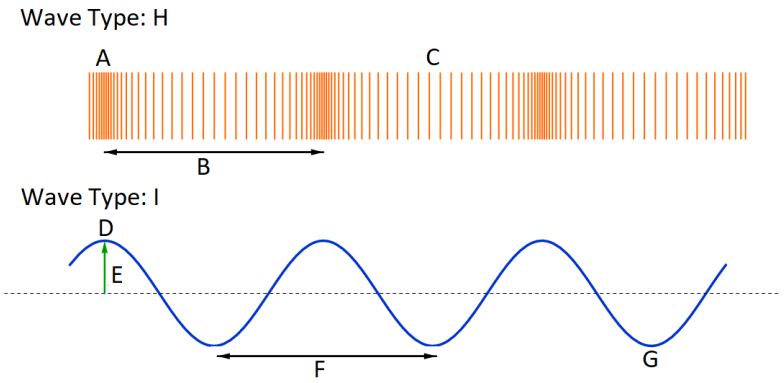
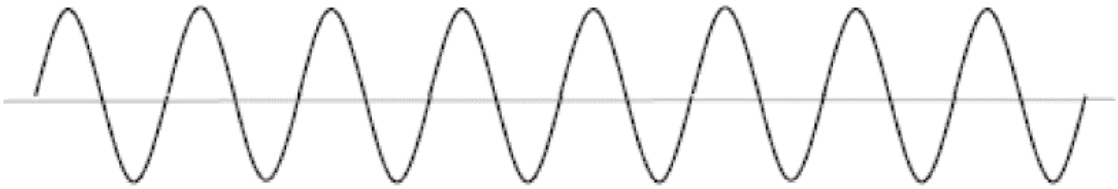
Properties of Waves – Unit Practice Problems

Wave Terminology

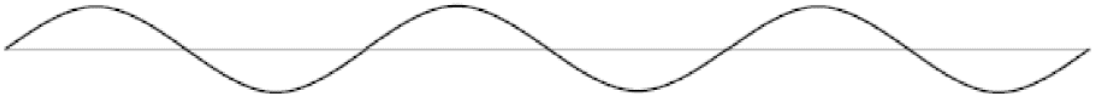
1. For the two waves below, write the correct term (or terms) to describe part of the wave at each letter.



2. For each wave, use a ruler to measure the amplitude, wavelength and time for one pulse to occur. The length of time from the beginning to the end of the line (the "wave train") is <u>one second</u>.
   a. Wave 1:



   b. Wave 2:



3. For the two waves in Question 2, compare them in terms of amplitude, frequency and wavelength.
4. Explain the difference between the terms "wave" and "pulse".
5. A wave occurs when particles in a medium are displaced from their rest (equilibrium) state.
   a. Define parallel and perpendicular.
   b. Use these words to explain the difference between transverse and longitudinal waves.
6. Sketch two transverse waves that have the same amplitude but different wavelengths.
7. Sketch two longitudinal waves that have different wavelengths.
8. "Domino Toppling" is one entry in the Guinness Book of World Records. The event involves setting up a large number of dominoes, then letting the fall. Is the disturbance along a line of dominoes transverse, longitudinal or both? Explain.
9. Consider fans at a sporting event doing the wave.
   a. Explain how this is a great model for waves at the particle level.
   b. What type of wave is this modelling? Why?

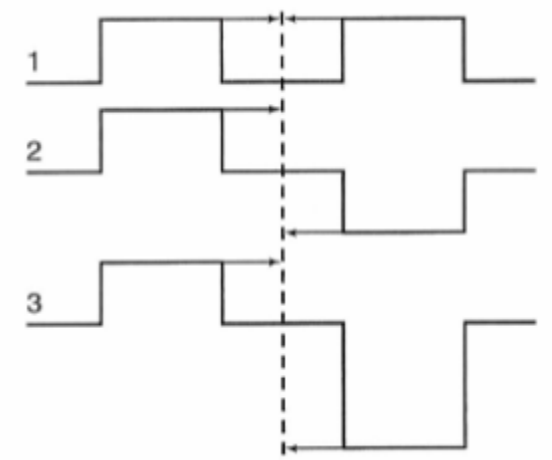
Universal Wave Equation

1. Imagine a drop of water is falling from a tap into a sink full of water, and circular waves are being formed. What happens to the wavelength if the drops fall faster?

