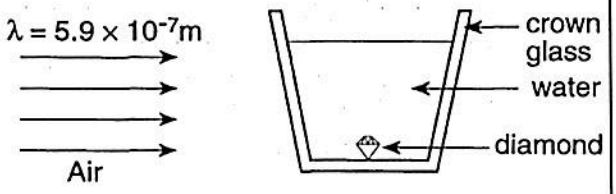
1. In the diagram below, monochromatic light ($l = 5.9 \times 10^{-7}$ meter) in air is about to travel through crown glass, water, and diamond.



(not drawn to scale)

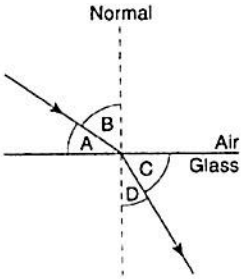
In which substance does the light travel the slowest?

(1) air (3) water
(2) diamond (4) crown glass

2. Parallel light rays are incident on the surface of a plane mirror. Upon reflection from the mirror the light rays will

(1) converge (3) be parallel
(2) diverge (4) be scattered

3. A light ray passes from air into glass as shown in the diagram below.



Which relationship represents the index of refraction of the glass?

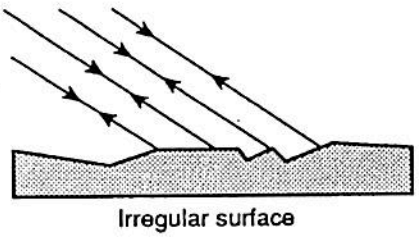
(1) $\frac{\sin A}{\sin C}$ (3) $\frac{\sin B}{\sin C}$
(2) $\frac{\sin A}{\sin D}$ (4) $\frac{\sin B}{\sin D}$

4. Refraction of a wave is caused by a change in the wave's

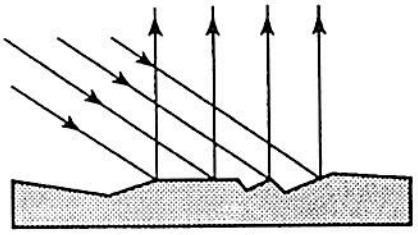
5. The speed of light in a material is 2.5×10^8 meters per second. What is the absolute index of refraction of the material?

6. Which diagram best represents the reflection of light from an irregular surface?

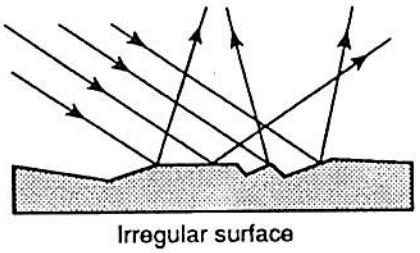
(1)



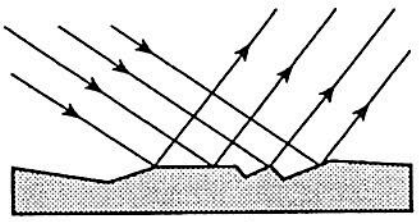
(2)



(3)



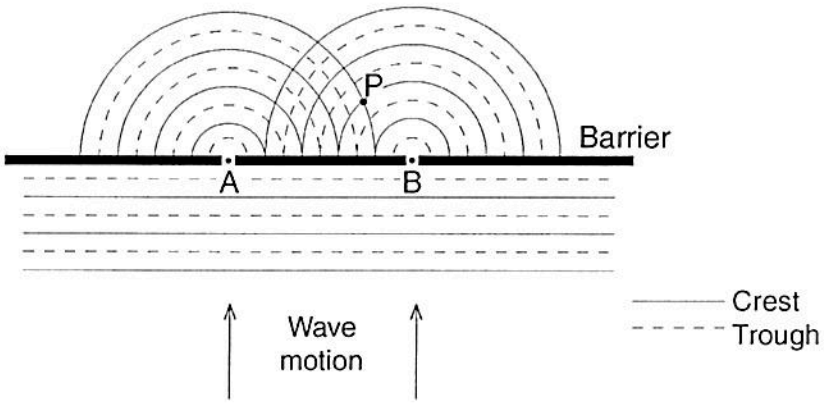
(4)



