Name: _____ *Key* _____

AP Physics

Date _____

Optics

Questions 1 and 2 refer to the following: **FAST**

#2 into Fast Away
#1 Into Slow Toward
#2 into slow toward
#2
#2
#1
#1
into fast #1 Away
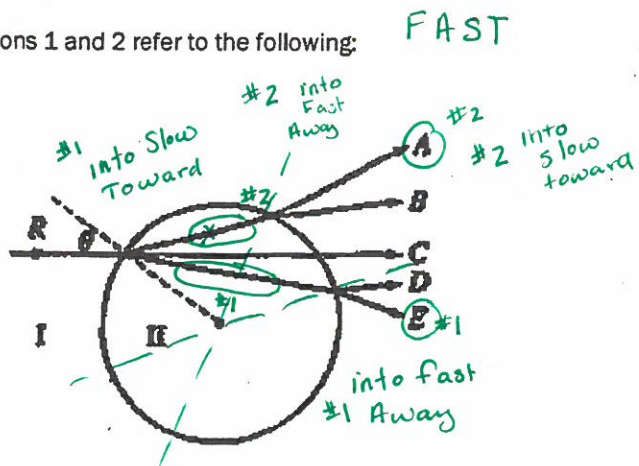
A light ray R in medium I strikes a sphere of medium II with angle of incidence θ, as shown above. The figure shows five possible subsequent paths for the light ray.

1) Which path is possible if medium I is air and medium II is glass?

   A) D
   B) C
   C) B
   D) A
   E) E ← (circled)

2) Which path is possible if medium I is glass and medium II is air?

   A) A ← (circled)
   B) B
   C) D
   D) E
   E) C

3) The wavelength of yellow sodium light in vacuum is 5.89×10^{-7} m. The speed of this light in glass with an index of refraction of 1.5 is most nearly

   A) 3×10^8 m/s
   B) 4×10^{-7} m/s
   C) 9×10^{-7} m/s
   D) 2×10^8 m/s ← (circled)
   E) 4×10^8 m/s

   $V = \dfrac{C}{n} = \dfrac{3 \times 10^8 \, m/s}{1.5}$

4) An object O is in front of a convex mirror. The focal point of the mirror is labeled F and the center of curvature is labeled C. The direction of the reflected ray is correctly illustrated in all of the following EXCEPT which diagram?

   A) ✓

   B) (circled) *in f out //*

   C) ✓

   D) ✓

   E) ✓
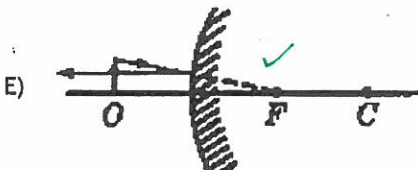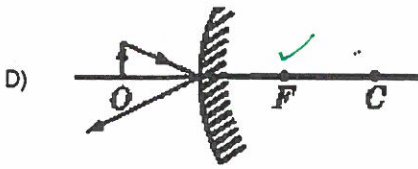
5) When light passes from air into water, the frequency remains the same. What happens to the speed and the wavelength of light as it crosses the boundary in going from air into water?

   A) Speed: decreases
      Wavelength: ~~increases~~ ↑n
   B) Speed: ~~increases~~ ↓v
      Wavelength: remains the same ↓λ
   C) Speed: ~~remains the same~~
      Wavelength: ~~remains the same~~
   D) Speed: decreases ← (circled)
      Wavelength: decreases
   E) Speed: ~~remains the same~~
      Wavelength: decreases

6) Observations that indicate that visible light has a wavelength much shorter than a centimeter include which of the following?

I. The colored pattern seen in a soap bubble $2t = \lambda$
II. The colored pattern seen when light passes through a diffraction grating $\lambda = \frac{m\lambda L}{d}$
III. The bending of light when it passes from one medium to another medium $n_1 \sin\theta_1 = n_2 \sin\theta$

10λ

A) I and II only
B) III only
C) II and III only
D) I, II, and III
E) I only

7) A concave mirror is used to collect light from a distant star. The distance between the mirror and the image of the star is 1.0 m. What is the radius of curvature of the mirror?

