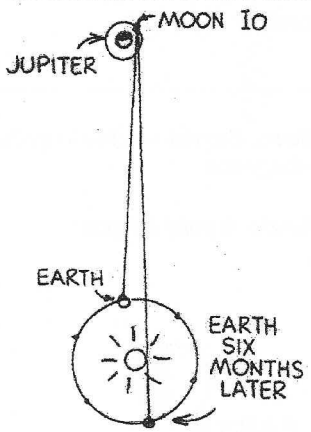
Name _____ Date _____

CONCEPTUAL **Physics** PRACTICE PAGE

Chapter 26 Properties of Light

Speed, Wavelength, and Frequency

1. The first investigation that led to a determination of the speed of light was performed in about 1675 by the Danish astronomer Olaus Roemer. He made careful measurements of the period of Io, a moon about the planet Jupiter, and was surprised to find an irregularity in Io's observed period. While Earth was moving away from Jupiter, the measured periods were slightly longer than average. While Earth approached Jupiter, they were shorter than average. Roemer estimated that the cumulative discrepancy amounted to about 16.5 minutes. Later interpretations showed that what occurs is that light takes about 16.5 minutes to travel the extra 300,000,000-km distance across Earth's orbit. Aha! We have enough information to calculate the speed of light!



a. Write a formula for speed in terms of the distance traveled and the time spent traveling that distance.

_____

b. Using Roemer's data, and changing 16.5 minutes to seconds, calculate the speed of light.

_____

Study Figure 26.3 in your textbook and answer the following:

2. a. Which has the longer *wavelengths*? [radio waves] [light waves].

b. Which has the longer *wavelengths*? [light waves] [gamma waves].

c. Which has the higher *frequencies*? [ultraviolet waves] [infrared waves].

d. Which has the higher *frequencies*? [ultraviolet waves] [gamma rays].

Carefully study the section "Transparent Materials" in your textbook and answer the following:

3. a. Exactly what do vibrating electrons emit?

_____

b. When ultraviolet light shines on glass, what does it do to electrons in the glass structure?

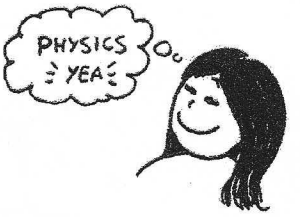
_____

c. When energetic electrons in the glass structure vibrate against neighboring atoms, what happens to the energy of vibration?

_____

d. What happens to the energy of a vibrating electron that does not collide with neighboring atoms?

_____



Hewitt Drew it!

Chapter 26 Properties of Light

***Speed, Wavelength, and Frequency**—continued*

e. Light in which range of frequencies is absorbed in glass? [visible] [ultraviolet].

f. Light in which range of frequencies is transmitted through glass? [visible] [ultraviolet].

g. How is the speed of light in glass affected by the succession of time delays that accompany the absorption and re-emission of light from atom to atom in the glass?

_____

h. How does the speed of light compare in water, glass, and diamond?

_____

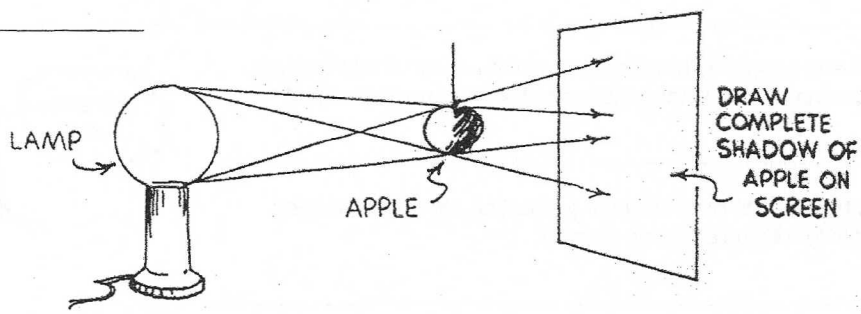
4. The Sun normally shines on both Earth and Moon. Both cast shadows. Sometimes the Moon's shadow falls on Earth, and at other times Earth's shadow falls on the Moon.

a. The sketch shows the Sun and Earth. Draw the Moon at a position for a solar eclipse.

b. This sketch also shows the Sun and Earth. Draw the Moon at a position for a lunar eclipse.

5. The diagram shows the limits of light rays when a large lamp makes a shadow of a small object on a screen. Make a sketch of the shadow on the screen, shading the umbra darker than the penumbra. In what part of the shadow could an ant on the screen see part of the lamp?

_____



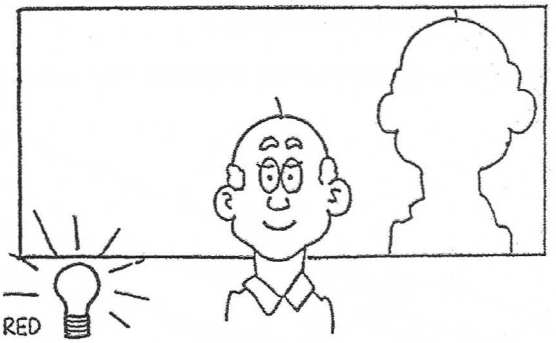
Name _____ Date _____

CONCEPTUAL **Physics** PRACTICE PAGE

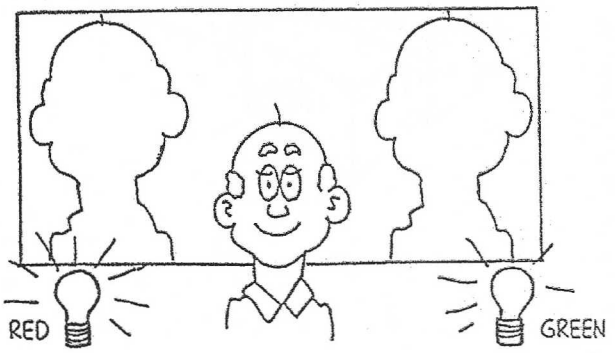
Chapter 27 Color

Color Addition

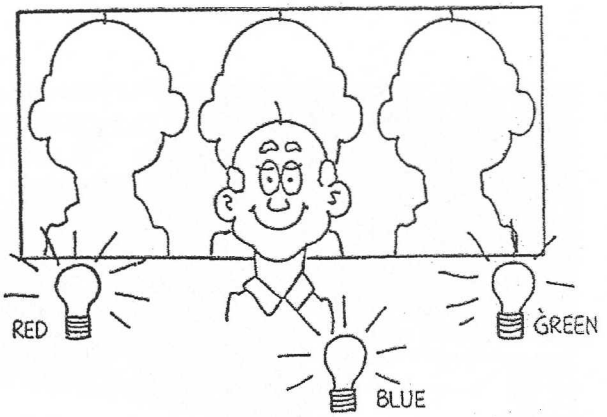
The sketch to the right shows the shadow of an instructor in front of a white screen in a dark room. The light source is red, so the screen looks red and the shadow looks black. Color the sketch, or label the colors with pen or pencil.



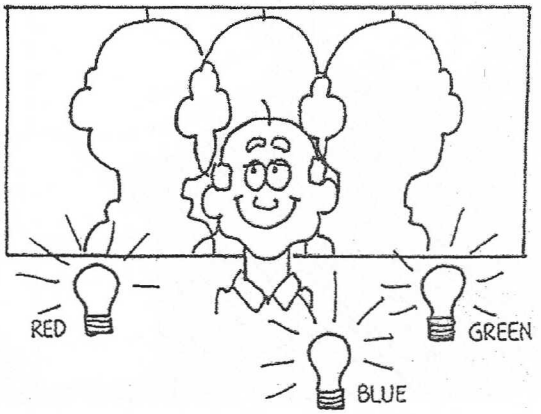
A green lamp is added and makes a second shadow. The shadow cast by the red lamp is no longer black, but is illuminated by green light. So it is green. Color or mark it green. The shadow cast by the green lamp is not black because it is illuminated by the red lamp. Indicate its color. Do the same for the background, which receives a mixture of red and green light.



A blue lamp is added and three shadows appear. Indicate the appropriate colors of the shadows and the background.



The lamps are placed closer together so the shadows overlap. Indicate the colors of all screen areas.

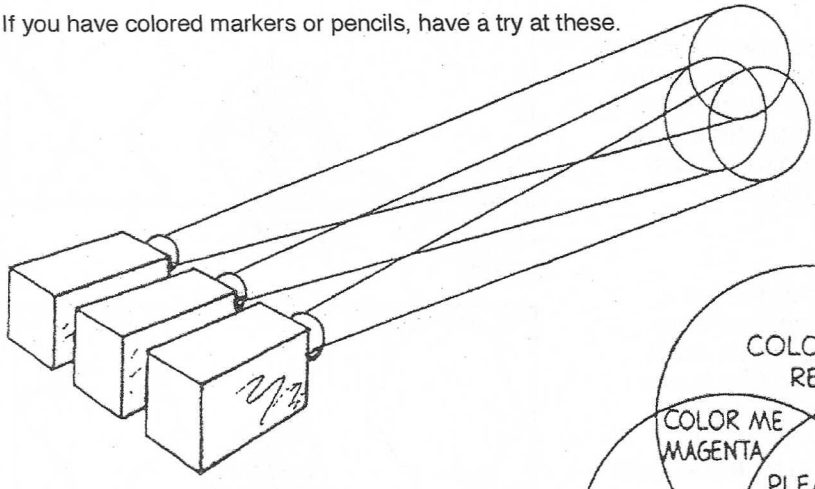


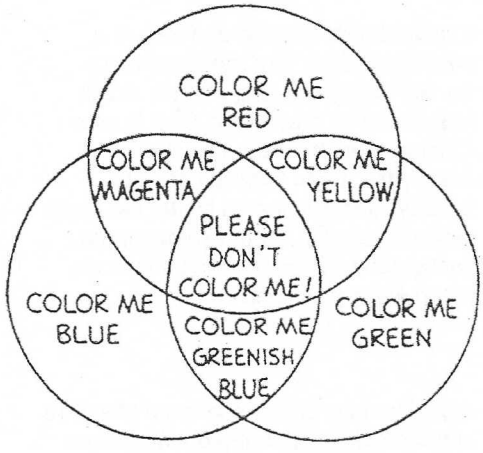
Hewitt Drew it!