2. Calculate the frequency for each of the following periods:
   a. 6.0 s b. 9.5×10^{-2} s c. 9.32×10^{-5} s
3. Calculate the period for each of the following frequencies:
   a. 11 Hz b. 508 Hz c. 0.27 Hz
4. Sound travels at 5600 m/s through a steel rod. If the frequency of the wave is 1982 Hz, what is the wavelength?
5. What is the speed of a wave that has a frequency of 0.78 Hz and a wavelength of 0.39 m?
6. A pendulum swings back and forth 48 times in 6.0 seconds.
   a. What is the period of the pendulum?
   b. What is the frequency?
   c. If the wavelength of the pendulum is 38 cm (a swing in one direction is 19 cm), what speed is it traveling?
7. A spring moves up and down 152 times in 57 seconds. The distance the spring travels in one full up and down motion is 2.1 metres.
   a. What is the frequency of the wave created by the spring's motion?
   b. What is the period?
   c. At what speed is the spring moving?
   d. How far does the end of the spring travel in 35 seconds?
8. In one minute, a boat tethered in the marina bobs up and down 17 times.
   a. What is the frequency of the waves?
   b. In the time it takes one wave to travel from the boat to the shore, a distance of 8.6 m, the boat bobs up and down eight times. What is the wavelength of the waves?
   c. What speed are the water waves travelling?
   d. How long does it take for a wave to get from the boat to the shore?
9. A sound wave of wavelength 0.60 m and a velocity of 330 m/s is produced for 0.50 s.
   a. What is the frequency of the wave?
   b. How many complete waves are emitted in this time?
   c. After 0.50 s, how far is the front of the wave from the source of the sound?
10. A yodeler sings a note towards a flat cliff that is 622 m away. She hears the echo 3.75 s later.
    a. What speed is the wave travelling? (Hint: the sound has to go to the cliff and back for the yodeler to hear it.)
    b. The yodeler sings the same note towards a cliff in a different direction, and hears the echo 2.92 s later. How far away is the cliff?
11. The speed of sound in water is 1498 m/s. A sonar signal is sent straight down from a ship at the surface of the water and 1.80 s later, the reflected signal is detected. How deep is the water?

One-Dimensional Wave Behaviour

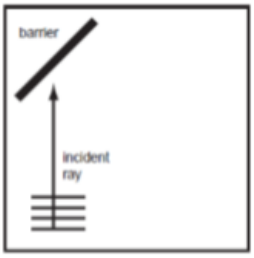
1. Waves are sent along a spring of fixed length.
   a. Can the speed of the waves in the spring be changed? Explain.
   b. Can the frequency of the waves in the spring be changed? Explain.
2. A transverse wave pulse is sent down a spring. The end of the spring is free to move along a post.
   a. Describe what the pulse will look like after it reflects back along the spring.
   b. How would the pulse be different if someone were holding the opposite end of the spring?
3. A wave crosses a boundary between a thin rope and a thick rope. Explain what happens to the speed of the wave, the wavelength, the amplitude, and the frequency.
4. Sketch the result for each of the three cases shown below, when the centres of each approaching pulse lie on the dashed lines (when the pulses exactly overlap). Identify each as constructive or destructive interference.



5. *Challenge Question*: Amplitude of a wave pulse along a string should, ideally, remain constant until the pulse is reflected or refracted. During the slinky lab, you should have observed that this is not the case. Explain why.

Two-Dimensional Wave Behaviour

1. Write the correct term for each definition:
   a. Amplitudes of different waves combine to form a new wave pattern.
   b. The angle at which a wave approaches a barrier.
   c. A wave moves from one medium to another.
   d. The path of waves after they bounce off a barrier.
   e. Waves bouncing off a barrier.
   f. Waves bending as they pass through an opening.
2. What will happen to the wave in the following image?

