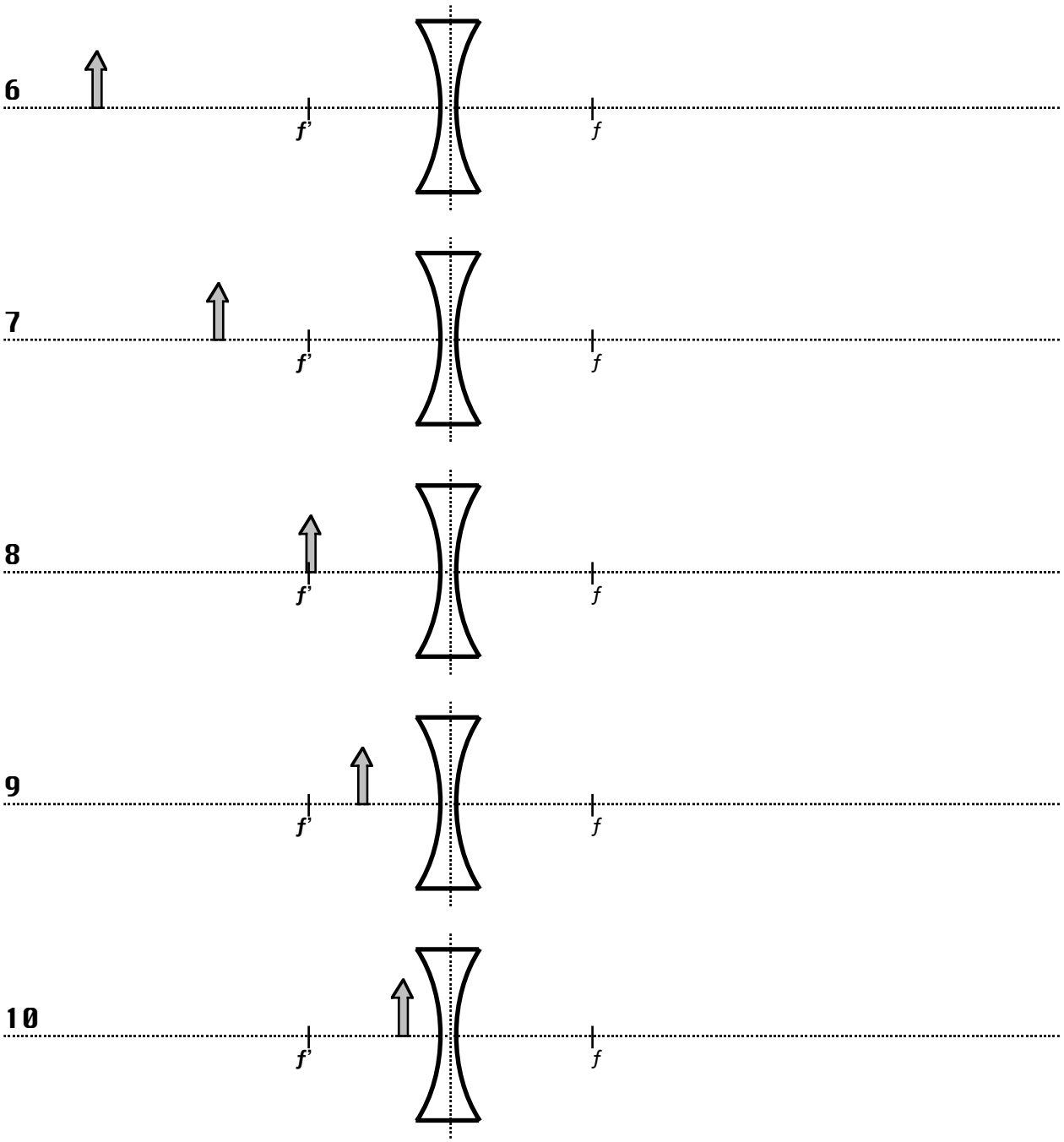




Draw the location of the object using the 3 rays for lenses.




**What trends in the image's location, height do you see happening as the object moves towards the lenses?**




**What trends in the image's location, height do you see happening as the object moves towards the lenses?**

# LENSES SUMMARY

| CONVERGING LENS | Focal length's sign is … | | |
|---|---|---|---|
| | Image real or virtual | Image upright or inverted | Image magnification |
| For images where p > f | | | |
| For images where p = f | | | |
| For images where p < f | | | |

| DIVERGING LENS | Focal length's sign is … | | |
|---|---|---|---|
| | Image real or virtual | Image upright or inverted | Image magnification |
| For images where p > f | | | |
| For images where p = f | | | |
| For images where p < f | | | |

# Objectives

## Fluid Dynamics

**Students will be able to:**

1. Define pressure mathematically and in words.
2. Define density mathematically and in words.
3. Define what affects pressure at a known depth.
4. Describe static pressure at a known depth.
5. Define Bernoulli's equation for the flow of a fluid.
6. Define the flow rate two ways.
7. Identify and interpret the implied givens associated with fluid flow and pressure situations.
8. Solve problems using all the concepts listed above