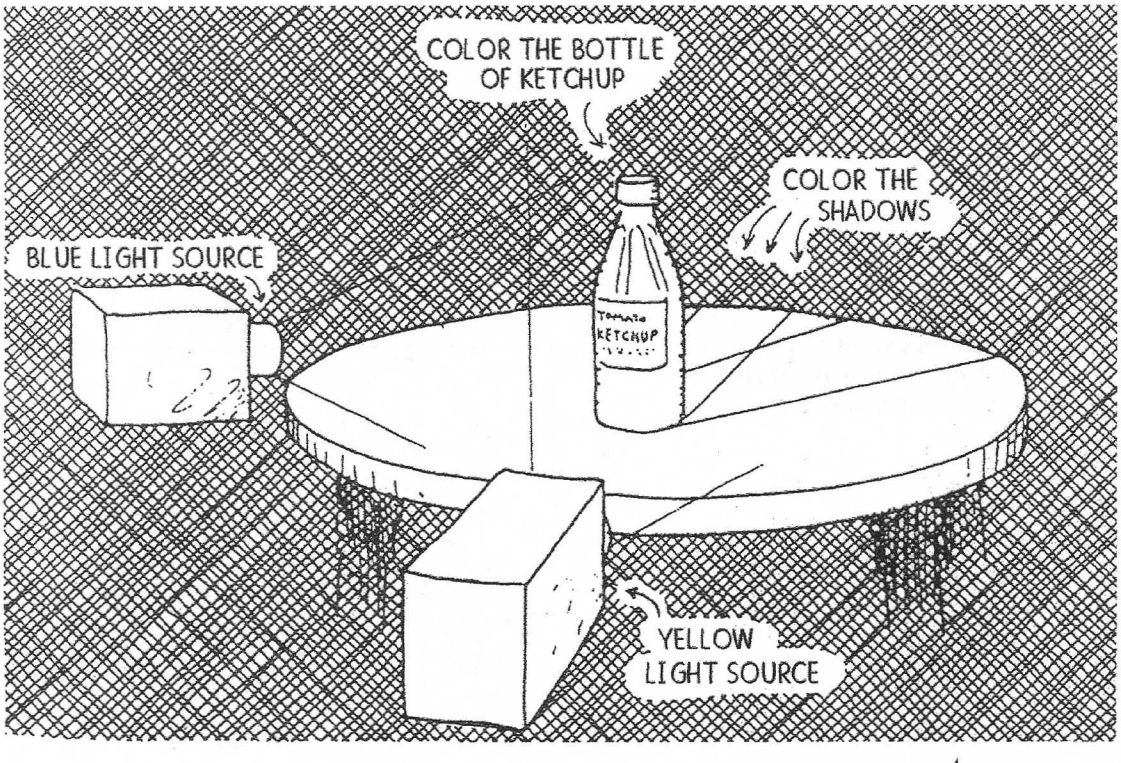
Chapter 27 Color

Color Addition—continued

If you have colored markers or pencils, have a try at these.







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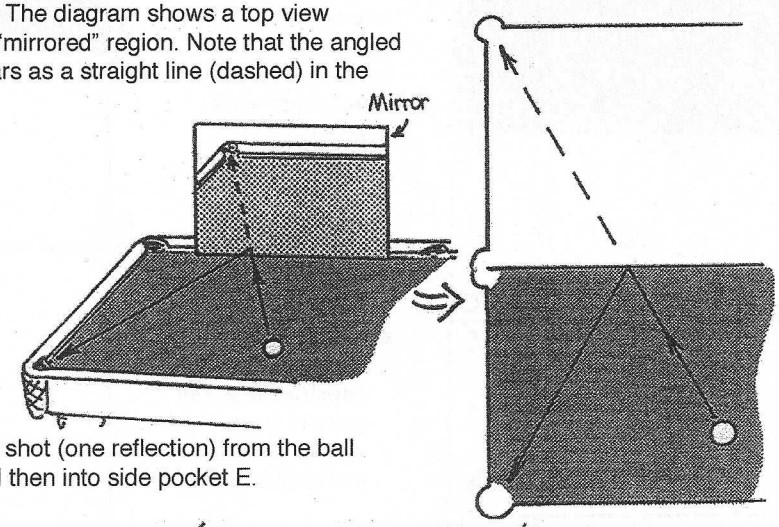
CONCEPTUAL **Physics** PRACTICE PAGE

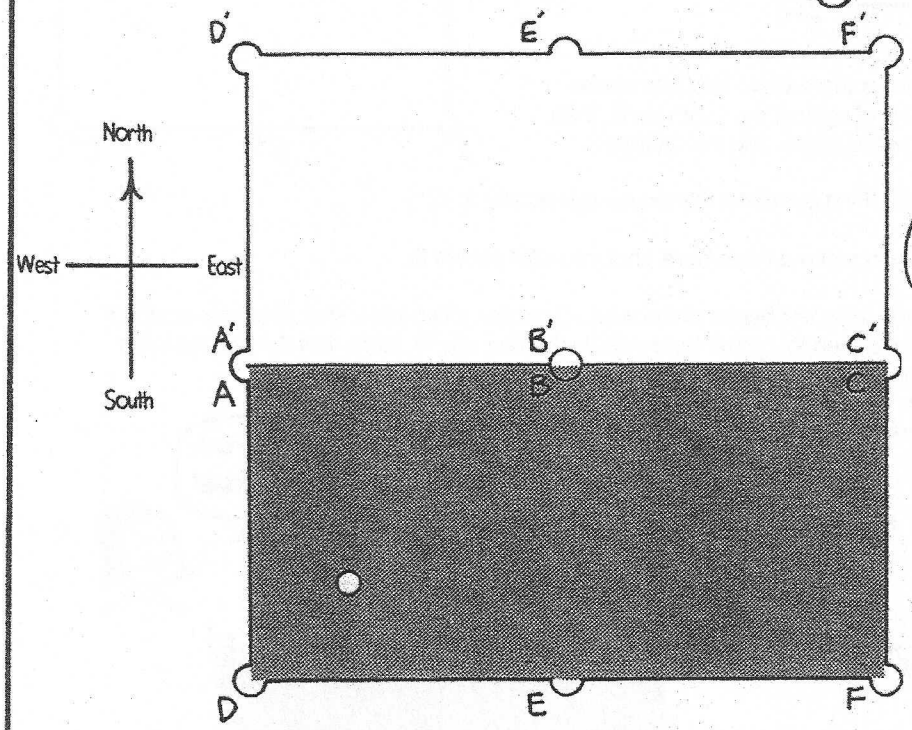
Chapter 28 Reflection and Refraction

Pool Room Optics

The law of reflection for optics is useful in playing pool. A ball bouncing off the bank of a pool table behaves like a photon reflecting off a mirror. As the sketch shows, angles become straight lines with the help of mirrors. The diagram shows a top view of this, with a flattened "mirrored" region. Note that the angled path on the table appears as a straight line (dashed) in the mirrored region.



1. Consider a one-bank shot (one reflection) from the ball to the north bank and then into side pocket E.



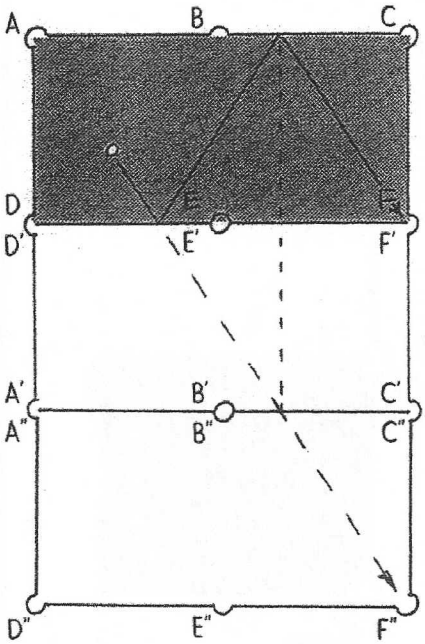
a. Use the mirror method to construct a straight line path to mirrored E'. Then construct the actual path to E.

b. Without using off-center strokes or other tricks, can a one-bank shot off the north bank put the ball in corner pocket F? _____ Show why or why not using the diagram.

Hewitt Drew it!