$+F$

A) 0.75 m
B) 2.0 m
C) 1.0 m
D) 0.25 m
E) 0.50 m

$F = 1m$
$R = 2f = 2m$

8) A concave mirror with a radius of curvature of 1.0 m is used to collect light from a distant star. The distance between the mirror and the image of the star is most nearly

R

A) 0.25 m
B) 2.0 m
C) 0.75 m
D) 0.50 m
E) 1.0 m

$F = \frac{R}{2} \sim \frac{1.0m}{2}$

9) A physics student places an object 6.0 cm from a converging lens of focal length 9.0 cm. What is the magnitude of the magnification of the image produced?

d_o
$+F$

A) 3.0
B) 0.6
C) 2.0
D) 1.5
E) 3.6

① $d_i = \left(\frac{1}{f} - \frac{1}{d_o}\right)^{-1}$
$= \left(\frac{1}{9} - \frac{1}{6}\right)^{-1}$
$= -18$

② $m = -\frac{d_i}{d_o}$
$= -\frac{(-18)}{6}$

10) Which of the following CANNOT be accomplished by a single converging lens with spherical surfaces?

A) ✓ Converting a spherical wave front into a plane wave front $\text{in } F \text{ out } \parallel$
B) Forming a real upright image of a real upright object real are inverted
C) ✓ Converting a plane wave from into a spherical wave front
D) ✓ Forming a real inverted image of a real upright object
E) ✓ Forming a virtual image of a real object in front F

11)

An object is placed at a distance of 1.5f from a converging lens of focal length f, as shown above. What type of image is formed and what is its size relative to the object?

A) Type: Real
   Size: Smaller
B) Type: Virtual
   Size: Smaller
C) Type: Real
   Size: Larger
D) Type: Virtual
   Size: Same Size
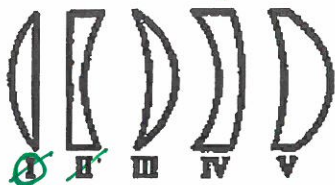E) Type: Virtual
   Size: Larger

12)

left right reflection

An object, slanted at an angle of 45^0, is placed in front of a vertical plane mirror, as shown above. Which of the following shows the apparent position and orientation of the object's image?
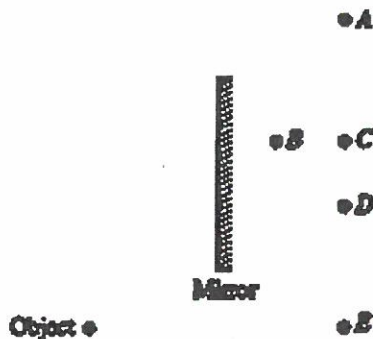
A)

B)

C)

D)

E)

13) *(handwritten: more concave than convex ↓)*

(handwritten labels below lenses: I II III IV V)

Which three of the glass lenses above, when placed in air, will cause parallel rays of light to converge?

A) I, X and III
B) II, IV, and V
C) II, III, and V
D) X, III, and IV
E) X, IV, and V

(handwritten: ① definitely not II, ② definitely I, ③ Compare III + IV)

14)

(diagram: points A, B, C, D, E, Mirror, Object)

An object is placed near a plane mirror, as shown above. Which of the labeled points is the position of the image?

A) A
B) D
C) B
D) E
E) C

(handwritten: left right reflection)

15) If the object distance for a <u>converging thin lens</u> is more than twice the focal length of the lens, the image is

(handwritten: Beyond C)

A) located at a distance more than 2f from the lens
B) larger than the object
C) virtual and erect *(handwritten: inside F)*
D) located at a distance between f and 2f from the lens
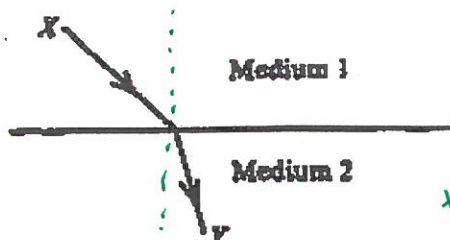E) located inside the focal point