7. When a pulse traveling in a medium strikes the boundary of a different medium, the energy of the pulse will be

(1) completely absorbed by the boundary
(2) entirely transmitted into the new medium
(3) entirely reflected back into the original medium
(4) partly reflected back into the original medium and partly transmitted or absorbed into the new medium

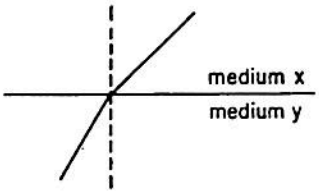
8. The diagram below represents shallow water waves of wavelength λ passing through two small openings, *A* and *B*, in a barrier.



How much longer is the length of path *AP* than the length of path *BP*?

(1) 1λ (2) 2λ (3) 3λ (4) 4λ

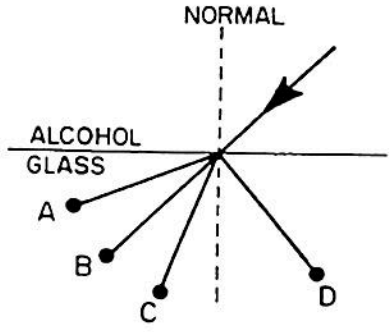
9. The accompanying diagram represents a light ray passing from one medium into another.



The light ray must be traveling

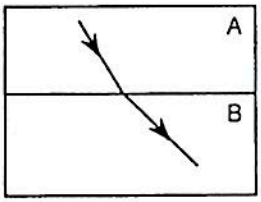
(1) from medium x into medium y
(2) from medium y into medium x
(3) faster in medium x than in medium y
(4) faster in medium y than in medium x

10. The diagram below represents a light ray passing from alcohol into glass. Through which point will the ray most likely pass?



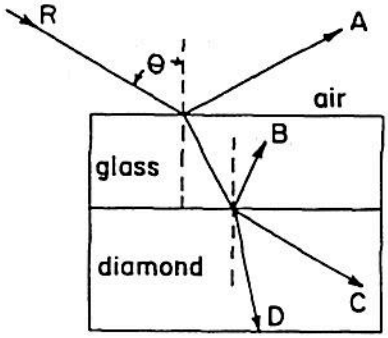
(1) *A* (3) *C*
(2) *B* (4) *D*

11. The diagram at the right represents the path of periodic waves passing from medium *A* into medium *B*. As the waves enter medium *B*, their speed



(1) decreases (3) remains the same
(2) increases

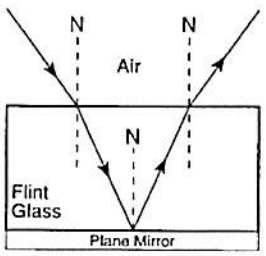
12. The ray *R* of monochromatic yellow light shown in the diagram is incident upon a glass surface at an angle of θ. Which resulting ray is *not* possible?

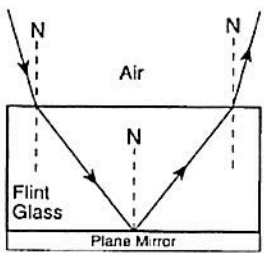


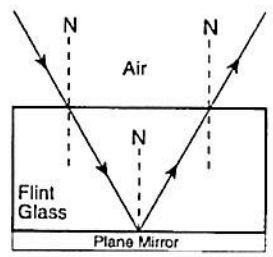
(1) *A* (3) *C*
(2) *B* (4) *D*

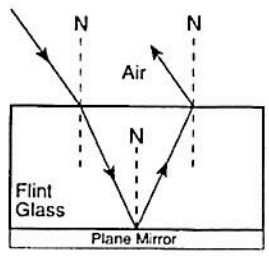
13. A beam of light crosses a boundary between two different media. Refraction can occur if
    (1) the angle of incidence is 0°
    (2) there is no change in the speed of the wave
    (3) the media have different indices of refraction
    (4) all of the light is reflected

14. A ray of monochromatic light traveling in air enters a rectangular glass block obliquely and strikes a plane mirror at the bottom. Then the ray travels back through the glass and strikes the air-glass interface. Which diagram below best represents the path of this light ray? [N represents the normal to the surface.]