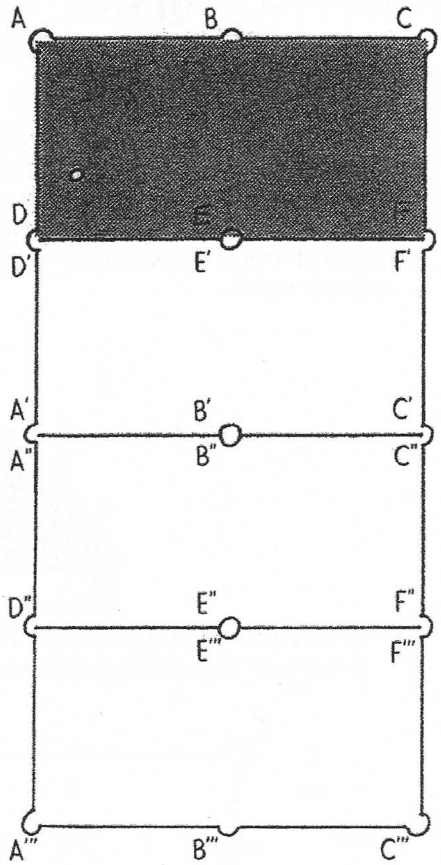
Chapter 28 Reflection and Refraction

***Pool Room Optics**—continued*



2. Consider the left diagram, a two-bank shot (2 reflections) into corner pocket F. Here we use 2 mirrored regions. Note the straight line of sight to F", and how the north-bank impact point matches the intersection between B' and C'.

   a. On the same diagram to the left, construct a similar path for a two-bank shot to get the ball in the side pocket E.

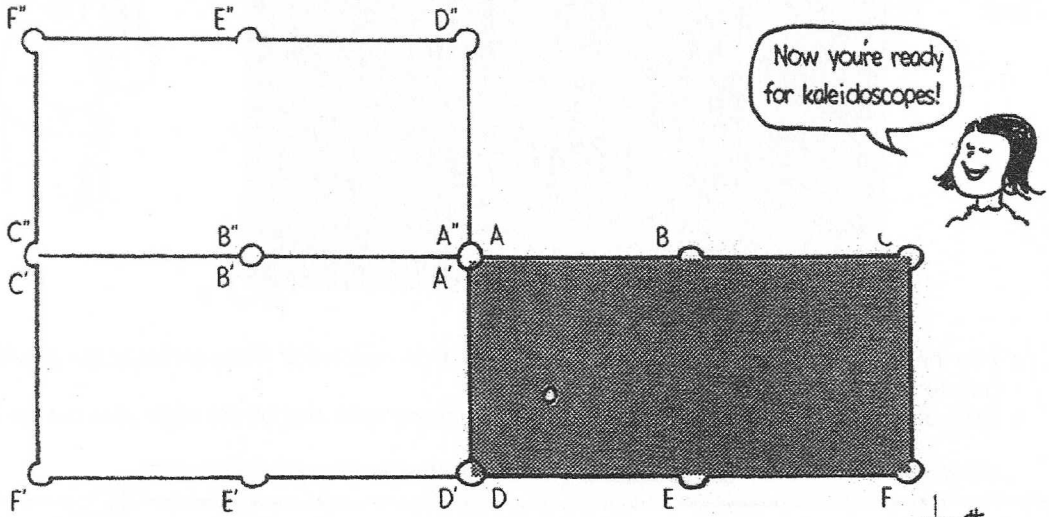


3. Consider above right, a three bank-shot into corner pocket C, first bouncing against the south bank, then to the north, again to the south, and into pocket C.

   a. Construct the path. (First construct the single dashed line to C'''.)

   b. Construct the path to make a three-bank shot into side pocket B.

4. Let's try banking from adjacent banks of the table. Consider a two-bank shot to corner pocket F (first off the west bank, then to and off the north bank, then into F). Note how our two mirrored regions permit a straight-line path from the ball to F".



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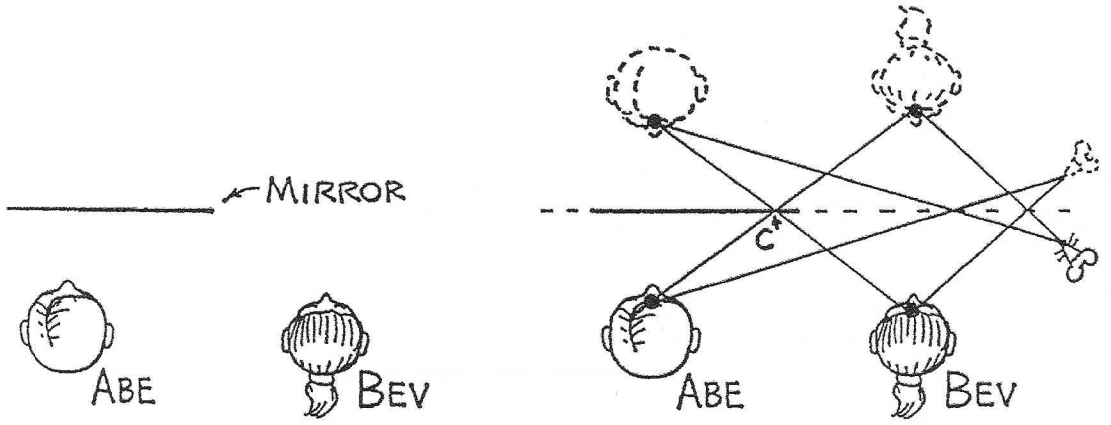
CONCEPTUAL Physics PRACTICE PAGE

Chapter 28 Reflection and Refraction

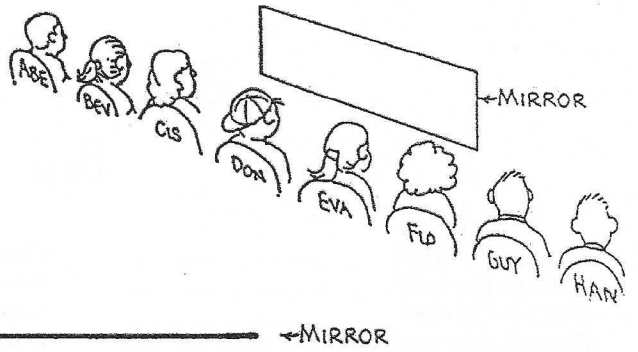
Reflection

Abe and Bev both look in a plane mirror directly in front of Abe (left view). Abe can see himself while Bev cannot see herself—but can Abe see Bev, and can Bev see Abe?



To find the answer, we construct their artificial locations "through" the mirror, the same distance behind as Abe and Bev are in front (right view). If straight-line connections intersect the mirror, as at point C, then each sees the other. The mouse, for example, cannot see or be seen by Abe and Bev (because there's no mirror in its line of sight).

Here we have eight students in front of a small plane mirror. Their positions are shown in the diagram below. Make appropriate straight-line constructions to answer the following:



ABE BEV CIS DON EVA FLO GUY HAN

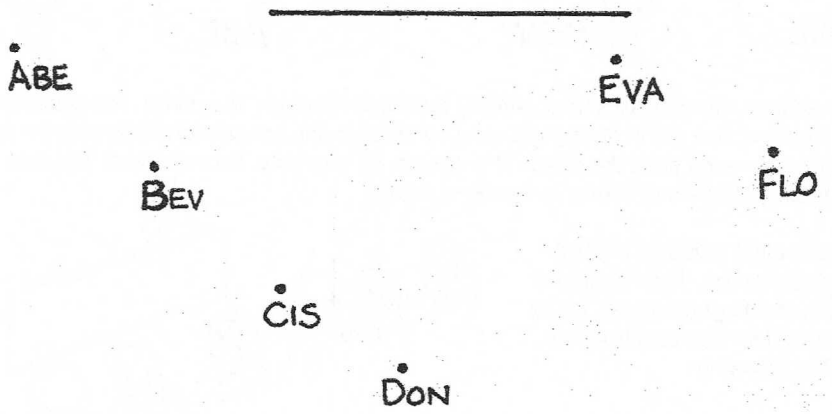
Abe can see	_____	Abe cannot see	_____
Bev can see	_____	Bev cannot see	_____
Cis can see	_____	Cis cannot see	_____
Don can see	_____	Don cannot see	_____
Eva can see	_____	Eva cannot see	_____
Flo can see	_____	Flo cannot see	_____
Guy can see	_____	Guy cannot see	_____
Han can see	_____	Han cannot see	_____

thanx to Marshall Ellenstein

Chapter 28 Reflections and Refractions

***Reflection**—continued*

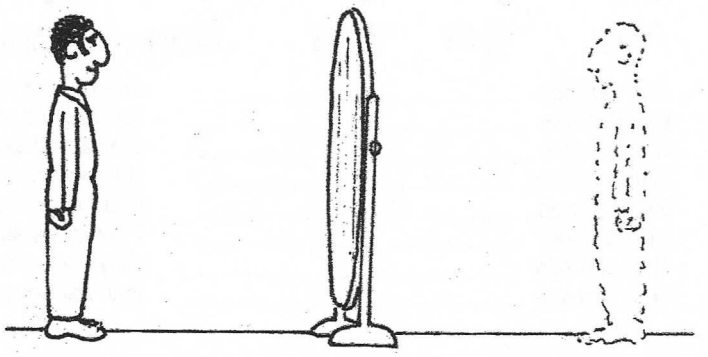
Six of our group are now arranged differently in front of the same plane mirror. Their positions are shown below. Make appropriate constructions for this interesting arrangement, and answer the questions provided below:



Who can Abe see? _____
Who can Bev see? _____
Who can Cis see? _____
Who can Don see? _____
Who can Eva see? _____
Who can Flo see? _____

Who can Abe not see? _____
Who can Bev not see? _____
Who can Cis not see? _____
Who can Don not see? _____
Who can Eva not see? _____
Who can Flo not see? _____

Harry Hostshot views himself in a full-length mirror (right). Construct straight lines from Harry's eyes to the image of his feet, and to the top of his head. Mark the mirror to indicate the minimum area Harry uses to see a full view of himself.