16) A postage stamp is placed <u>30 centimeters</u> to the <u>left</u> of a converging lens of focal length 60 centimeters. Where is the image of the stamp located? *(handwritten: +F, d₀, F)*

A) 60 cm to the ~~right of the lens~~
B) ~~20 cm to~~ the left of the lens
C) ~~20 cm to the right of the lens~~
D) 60 cm to the left of the lens
E) ~~30 cm to the right of the lens~~

(handwritten: ① inside F is virtual)

$$② \quad d_i = \left(\frac{1}{F} - \frac{1}{d_0} \right)^{-1}$$
$$= \left(\frac{1}{60} - \frac{1}{30} \right)^{-1}$$
$$= -60$$

17)

(diagram: X, Medium 1, Medium 2, Y)

(handwritten: toward slower ↑n, straight)

Light leaves a source at X and travels to Y along the path shown above. Which of the following statements is correct?

A) The index of refraction is the same for the two media.
B) Light would arrive at Y in less time by taking a straight line path from X to Y than it does taking the path shown above. *(handwritten: ?)*
C) Light leaving a source at Y and traveling to X would follow the same path shown above, but in reverse.
D) Snell's law breaks down at the interface.
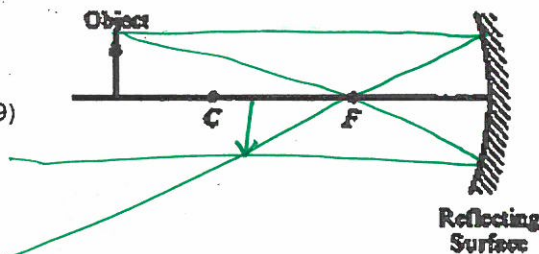E) Light travels faster in medium 2 than in medium 1.

18) The critical angle for a transparent material in air is 30⁰. The index of refraction of the material is most nearly

A) 1.0
B) 2.0
C) 1.5
D) 0.33
E) 0.50

(handwritten:)
$$\sin \theta_c = \frac{n_2}{n_1}$$
$$n_1 = \frac{n_2}{\sin \theta_c} = \frac{1}{\sin 30°}$$

19)

(diagram: Object, C, F, Reflecting Surface)

An object is placed as shown in the figure above. The center of curvature C and the focal point F of the reflecting surface are marked. As compared with the object, the image formed by the reflecting surface is

A) ~~erect~~ and smaller
B) ~~erect~~ and the same size
C) ~~erect~~ and larger
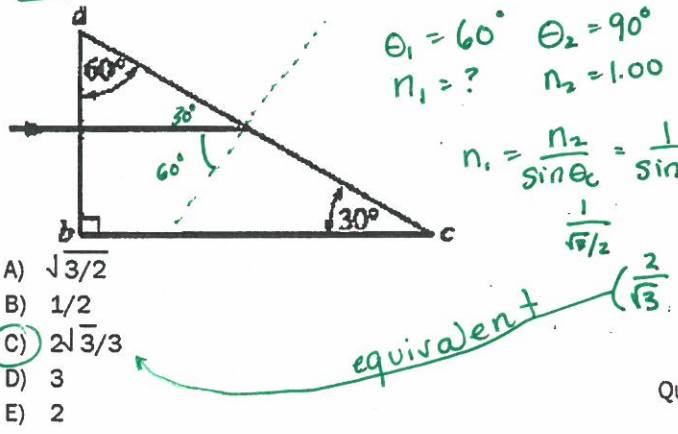D) inverted and smaller
E) inverted and larger