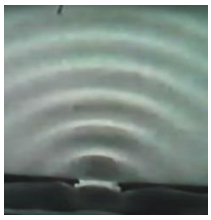


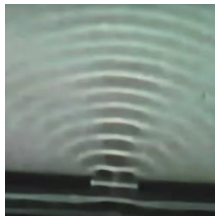
3. What will this wave do as it strikes the barrier?

4. As a water wave moves from deep to shallow water, what happens to its speed, wavelength, amplitude, and frequency?
5. In this ripple tank:

   a. What is the wave behaviour that is occurring? (There are two; only one is clearly seen.)
   b. Which side is deep water? Explain how you know.

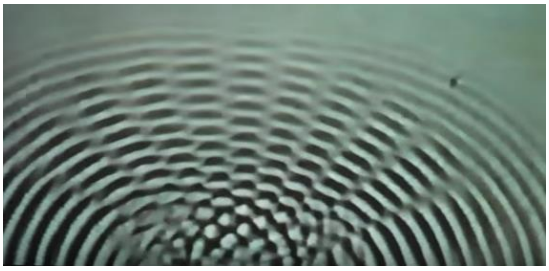
6. Wave pulses pass at an angle from one medium into another. Identify what properties of the waves will change, and what will remain constant.
7. For these two images of the same ripple tank:





   a. What is the wave behaviour that is occurring?
   b. What is causing the difference between the wave shapes in the two images?
   c. What two things could you change in this tank for this wave behaviour to *not* occur?

8. Why can you hear around corners, but not see around corners?
9. In this ripple tank, showing interference of waves, identify where constructive and destructive interference are occurring.



10. Identify all the wave behaviours occurring in this ripple tank:

11. *Challenge Question*: If you wanted to build a sea wall around a marina to protect the boats, use what you know about wave behaviour to determine the best way to build it, while keeping costs minimal.

Sound Waves

1. Write the correct term for each blank:
   a. Sound waves require a _____ to travel through. This makes it a _____ wave.
   b. High frequency sounds are said to be high _____.
   c. Sounds below the range of human hearing are _____, and above are _____.

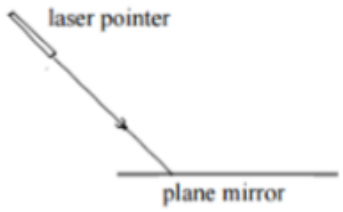
d. _____ is proportional to the amplitude of a sound wave, and is measured in _____.

2. An asteroid hits the surface of the moon, just as a satellite is passing by. The satellite is 100 km away from the point of impact. Will the microphone on the outside of the satellite pick up the sound of the collision? Why or why not?
3. In old western movies, people are often shown putting their ear to the tracks to determine if a train is coming. Is this realistic? Why or why not?
4. The pitch of sound is increased. What happens to the frequency and wavelength?
5. What happens to the frequency of a sound wave when it changes medium?
6. A bass singer can produce sounds as low as 85 Hz. A soprano can sing at frequencies of 950 Hz. If the speed of sound is 345 m/s, what is the difference in wavelength of the sound waves produced by each singer?
7. Sound travels from a medium with a speed of sound of 350 m/s into a medium where the temperature is 0°C. The frequency of the sound is 1200 Hz. Calculate the wavelength of the sound in each medium.
8. 3.0 s after you see a lightning bolt, you hear the thunder. If the air temperature is 24°C, calculate the distance the storm is from your current position and the speed of sound in km/h.
9. In the morning, the temperature is 0°C. By the afternoon, the temperature has risen to 15°C. How much longer will it take sound to travel 1.0 km in the morning as opposed to in the afternoon?
10. A boat equipped with a sonar device is used to track the distance between the surface of the water and the bottom of the lake. The speed of sound in water is approximately 1500 m/s. A sound wave is launched, and 2.8 seconds later a reflection is detected. Calculate the distance between the boat and the bottom of the lake.
11. The temperature at the Grand Canyon is 38°C. A tourist yells toward the nearest canyon wall and hears the echo 0.85 s later. How far away is the wall?