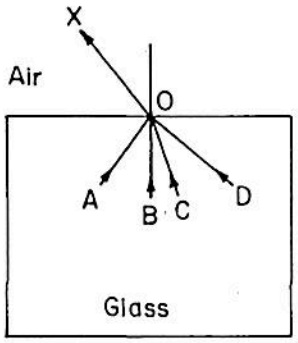
(1)


(2)


(3)


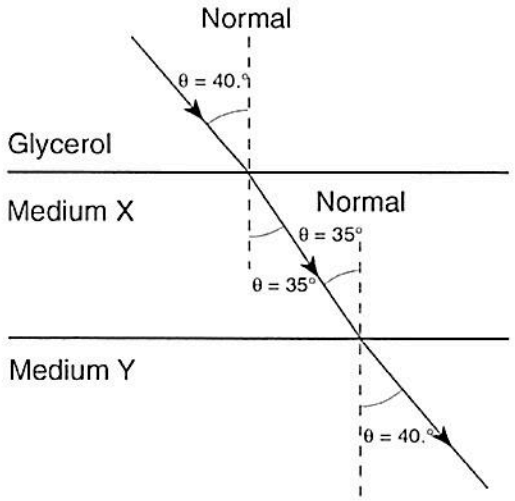
(4)


15. In the diagram shown below, at which point did the refracted ray *OX* originate?



(1) *A* (3) *C*
(2) *B* (4) *D*

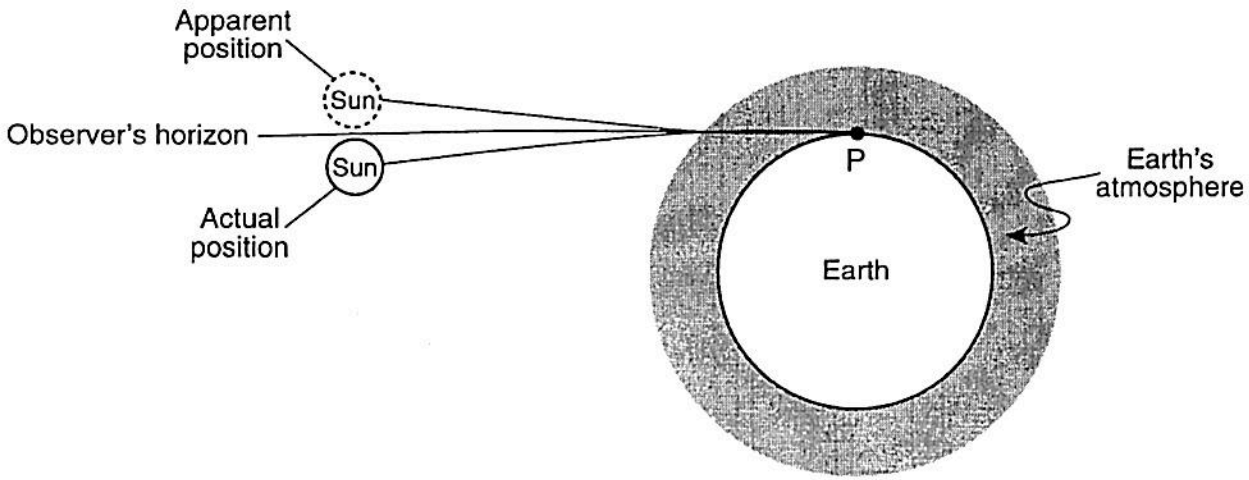
16. A beam of monochromatic light ($f = 5.09 \times 10^{14}$ hertz) passes through parallel sections of glycerol, medium *X*, and medium *Y* as shown in the diagram below.



What could medium *X* and medium *Y* be?
(1) *X* could be flint glass and *Y* could be corn oil.
(2) *X* could be corn oil and *Y* could be flint glass.
(3) *X* could be water and *Y* could be glycerol.
(4) *X* could be glycerol and *Y* could be water.