20) When one uses a magnifying glass to read fine print, one uses a

A) converging lens to produce a virtual image of the print
B) ~~diverging lens~~ to produce a virtual image of the print *(handwritten: Always smaller)*
C) converging lens to produce a ~~real image of the print~~
D) diverging lens to produce a ~~real image of the print~~
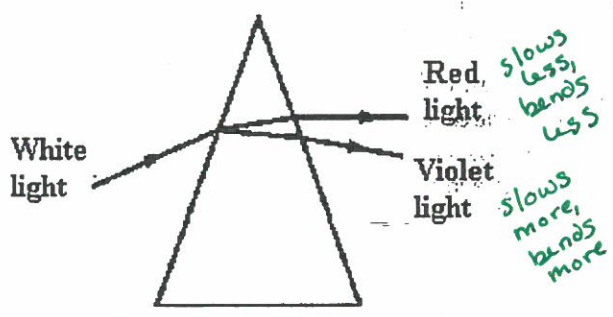E) ~~mirror to produce~~ a virtual image of the print

[handwritten top margin: -f = diverge lens, Always smaller closer virtual upright, do]

21) An illuminated object is placed 0.30 meter from a lens whose focal length is -0.15 meter. The image is

A) ~~inverted, real,~~ and 0.30 meter from the lens on the ~~opposite side~~ from the object

B) upright, virtual, and 0.30 meter from the lens on the ~~opposite side~~ from the object

C) upright, virtual, and 0.10 meter from the lens on the same side as the object   *(circled)*

D) ~~inverted, real,~~ and 0.10 meter from the lens on the same side as the object

E) upright, ~~real,~~ and 0.10 meter from the lens on the same side as the object

22) A ray of light in air is incident on a 30^0-60^0-90^0 prism, perpendicular to face *ab*, as shown in the diagram. The ray enters the prism and strikes face *ac* at the critical angle. What is the index of refraction of the prism?
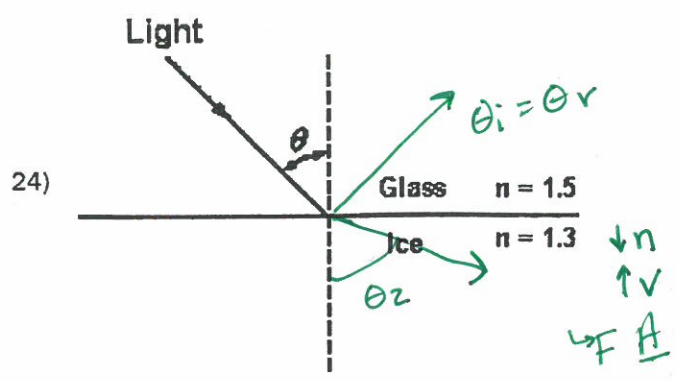
[handwritten diagram with angles 60°, 30°, 60°, 30°]

[handwritten: $\theta_1 = 60°$ $\theta_2 = 90°$ $n_1 = ?$ $n_2 = 1.00$]

[handwritten: $n_1 = \dfrac{n_2}{\sin\theta_c} = \dfrac{1}{\sin 60} = \dfrac{1}{\frac{\sqrt{3}}{2}}$]

A) $\sqrt{3}/2$

B) 1/2

C) $2\sqrt{3}/3$ *(circled)*

D) 3

E) 2

[handwritten: equivalent → $\left(\dfrac{2}{\sqrt{3}}\right)$]

23)

[handwritten prism diagram]

White light → Red, light   *[handwritten: slows less, bends less]*

Violet light   *[handwritten: slows more, bends more]*

As shown, a beam of white light is separated into separate colors when it passes through a glass prism. Red light is refracted through a smaller angle than violet light because red light has a

A) faster speed in the ~~incident beam~~ than violet light. *[handwritten brace: 3×10^8 m/s in air]*

B) slower speed in the ~~incident beam~~ than violet light.

C) faster speed in glass than violet light. *(circled)*

D) slower speed in glass than violet light.

E) greater intensity than violet light. *[handwritten: not brighter]*

24)

Light

[handwritten: $\theta_i = \theta_r$] θ

Glass   n = 1.5

Ice   n = 1.3   *[handwritten: ↓n ↑v 4 F A]*

θ_2

A ray of light in glass that is incident on an interface with ice, as shown, is partially reflected and partially refracted. The index of refraction *n* for each of the two media is given in the figure. How do the angle of reflection and the angle of refraction compare with the angle of incidence θ?