Reflection in Plane Mirrors

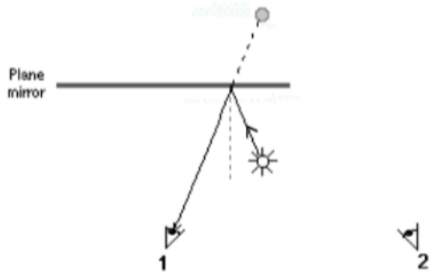
1. What is the Law of Reflection?
2. A light ray hits a mirror at an angle of 22° to the normal.
   a. What is the angle of reflection?
   b. What is the angle between the incident ray and the reflected ray?
3. What is the difference between a real image and a virtual image? Will a real image ever form in a plane mirror?

4. Given the following image:

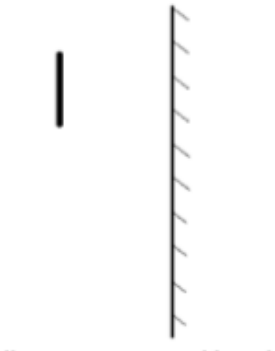


   a. Draw the reflected light ray.
   b. How do you think the reflection of the laser pointer would be different if it was hitting a sheet of white paper, as opposed to a mirror?

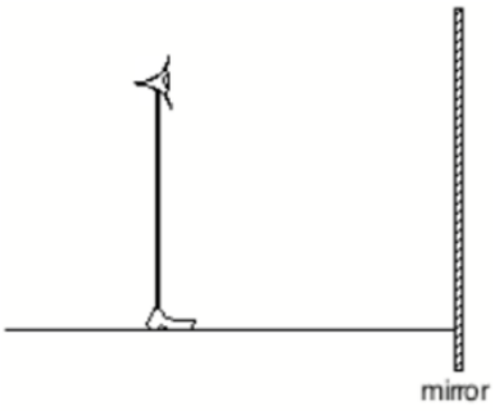
5. Explain why the second observer will not see an image of the light bulb in the mirror.



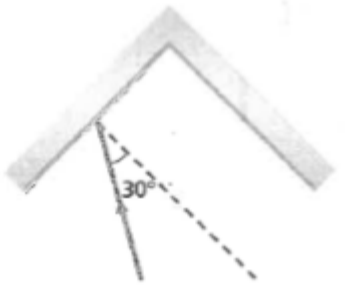
6. An object is placed in front of a plane mirror.
   a. Use a protractor and a ruler to do a ray diagram to locate the image behind the mirror.
   b. Describe the image location, orientation, size and type.



7. If you are using a full-length mirror to see your whole body at one time, how does the minimum size the mirror needs to be compare to your height? Use the image to draw a ray diagram to prove it. Does it matter how far away from the mirror you are?



8. Two plane mirrors form a right angle, as shown. A light ray hits one mirror at an angle of 30° to the normal. At what angle is the light ray reflected from the second mirror?