17. When a light wave enters a medium of greater optical density, there will be a decrease in the wave's
    (1) speed, only
    (2) frequency, only
    (3) speed and wavelength
    (4) frequency and wavelength

18. The diagram below shows how an observer located at point *P* on Earth can see the Sun when it is below the observer's horizon.



(not drawn to scale)

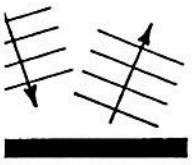
This observation is possible because of the ability of Earth's atmosphere to
(1) reflect light (2) diffract light (3) refract light (4) polarize light

19. Which diagram best illustrates wave refraction?

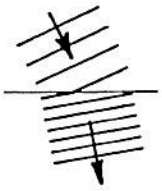
(1)

(3)

(2)

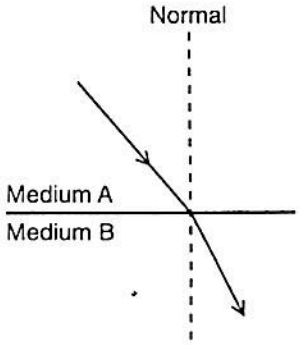


(4)



20. As a periodic wave travels from one medium to another, which pair of the wave's characteristics cannot change?
(1) period and frequency
(2) period and amplitude
(3) frequency and velocity
(4) amplitude and wavelength

21. The diagram below shows a ray of light passing through two media.

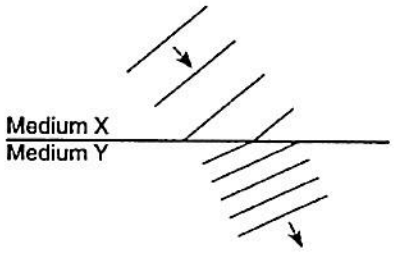


When the wave travels from medium *A* into medium *B*, its speed
(1) decreases (3) remains the same
(2) increases

22. Periodic waves with a wavelength of 0.05 meter move with a speed of 0.30 meter per second. When the waves enter a dispersive medium, they travel at 0.15 meter per second. What is the wavelength of the waves in the dispersive medium?

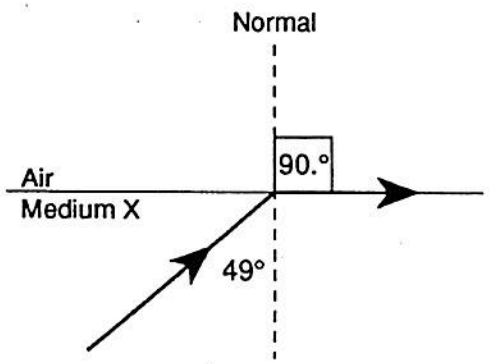
23. What occurs when light passes from water into flint glass?
    (1) Its speed decreases, its wavelength becomes shorter, and its frequency remains the same.
    (2) Its speed decreases, its wavelength becomes shorter, and its frequency increases.
    (3) Its speed increases, its wavelength becomes longer, and its frequency remains the same.
    (4) Its speed increases, its wavelength becomes longer, and its frequency decreases.

24. The diagram below represents wave fronts traveling from medium *X* into medium *Y*.



All points on any one wave front shown must be
(1) traveling with the same speed
(2) traveling in the same medium
(3) in phase
(4) superposed

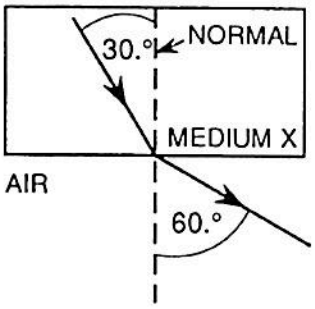
25. In the diagram below, a ray of monochromatic light ($\lambda = 5.9 \times 10^{-7}$ meter) reaches the boundary between medium **X** and air and follows the path shown.



Which medium is most likely medium **X**?