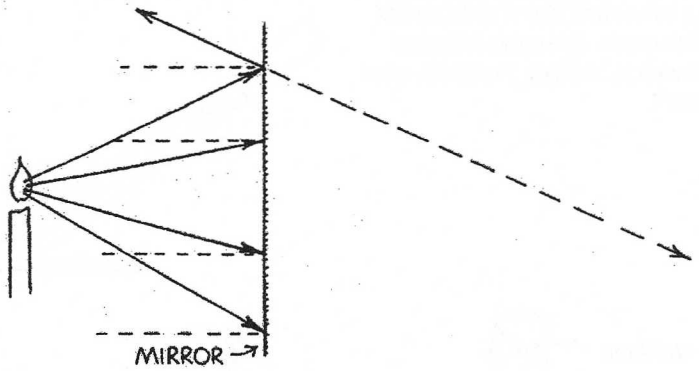


Does this region of the mirror depend on Harry's distance from the mirror? _____

Chapter 28 Reflection and Refraction

Reflected Views

1. The ray diagram below shows the extension of one of the reflected rays from the plane mirror.

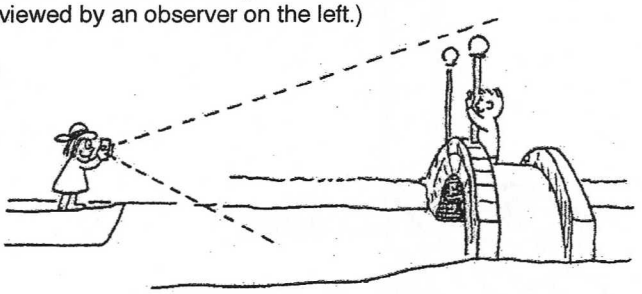


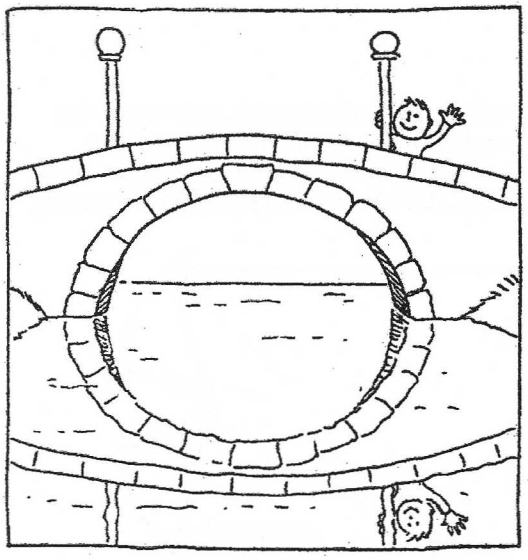
Complete the above diagram:

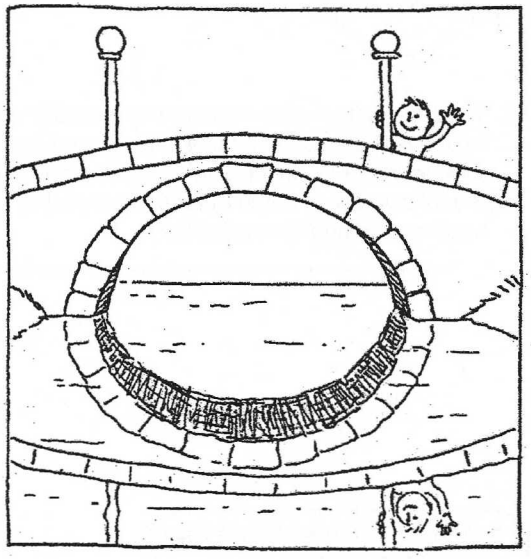
a. Carefully draw the three other reflected rays.

b. Extend your drawn rays behind the mirror to locate the image of the flame. (Assume the candle and image are viewed by an observer on the left.)

2. A girl takes a photograph of the bridge as shown. Which of the two sketches below correctly shows the reflected view of the bridge? Defend your answer.







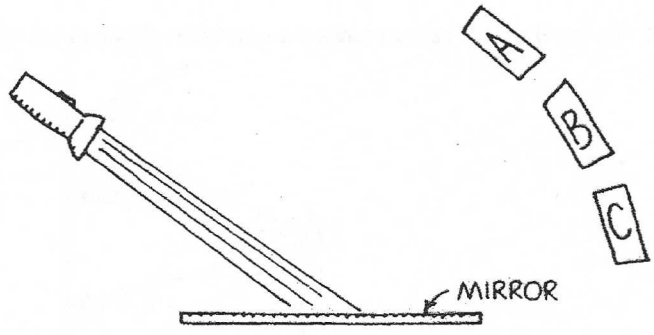
_____

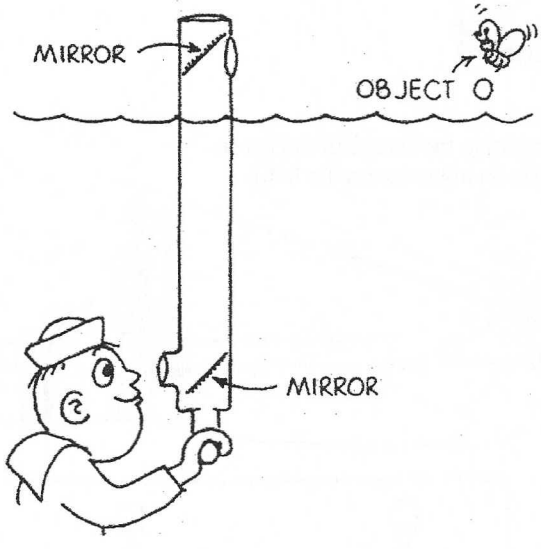
_____

Chapter 28 Reflection and Refraction

More Reflection

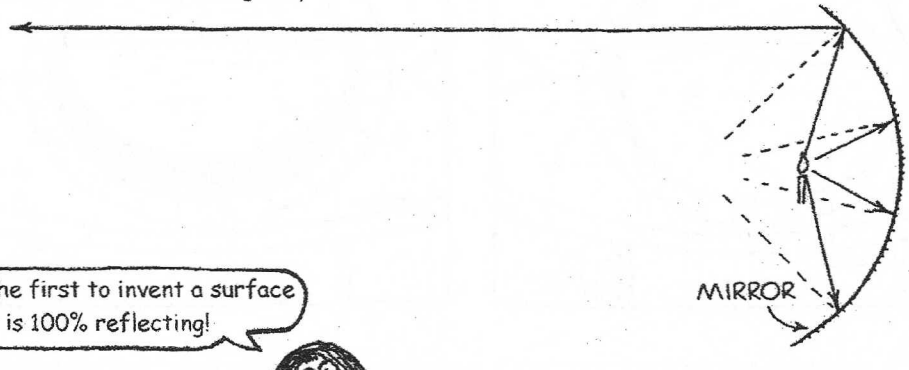
1. Light from a flashlight shines on a mirror and illuminates one of the cards. Draw the reflected beam to indicate the illuminated card.

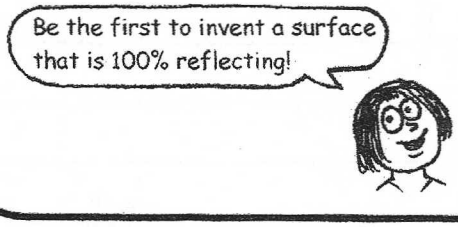




2. A periscope has a pair of mirrors in it. Draw the light path from the object "O" to the eye of the observer.

3. The ray diagram below shows the reflection of one of the rays that strikes the parabolic mirror. Notice that the law of reflection is obeyed, and the angle of incidence (from the normal, the dashed line) equals the angle of reflection (from the normal). Complete the diagram by drawing the reflected rays of the other three rays that are shown. (Do you see why parabolic mirrors are used in automobile headlights?)