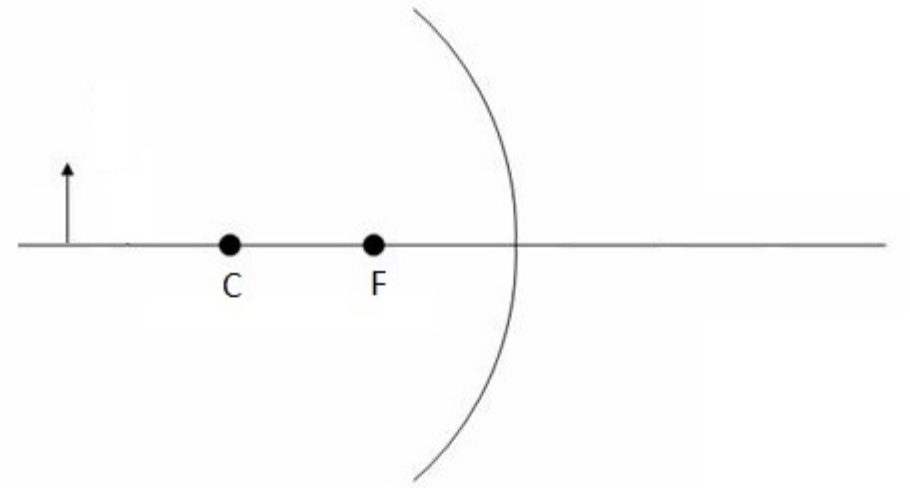


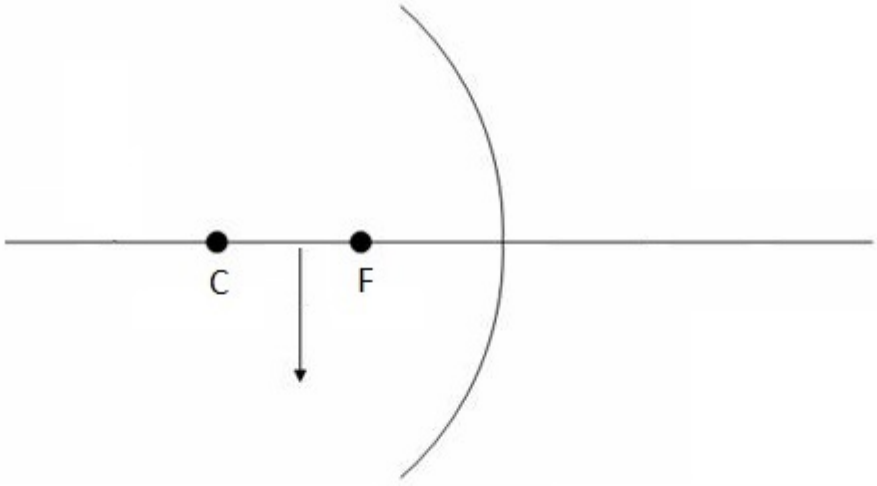
9. *Challenge Question:* Ms. Hayduk is 160 cm tall. Mr. Hayduk is 190 cm tall. If they both want to be able to use the full-length mirror, determine:
   a. The minimum size of mirror they need, and;
   b. How far off the floor it needs to hang.

(Assume, for simplicity, their eyes are 10 cm from the tops of their heads.)

Reflection in Curved Mirrors

1. Give an example of when you would use a concave mirror, and when you would use a convex mirror.
2. Draw the ray diagrams, then indicate the characteristics of the image.