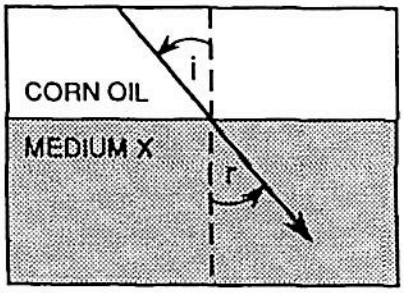
26. A ray of light (λ = 5.9 x 10-7 meter) traveling in air is incident on an interface with medium X at an angle of 30°. The angle of refraction for the light ray in medium X is 12.°. Medium X could be

27. The diagram below shows a ray of light passing from medium *X* into air.



What is the absolute index of refraction of medium *X*?

28.

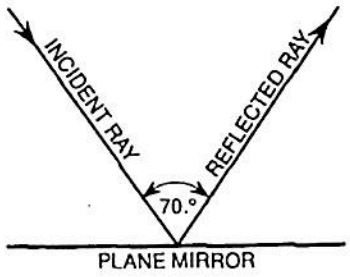


In this diagram, medium *X* could be

29. A monochromatic ray of light ($f = 5.09 \times 10^{14}$ hertz) traveling in air is incident upon medium A at an angle of 45°. If the angle of refraction is 29°, medium A could be

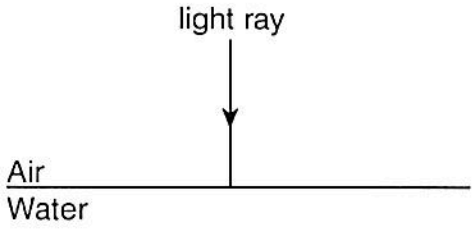
30. When a ray of light strikes a mirror perpendicular to its surface, the angle of reflection is

31. The diagram below represents a light ray being reflected from a plane mirror. The angle between the incident ray and the reflected ray is 70.°.



What is the angle of incidence for this ray?

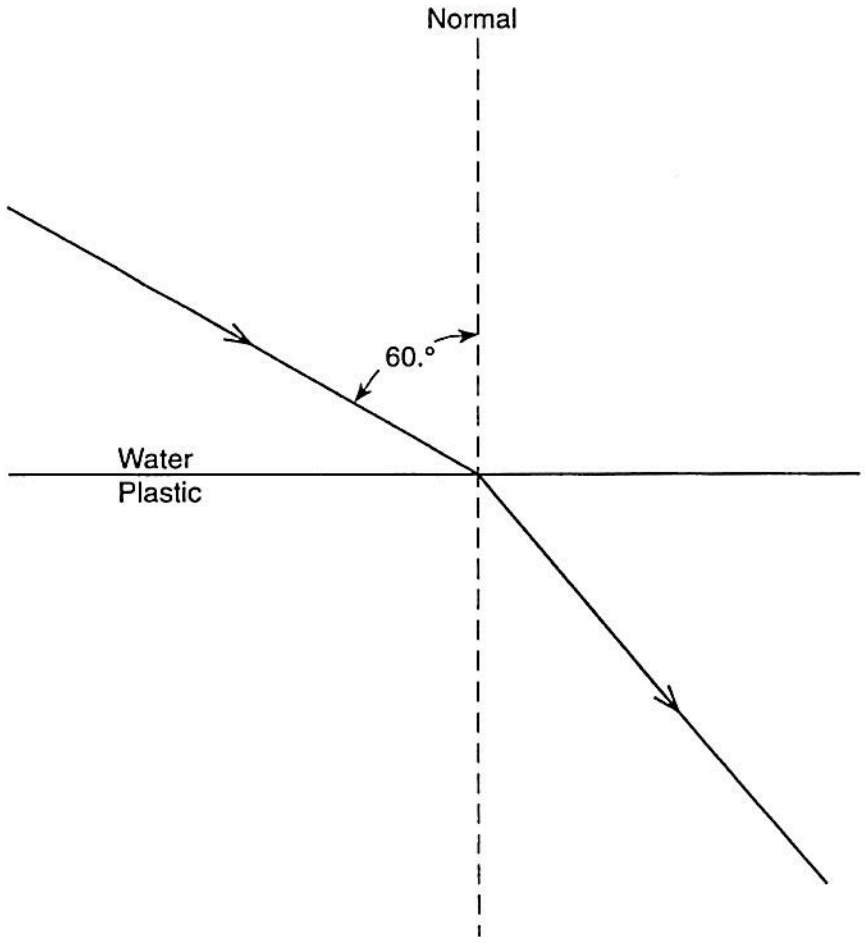
1. A ray of light traveling in air is incident on an air-water boundary as shown below.