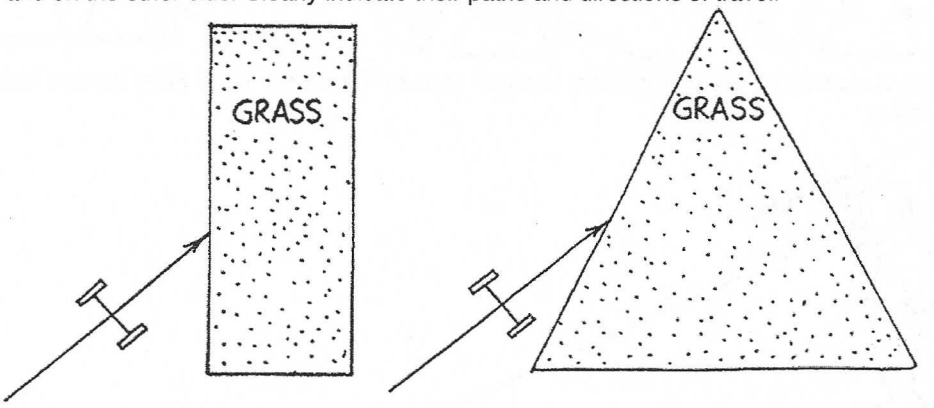
Name _____ Date _____

CONCEPTUAL **Physics** PRACTICE PAGE

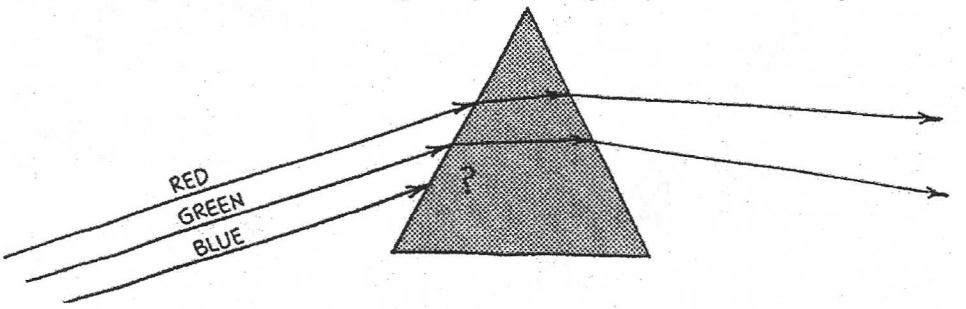
Chapter 28 Reflection and Refraction

Refraction

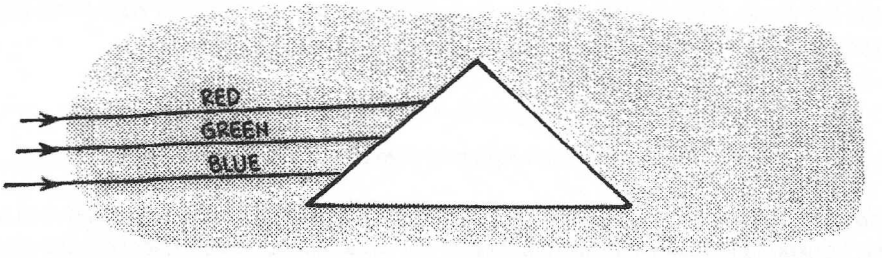
1. A pair of toy cart wheels are rolled obliquely from a smooth surface onto two plots of grass—a rectangular plot on the left, and a triangular plot on the right. The ground is on a slight incline so that after slowing down in the grass, the wheels speed up again when emerging on the smooth surface. Finish each sketch and show some positions of the wheels inside the plots and on the other side. Clearly indicate their paths and directions of travel.



2. Red, green, and blue rays of light are incident upon a glass prism as shown below. The average speed of red light in the glass is less than in air, so the red ray is refracted. When it emerges into the air it regains its original speed and travels in the direction shown. Green light takes longer to get through the glass. Because of its slower speed it is refracted as shown. Blue light travels even slower in glass. Complete the diagram by estimating the path of the blue ray.



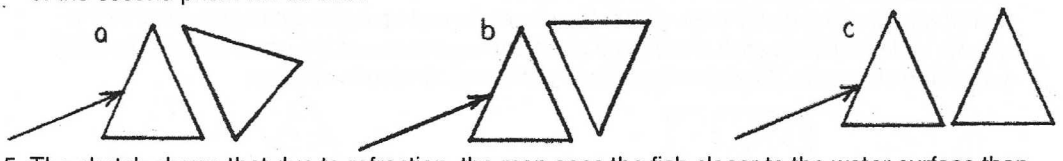
3. Below we consider a prism-shaped hole in a piece of glass—that is, an "air prism." Complete the diagram, showing likely paths of the beams of red, green, and blue light as they pass through this "prism" and then into glass.



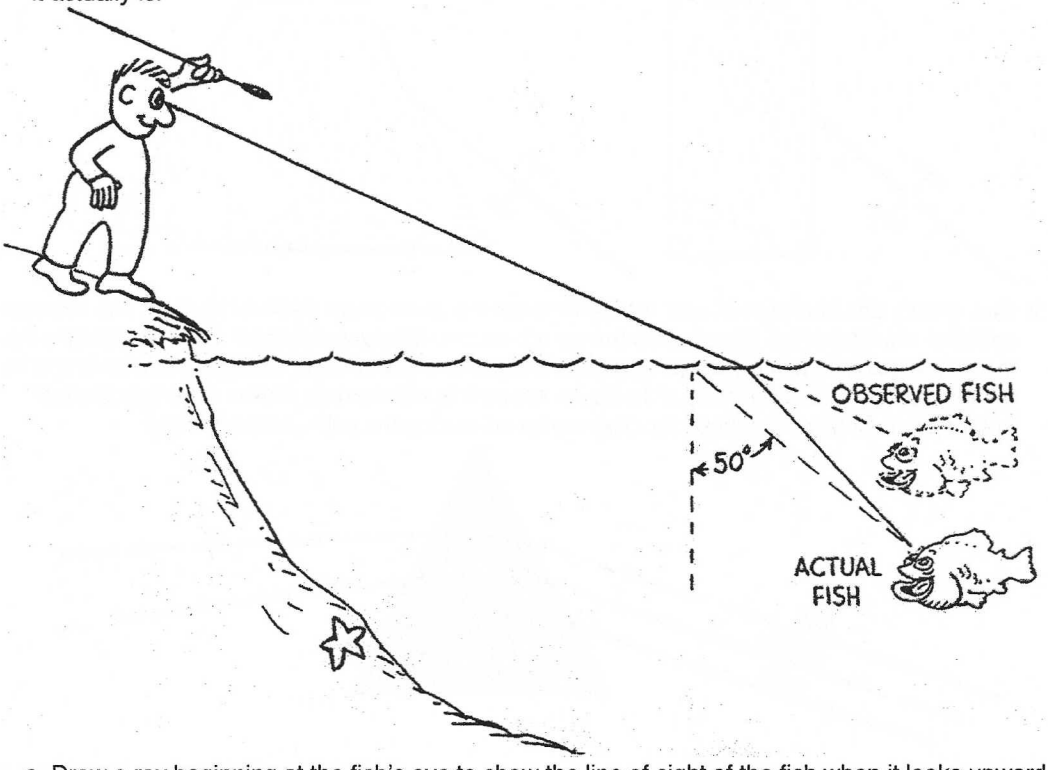
Chapter 28 Reflection and Refraction

***Refraction**—continued*

4. Light of different colors diverges when emerging from a prism. Newton showed that with a second prism he could make the diverging beams become parallel again. Which placement of the second prism will do this?



5. The sketch shows that due to refraction, the man sees the fish closer to the water surface than it actually is.



a. Draw a ray beginning at the fish's eye to show the line of sight of the fish when it looks upward at 50° to the normal at the water surface. Draw the direction of the ray after it meets the surface of water.

b. At the 50° angle, does the fish see the man, or does it see the reflected view of the starfish at the bottom of the pond? Explain.

_____

c. To see the man, should the fish look higher or lower than the 50° path? _____

d. If the fish's eye were barely above the water surface, it would see the world above in a 180° view, horizon to horizon. The fisheye view of the world above as seen beneath the water, however, is very different. Due to the 48° critical angle of water, the fish sees a normally 180° horizon-to-horizon view compressed within an angle of _____.

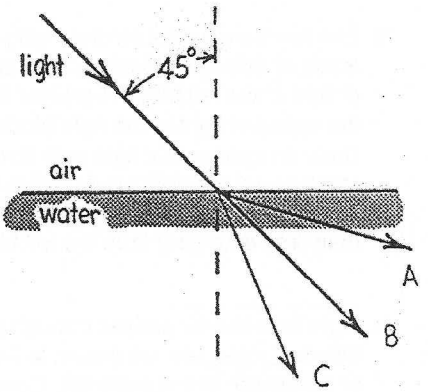
Name _____ Date _____

CONCEPTUAL **Physics** PRACTICE PAGE

Chapter 28 Reflection and Refraction

More Refraction

1. The sketch to the right shows a light ray moving from air into water, at 45° to the normal. Which of the three rays indicated with capital letters is most likely the light ray that continues inside the water?



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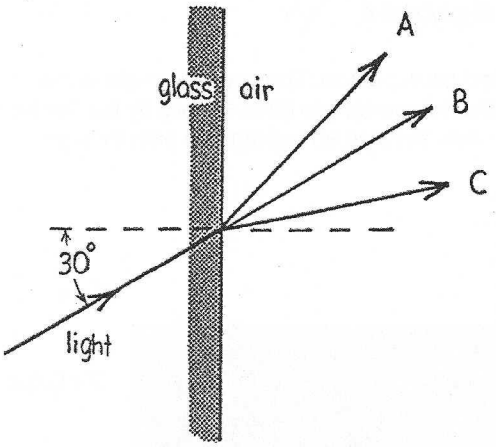
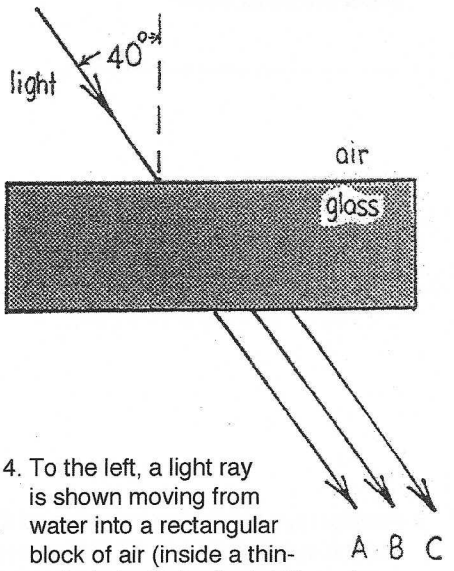


2. The sketch on the left shows a light ray moving from glass into air, at 30° to the normal. Which of the three is most likely the light ray that continues in the air?

_____

3. To the right, a light ray is shown moving from air into a glass block, at 40° to the normal. Which of the three rays is most likely the light ray that travels in the air after emerging from the opposite side of the block? (Sketch the path the light would take inside the glass.)