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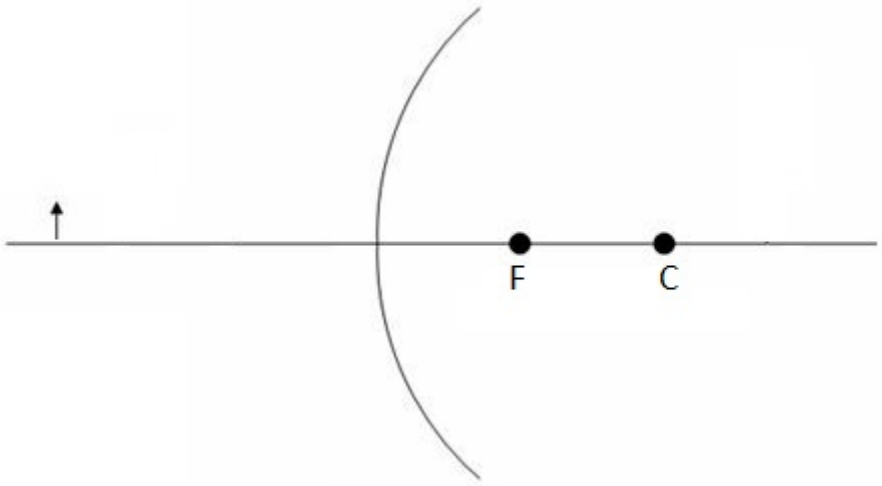
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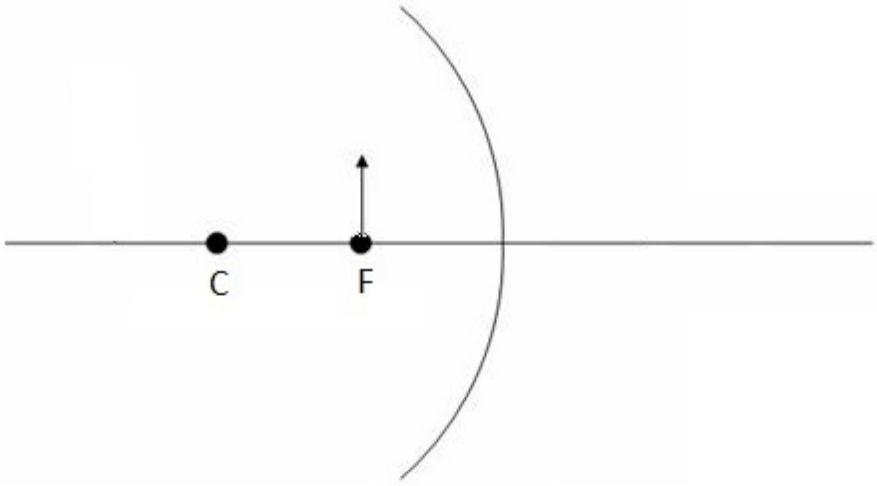
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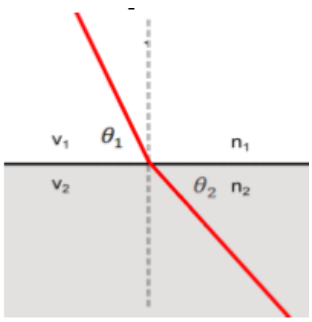
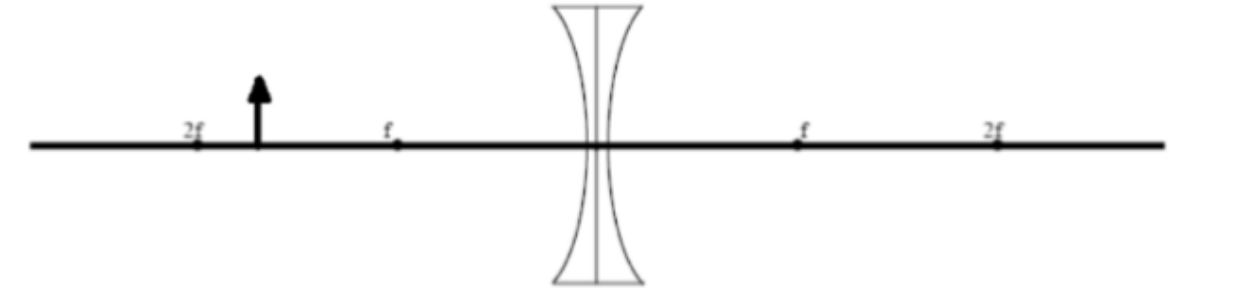
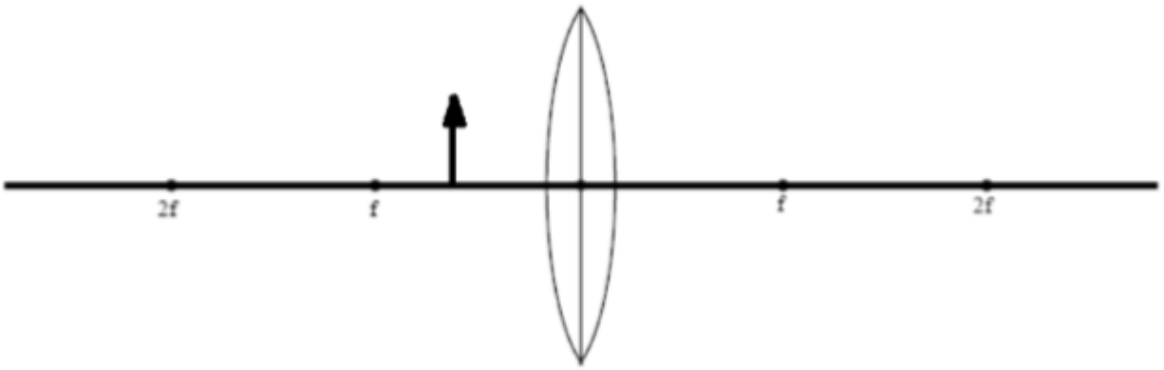
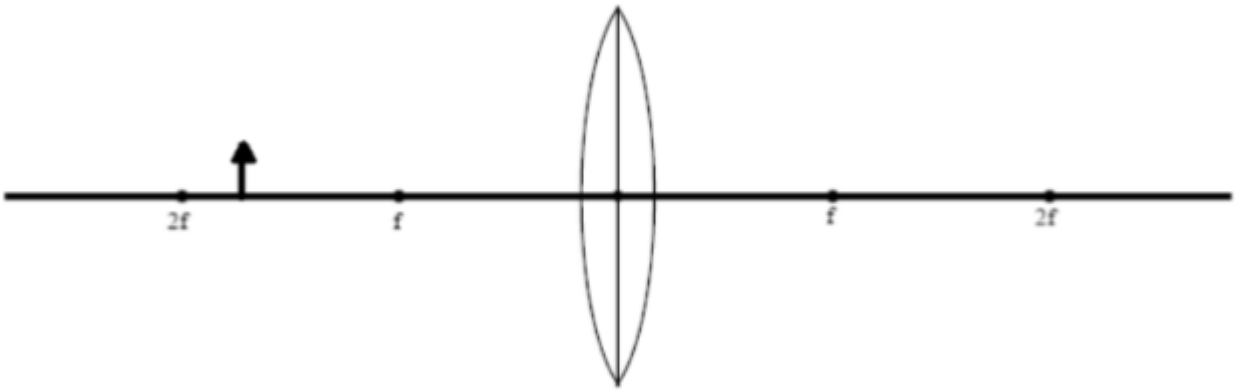
Refraction of Light