On the diagram above, draw the path of the ray in the water.

2. Determine the color of a ray of light with a wavelength of 6.21×10^{-7} meter.

Base your answers to questions **3** and **4** on the diagram below, which shows a light ray in water incident at an angle of 60.° on a boundary with plastic.

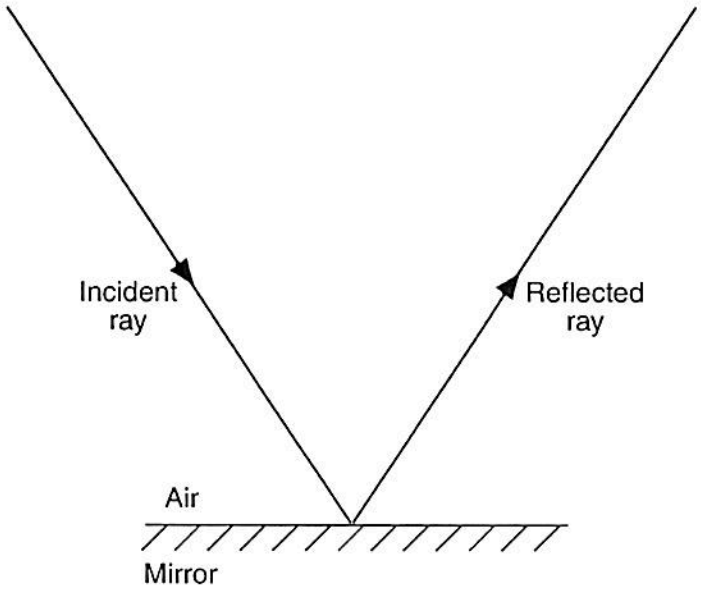


3. Using a protractor, measure the angle of refraction to the *nearest degree*.

4. Determine the absolute index of refraction for the plastic.
[Show all calculations, including the equation and substitution with units.]

Base your answers to questions **5** and **6** on the diagram below.

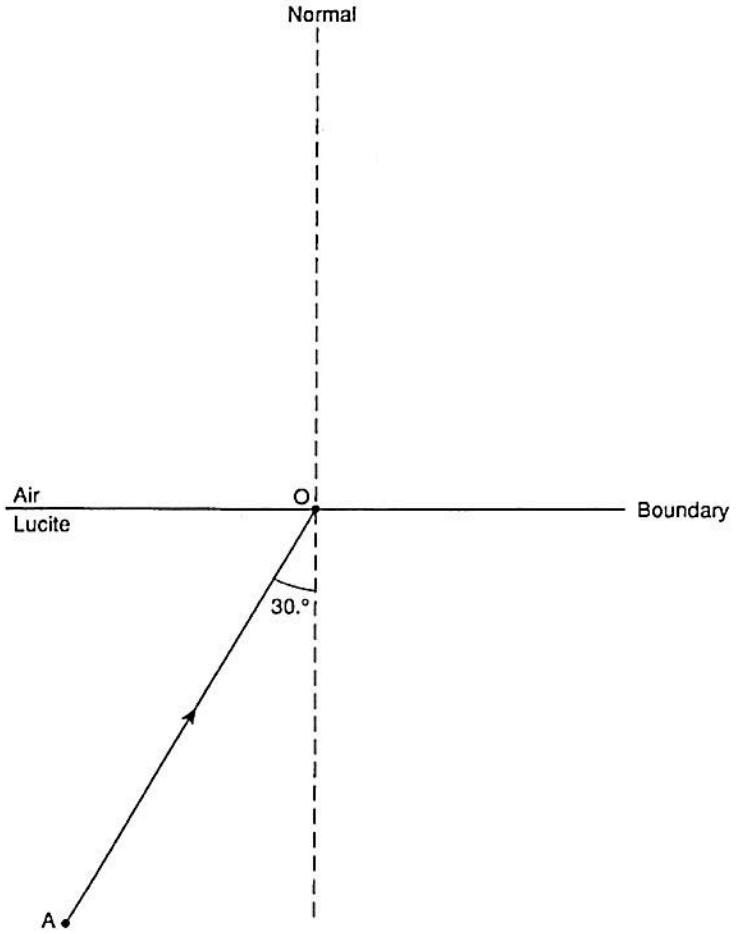
A ray of monochromatic light of frequency 5.00×10^{14} hertz is incident on a mirror and reflected, as shown.