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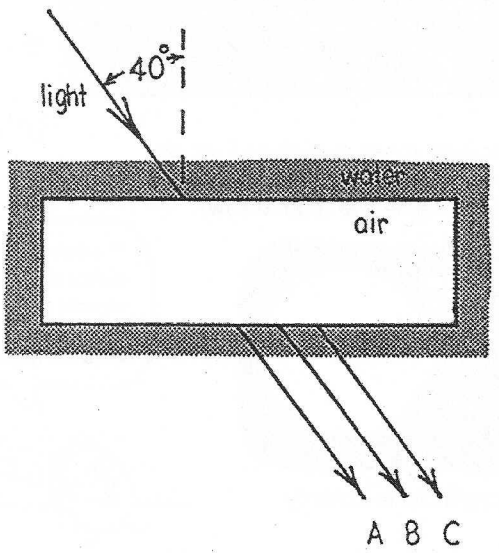


4. To the left, a light ray is shown moving from water into a rectangular block of air (inside a thin-walled plastic box), at 40° to the normal. Which of the rays is most likely the light ray that continues into the water on the opposite side of the block?

_____

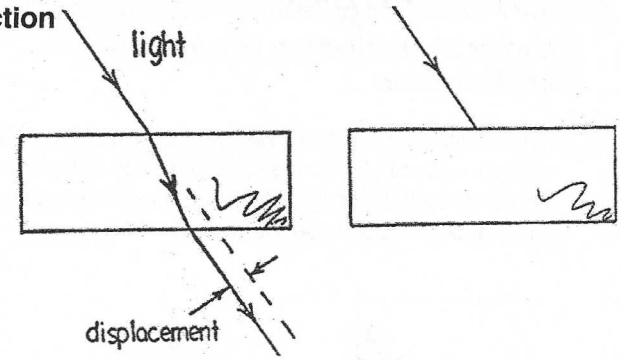
Sketch the path the light would take inside the air.

thanx to Clarence Bakken

Chapter 28 Reflection and Refraction

***More Refraction**—continued*

5. The two transparent blocks (right) are made of different materials. The speed of light in the left block is greater than the speed of light in the right block. Draw an appropriate light path through and beyond the right block. Is the light that emerges displaced more or less than light emerging from the left block?

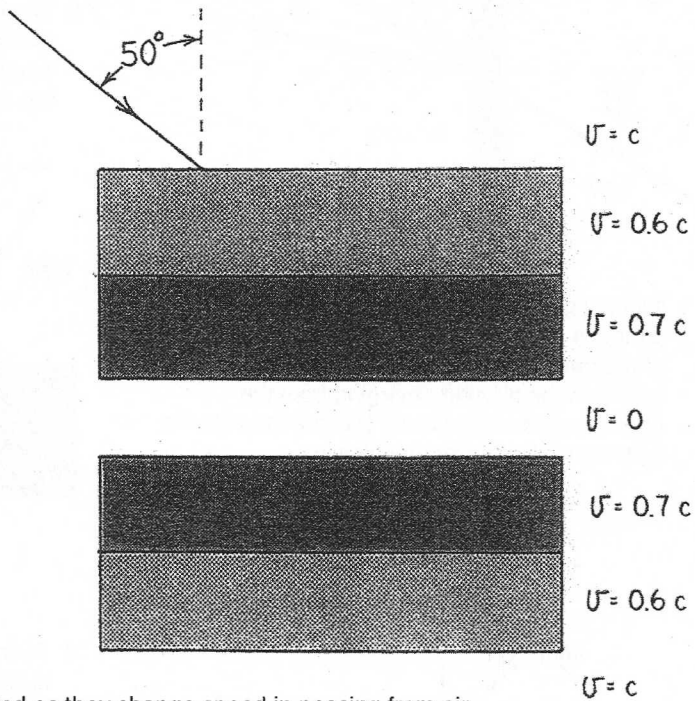


_____

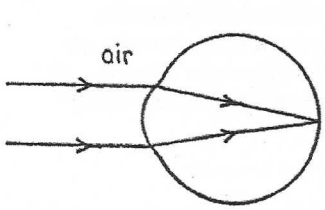
6. Light from the air passes through plates of glass and plastic below. The speeds of light in the different materials are shown to the right (these different speeds are often implied by the "index of refraction" of the material). Construct a rough sketch showing an appropriate path through the system of four plates.

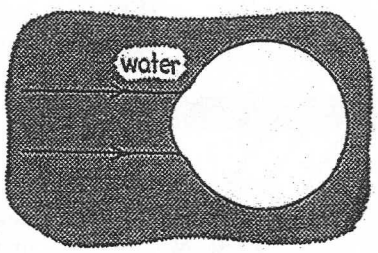
   Compared to the 50° incident ray at the top, what can you say about the angles of the ray in the air between and below the block pairs?

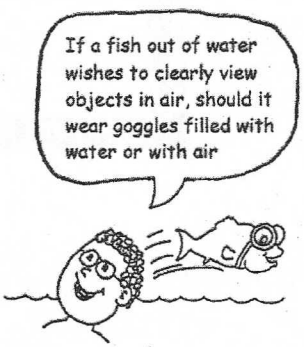
   _____



7. Parallel rays of light are refracted as they change speed in passing from air into the eye (left below). Construct a rough sketch showing appropriate light paths when parallel light under water meets the same eye (right below).







8. Why do we need to wear a face mask or goggles to see clearly when under water?

_____

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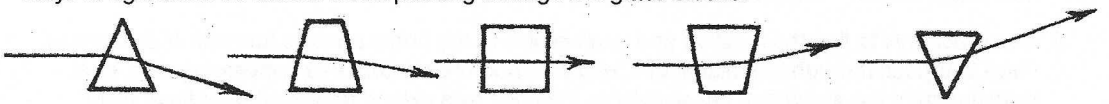
CONCEPTUAL **Physics** PRACTICE PAGE

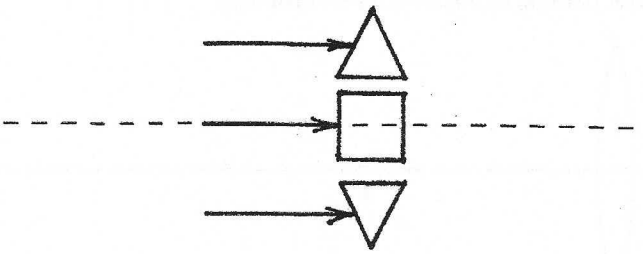
Chapter 28 Reflection and Refraction

Lenses

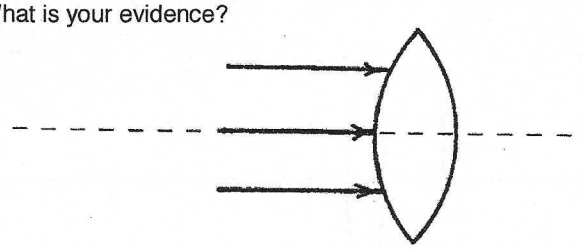
Rays of light bend as shown when passing through the glass blocks.



1. Show how light rays bend when they pass through the arrangement of glass blocks below.

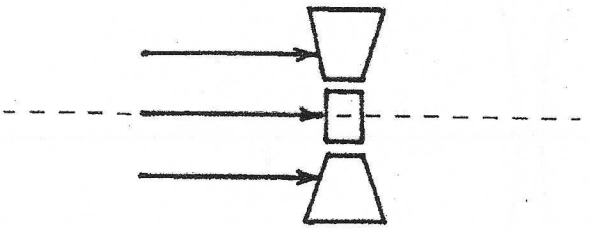


2. Show how light rays bend when they pass through the lens below. Is the lens a converging or a diverging lens? What is your evidence?

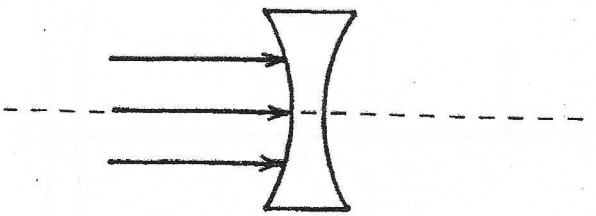


_____

3. Show how light rays bend when they pass through the arrangement of glass blocks below.



4. Show how light rays bend when they pass through the lens shown below. Is the lens a converging or diverging lens? What is your evidence?



_____

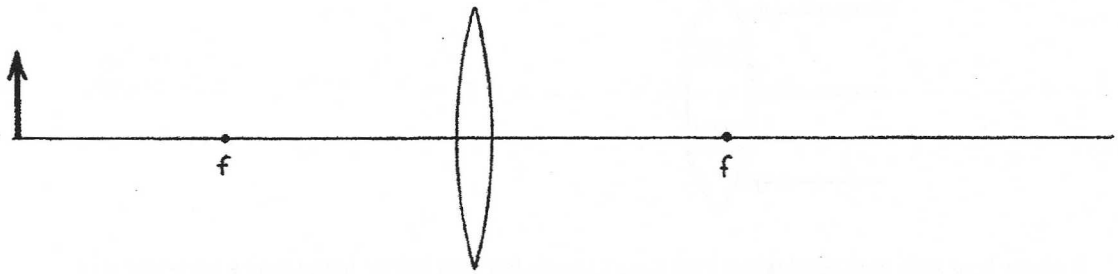
Hewitt Drew it!