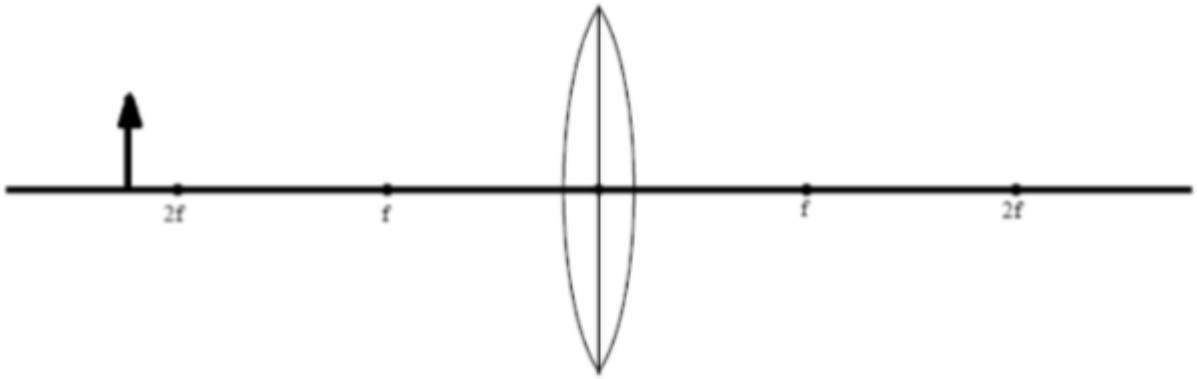
1. Why does light bend when it changes medium?
2. What is a refractive index? What does it tell you about a substance?
3. Medium 1 has a refractive index of 1.20. Medium 2 has a refractive index of 2.65. If light passes from medium 1 to medium 2, will it be refracted towards or away from the normal?
4. What is the angle of refraction when light passes from air into diamond at an incident angle of 60.0°?
5. In the image on the right, θ_1 is 78°. Medium 1 is crown glass and medium 2 is water. What is θ_2?
6. An unknown substance is in a tank of water. A light beam in the water strikes the surface of substance at an angle of 42.2° and refracts into it at an angle of 27.7°. What is the unknown substance?
7. What is total internal reflection? What is a practical use for it?
8. Determine the critical angle for light passing out of water into air.
9. Draw the ray diagrams, then determine the characteristics of each image.