A) Angle of Reflection: Same
   Angle of Refraction: Larger   *(circled)*

B) Angle of Reflection: Same
   Angle of Refraction: ~~Smaller~~

C) Angle of Reflection: ~~Larger~~
   Angle of Refraction: Larger

D) Angle of Reflection: ~~Smaller~~
   Angle of Refraction: ~~Same~~

E) Angle of Reflection: ~~Smaller~~
   Angle of Refraction: ~~Smaller~~

Questions 25 and 26 refer to the following:

[handwritten: magnify glass, Inside F Virtual larger upright]

O

F_1 P F_2
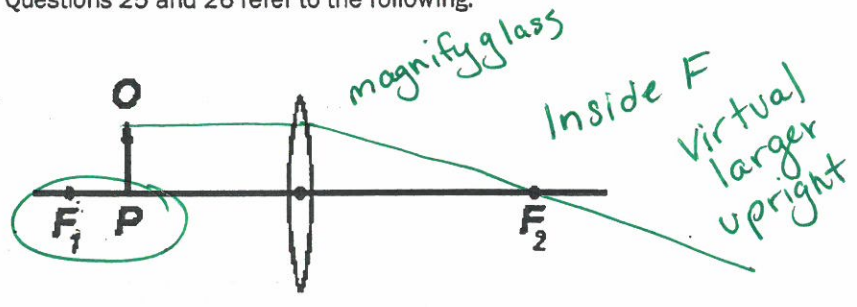
An object O is located at point P to the left of a converging lens, as shown in the figure. F_1 and F_2 are the focal points of the lens.

25) Which of the following characterizes the image when the object is in the position shown?

A) Virtual, upright, and smaller than the object

B) Real, upright, and larger than the object

C) Virtual, upright, and larger than the object   *(circled)*

D) Real, inverted, and larger than the object

E) Real, inverted, and smaller than the object

26) If the focal length of the lens is 0.40 m and point P is 0.30 m to the left of the lens, where is the image of the object located?
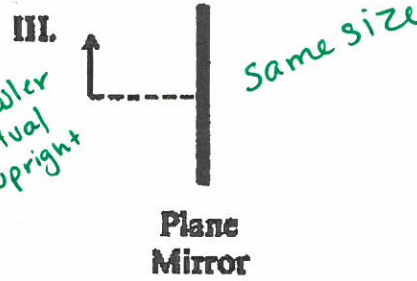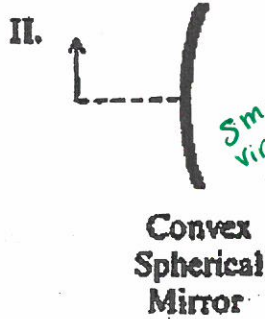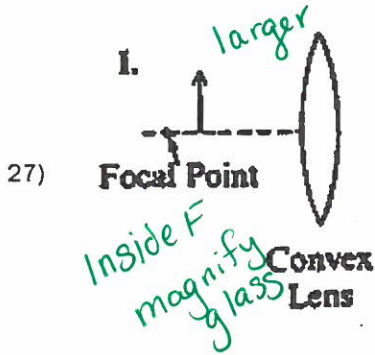
[handwritten: F, do]

A) 0.17 m to the left of the lens
B) 0.17 m to the right of the lens
C) 1.2 m to the right of the lens
D) 1.2 m to the left of the lens *(circled)*
E) at the lens

[handwritten: inside F virtual]

[handwritten:
$$d_i = \left(\frac{1}{P} - \frac{1}{d_o}\right)^{-1}$$
$$= \left(\frac{1}{.4} - \frac{1}{.3}\right)^{-1}$$
$$= -1.2$$
]

27)

[handwritten annotations: I. larger, Inside F magnify glass; II. smaller virtual upright; III. same size]

I. Focal Point — Convex Lens
II. Convex Spherical Mirror
III. Plane Mirror

The image of the arrow is larger than the arrow itself in which of the following cases?

A) I and III only
B) I, II, and III
C) II only
D) II and III only
E) I only *(circled)*