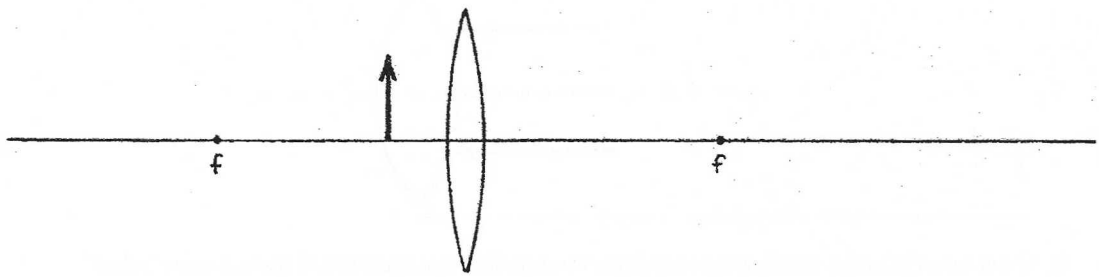
Chapter 28 Reflection and Refraction

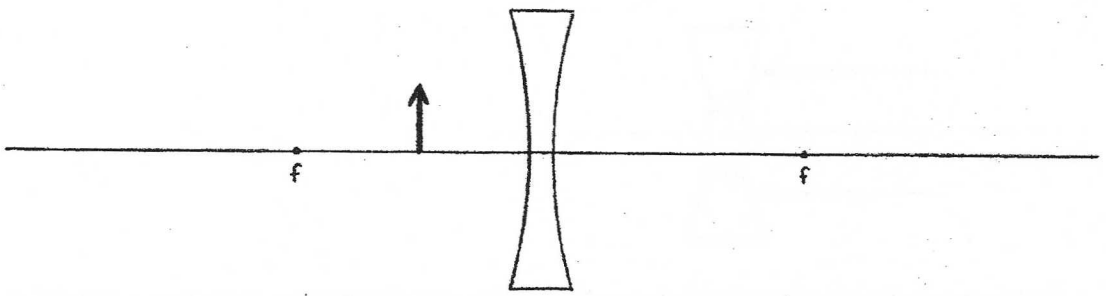
***Lenses**—continued*

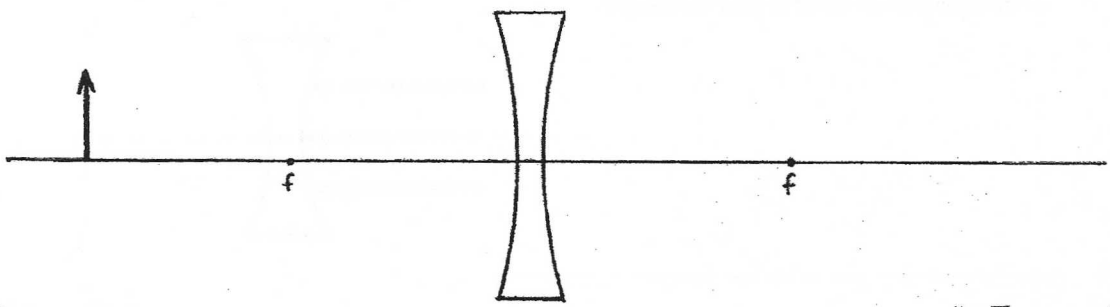
5. Which type of lens is used to corrected farsightedness? _____
   Nearsightedness? _____

6. Construct rays to find the location and relative size of the arrow's image for each of the lenses. Rays that pass through the middle of a lens continue undeviated. In a converging lens, rays from the tip of the arrow that are parallel to the optic axis extend through the far focal point after going through the lens. Rays that go through the near focal point travel parallel to the axis after going through the lens. In a diverging lens, rays parallel to the axis diverge and appear to originate from the near focal point after passing through the lens. Have fun!









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CONCEPTUAL Physics PRACTICE PAGE

Chapter 29 Light Waves

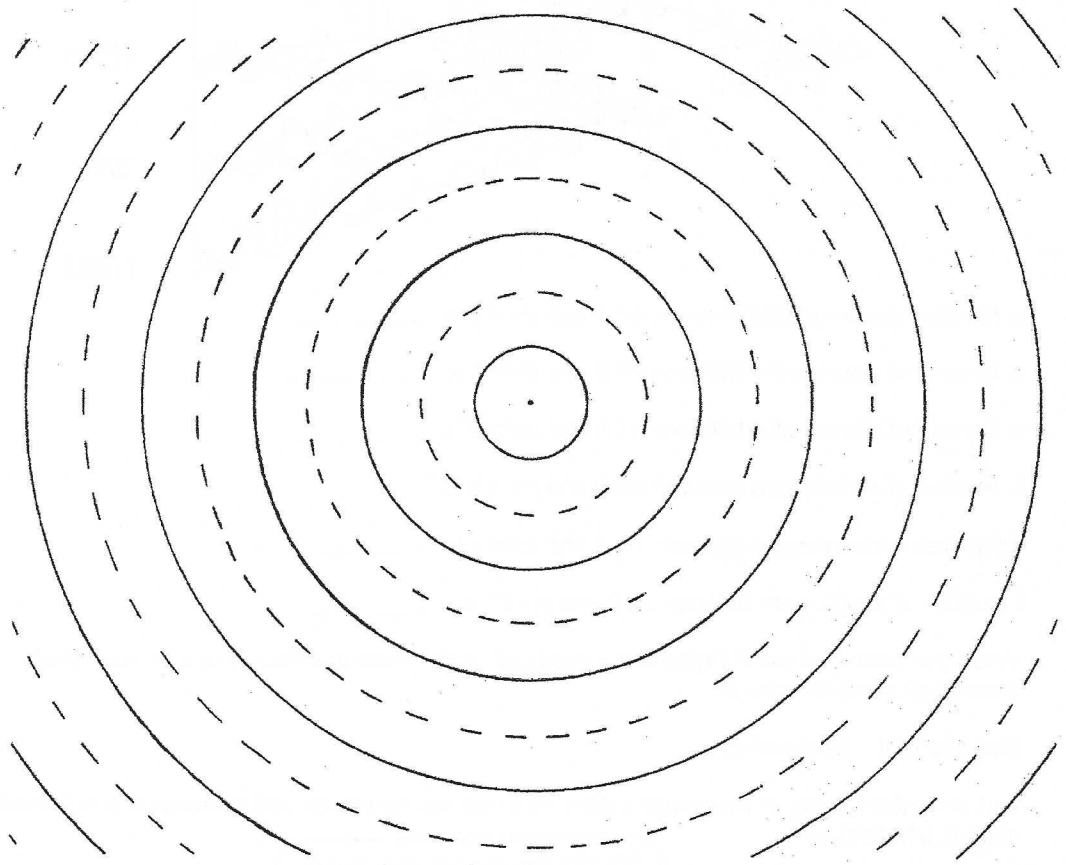
Diffraction and Interference

1. Shown are concentric solid and dashed circles, each different in radius by 1 cm. Consider the circular pattern a top view of water waves, where the solid circles are crests and the dashed circles are troughs.

   a. Draw another set of the same concentric circles with a compass. Choose any part of the paper for your center (except the present central point). Let the circles run off the edge of the paper.

   b. Find where a dashed line crosses a solid line and draw a large dot at the intersection. Do this for ALL places where a solid and dashed line intersect.

   c. With a wide felt marker, connect the dots with the solid lines. These *nodal lines* lie in regions where the waves have cancelled—where the crest of one wave overlaps the trough of another (see Figures 29.15 and 29.16 in your textbook).



Hewitt Drew it!

Chapter 29 Light Waves

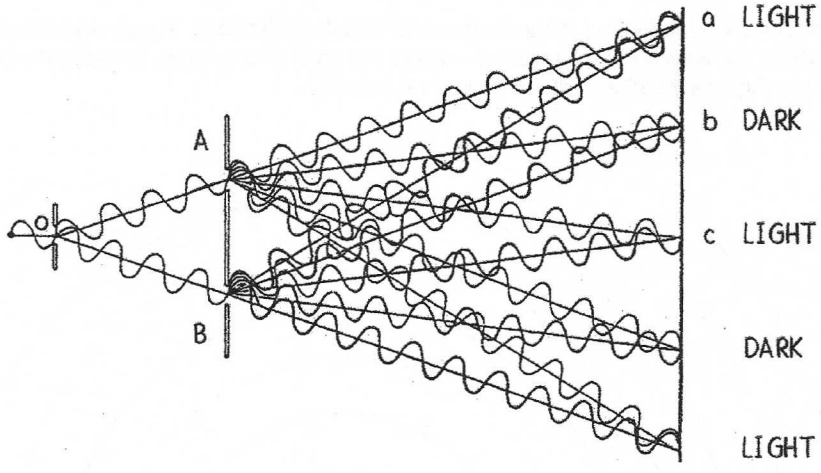
***Diffraction and Interference**—continued*

2. Look at the construction of overlapping circles on your classmates' papers. Some will have more nodal lines than others, due to different starting points. How does the number of nodal lines in a pattern relate to the distance between centers of circles, (or sources of waves)?

_____

_____

3. Figure 29.19 from your textbook is repeated below. Carefully count the number of wavelengths (same as the number of wave crests) along the following paths between the slits and the screen.



a. Number of wavelengths between slit A and point a is _____.

b. Number of wavelengths between slit B and point a is _____.

c. Number of wavelengths between slit A and point b is _____.

d. Number of wavelengths between slit B and point b is _____.

e. Number of wavelengths between slit A and point c is _____.

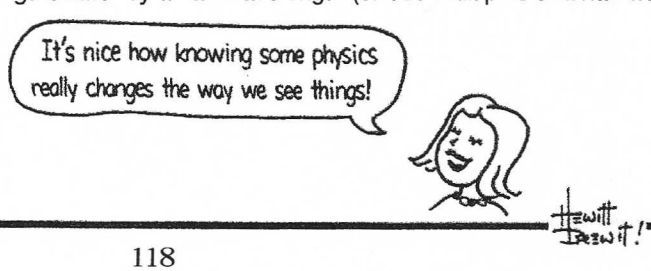
f. Number of wave crests between slit B and point c is _____.