5. Using a protractor, measure the angle of incidence to the nearest degree.

Using a protractor and ruler, construct and label the normal to the mirror at the point of incidence on the diagram.

Base your answers to questions **7** and **8** on the diagram below, which shows light ray AO in Lucite. The light ray strikes the boundary between Lucite and air at point 0 with an angle of incidence of 30.'. The dotted line represents the normal to the boundary at point 0.



7. Calculate the angle of refraction for incident ray AO. [Show all calculations, including the equation and substitutions with units.]

8. On the diagram, using your answer from question 121, construct an arrow with a protractor and straightedge, to represent the refracted ray.

Base your answers to questions **9** and **10** on the information below.

A 0.12-meter-long electromagnetic (radar) wave is emitted by a weather station and reflected from a nearby thunderstorm.

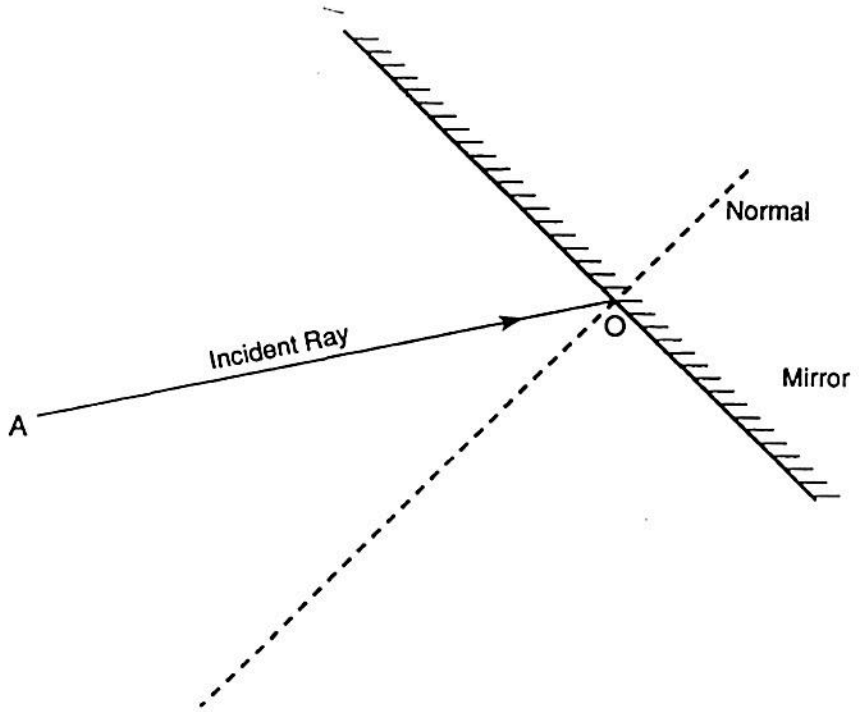
9. Using one or more complete sentences, define the Doppler effect.

10. The thunderstorm is moving toward the weather station. Using one or more complete sentences, explain how the Doppler effect could have been used to determine the direction in which the storm is moving.

---

11. Base your answers to parts a through c on the information and diagram below.

A ray of light AO is incident on a plane mirror as shown.



a Using a protractor, measure the angle of incidence for light ray AO and record the value.

b What is the angle of reflection of the light ray?

c Using a protractor and straightedge, construct the reflected ray.