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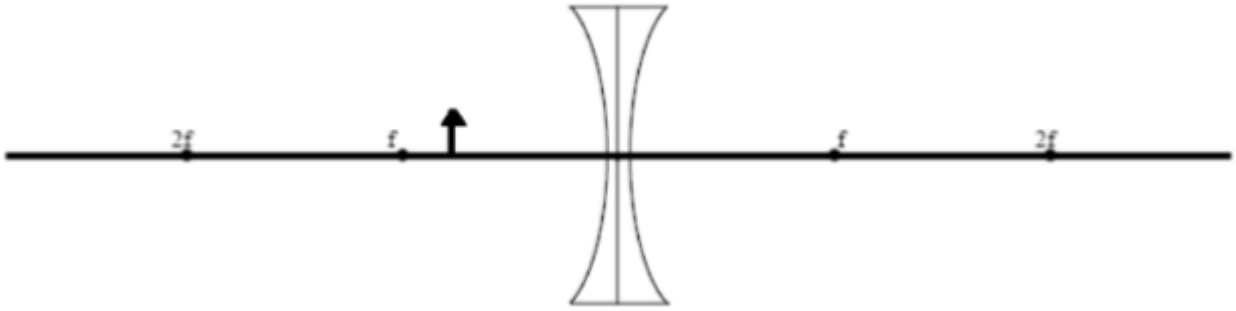
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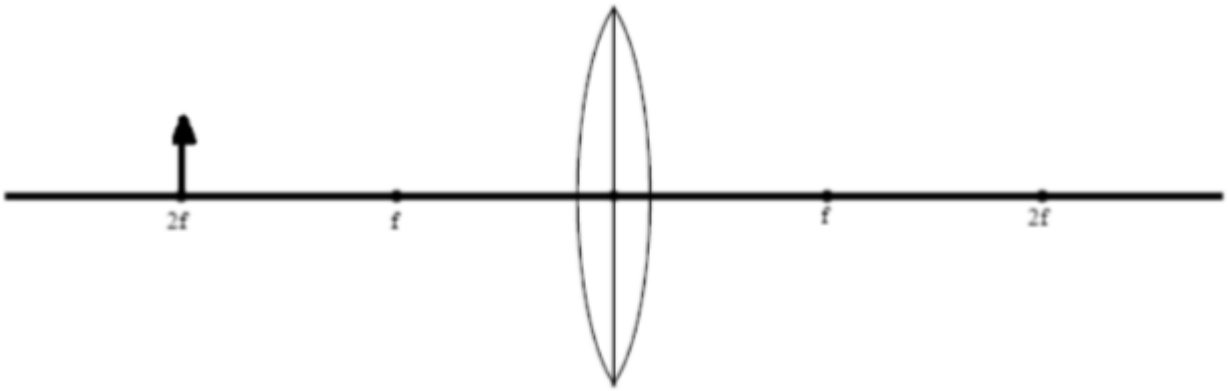
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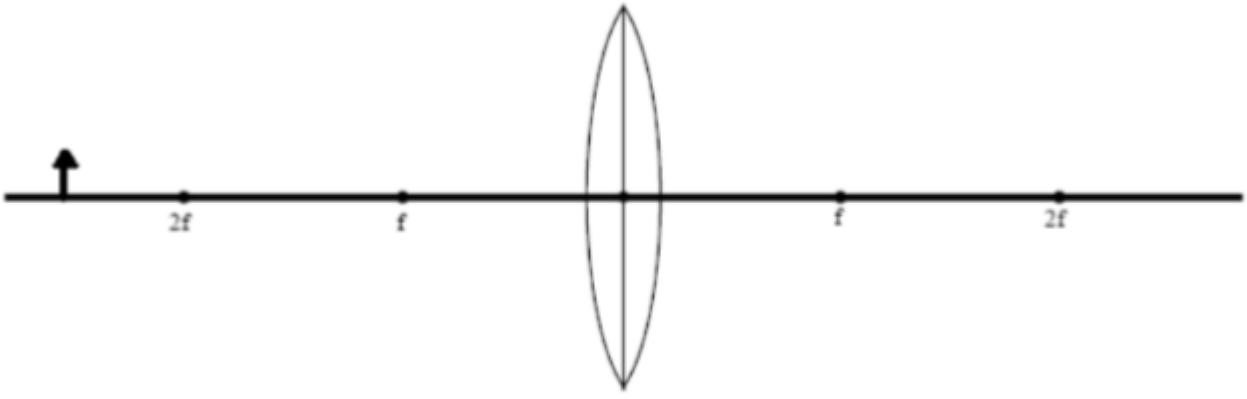
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