4. When the number of wavelengths along each path is the same or differs by one or more whole wavelengths, interference is

[constructive] [destructive]

and when the number of wavelengths differ by a half-wavelength (or odd multiples of a half-wavelength), interference is

[constructive] [destructive].



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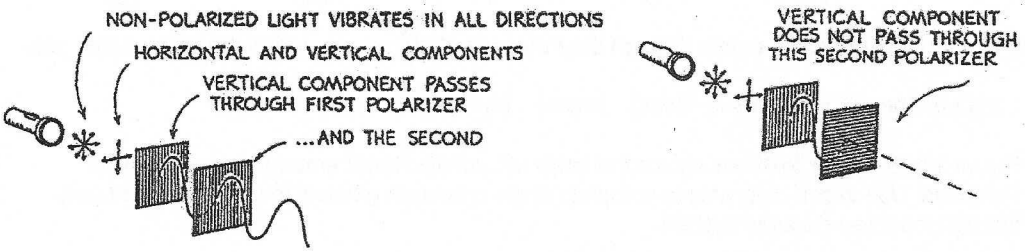
CONCEPTUAL **Physics** PRACTICE PAGE

Chapter 29 Light Waves

Polarization

The amplitude of a light wave has magnitude and direction, and can be represented by a vector. Polarized light that vibrates in a single direction is represented by a single vector. To the left the single vector represents vertically polarized light. The pair of perpendicular vectors to the right represents nonpolarized light. The vibrations of nonpolarized light are equal in all directions, with as many vertical components as horizontal components.

1. In the sketch below, nonpolarized light from a flashlight strikes a pair of Polaroid filters.

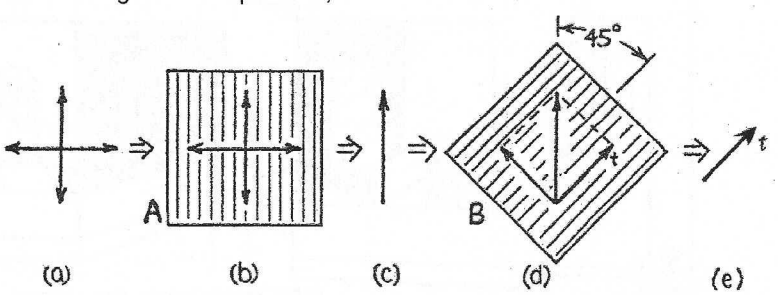


a. Light is transmitted by a pair of Polaroids when their axes are [aligned] [crossed at right angles]

and light is blocked when their axes are [aligned] [crossed at right angles].

b. Transmitted light is polarized in a direction [the same as] [different than] the polarization axis of the filter.

2. Consider the transmission of light through a pair of Polaroids with polarization axes at 45° to each other. Although in practice the Polaroids are one atop the other, we show them spread out side by side below. From left to right:
(a) Nonpolarized light is represented by its horizontal and vertical components.
(b) These components strike filter A.
(c) The vertical component is transmitted, and
(d) falls upon filter B. This vertical component is not aligned with the polarization axis of filter B, but it has a component that is aligned—component *t*,
(e) which is transmitted.



a. The amount of light that gets through Filter B, compared to the amount that gets through

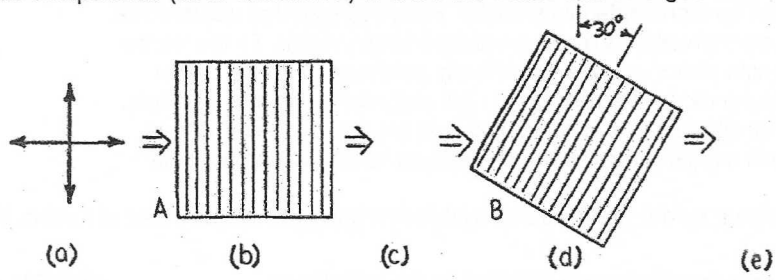
Filter A is [more] [less] [the same].

b. The component perpendicular to *t* that falls on Filter B is [also transmitted] [absorbed].

Chapter 29 Light Waves

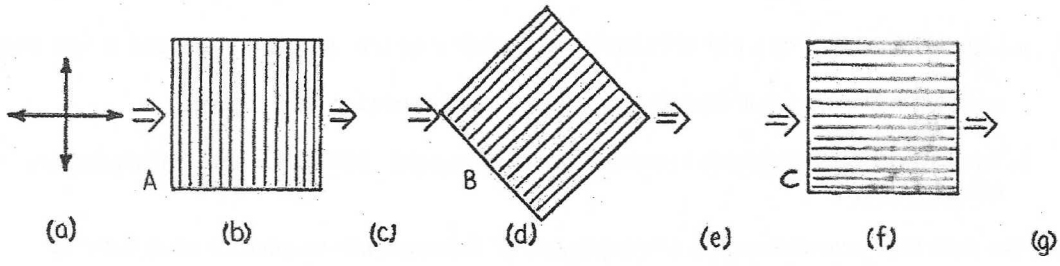
***Polarization**—continued*

3. Below are a pair of Polaroids with polarization axes at 30° to each other. Carefully draw vectors and appropriate components (as in Question 2) to show the vector that emerges at *e*.

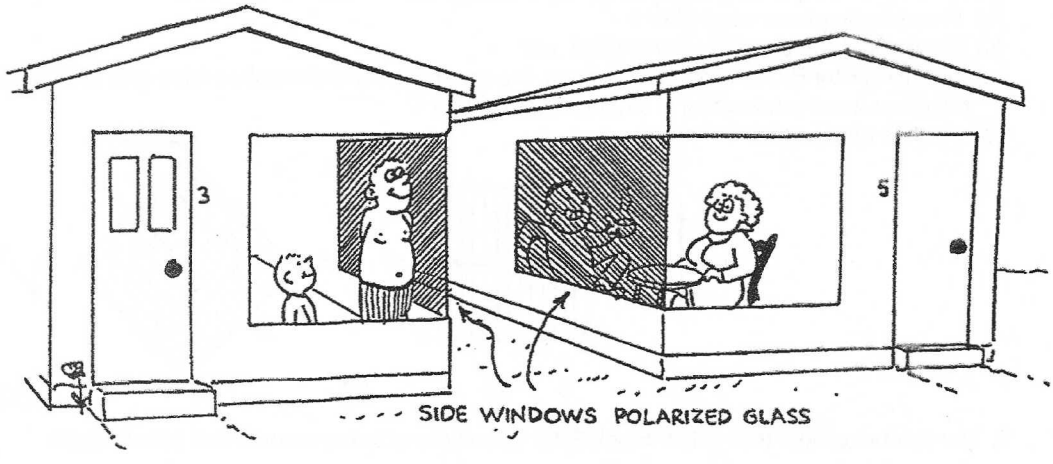


a. The amount of light that gets through the Polaroids at 30°, compared to the amount that gets through the 45° Polaroids is [less] [more] [the same].

4. Figure 29.35 in your textbook shows the smile of Ludmila Hewitt emerging through three Polaroids. Use vector diagrams to complete steps *b* through *g* below to show how light gets through the three-Polaroid system.



5. A novel use of polarization is shown below. How do the polarized side windows in these next-to-each-other houses provide privacy for the occupants? (Who can see what?)



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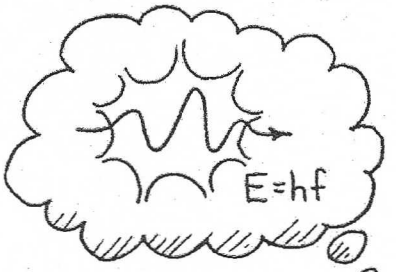
CONCEPTUAL **Physics** PRACTICE PAGE

Chapters 31 and 32 Light Quanta and The Atom and The Quantum

Light Quanta



1. To say that light is quantized means that light is made up of

   [elemental units] [waves].

2. Compared to photons of low-frequency light, photons of higher-frequency light have more

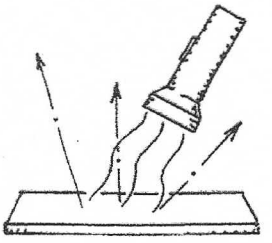
   [energy] [speed] [quanta].

3. The photoelectric effect supports the

   [wave model of light] [particle model of light].

4. The photoelectric effect is evident when light shone on certain

   photosensitive materials ejects [photon] [electrons].



5. The photoelectric effect is more effective with violet light than with red light because the photons

   [resonate with the atoms in the material]

   [deliver more energy to the material]

   [are more numerous].

6. According to De Broglie's wave model of matter, a beam of light

   and a beam of electrons [are fundamentally different] [are similar].

7. According to De Broglie, the greater the speed of an electron beam, the

   [longer is its wavelength] [shorter is its wavelength].

8. The discreteness of the energy levels of electrons about the atomic nucleus is best understood

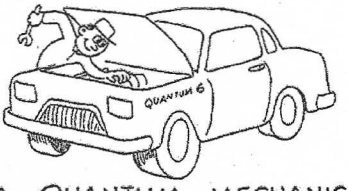
   by considering the electron to be a [wave] [particle].

9. Heavier atoms are not appreciably larger in size than lighter atoms. The main reason for this is that the greater nuclear charge

   [pulls surrounding electrons into tighter orbits]

   [holds more electrons about the atomic nucleus]

   [produces a denser atomic structure].



A QUANTUM MECHANIC!

10. Whereas in the everyday macroworld the study of motion is called *mechanics* in the microworld the study of quanta is called

    [Newtonian mechanics] [quantum mechanics].

Hewitt Drew it!