Physics 112 Sample Test 6

Write out your fundamental relationships.

Snell's Law

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

Thin Lens Equation

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

Magnification

$$M = -\frac{q}{p}$$

Sign Convention for Mirrors

Quantity	Positive	Negative
p	Object in front of mirror	(virtual) Object behind mirror
q	Image in front of mirror	(virtual) Image behind mirror
h'	Image Upright	Image Inverted
f and r	Concave	Convex
M	Image Upright	Image Inverted

Sign Convention for Lenses

Quantity	Positive	Negative
p	(real) Object in front of lens	(virtual) Object behind lens
q	(real) Image opposite object	(virtual) Image on same side as object
h'	Image Upright	Image Inverted
f	Converging lens	Diverging Lens
M	Image Upright	Image Inverted

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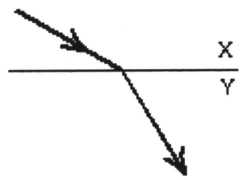
NAME ___________________________

1) Multiple Choice

1.1) When light travels from medium X to medium Y as shown:

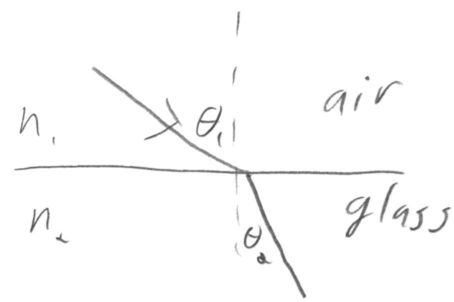


A) both the speed and the frequency decrease
B) both the speed and the frequency increase
C) both the speed and the wavelength decrease
D) both the speed and the wavelength increase

frequency is constant,

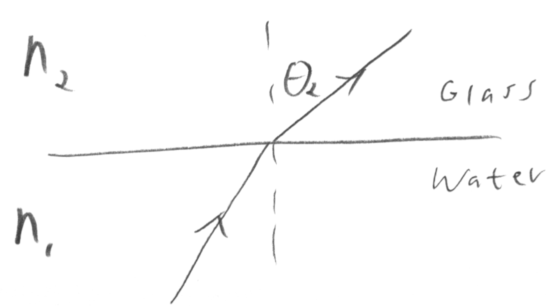
1.2) When light passes from air to glass, it bends:

A) toward the normal without changing speed
B) toward the normal and slows down
C) toward the normal and speeds up
D) away from the normal and slows down
E) away from the normal and speeds up



$n_2 > n_1 \Rightarrow \theta_2 < \theta_1$

1.3) If $n_{water} = 1.33$ and $n_{glass} = 1.50$, then total internal reflection at an interface between this glass and water:
A) occurs whenever the light goes from glass to water
B) occurs whenever the light goes from water to glass
C) may occur when the light goes from glass to water
D) may occur when the light goes from water to glass
E) can never occur at this interface



TIR when $\theta_2 = 90^\circ$

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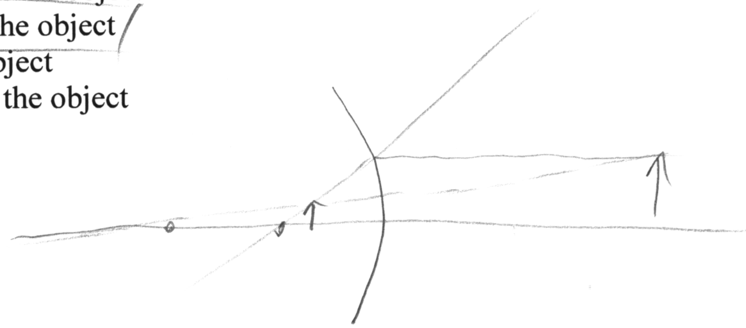
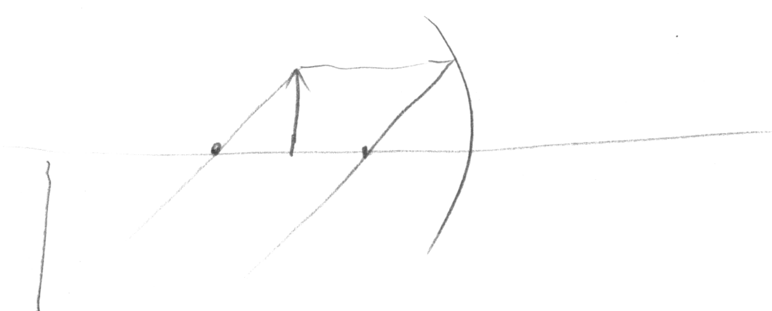
1.4) The image produced by a convex mirror of an object in front of the mirror is always:

A) virtual and larger than the object
B) virtual smaller than the object
C) real larger than the object
D) real and smaller than the object
E) none of the above



1.5) As an object is moved from the center of curvature of a concave mirror toward its focal point its image:

A) remains virtual and becomes larger
B) remains virtual and becomes smaller
C) remains real and becomes larger
D) remains real and becomes smaller
E) remains real and approaches the same size as the object



1.6) Where must an object be placed in front of a converging lens in order to obtain a virtual image?

A) At the focal point
B) At twice the distance to the focal point
C) Anywhere beyond the focal point
D) Between the focal point and the lens
E) Between the focal point and twice the distance to the focal point

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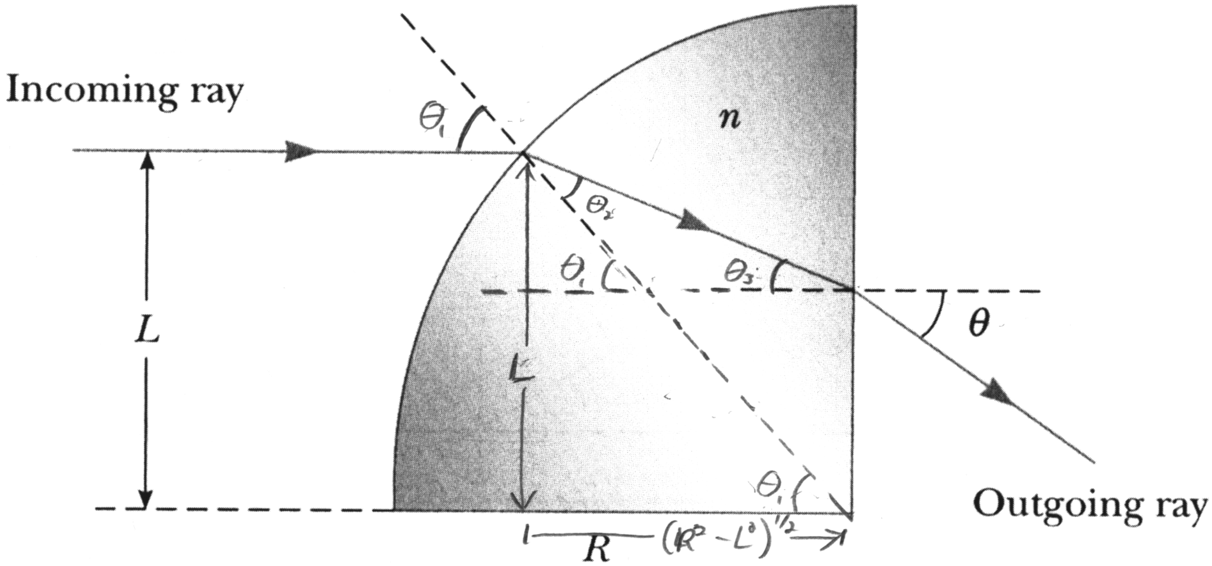
A material having an index of refraction n is surrounded by a vacuum and is in the shape of a quarter circle of radius R. A light ray parallel to the base of the material is incident from the left at a distance L above the base and emerges from the material at the angle θ.

Find an expression for θ.



$\sin\theta_1 = \frac{L}{R}$, $\sin\theta_1 = n\sin\theta_2$, $n\sin\theta_3 = \sin\theta$

We need θ_3: $\theta_3 = 180 - \theta_2 - (180 - \theta_1) = 180 - \theta_2 - 180 + \theta_1$

$\Rightarrow \boxed{\theta_3 = \theta_1 - \theta_2}$

So: $\sin\theta = n\sin(\theta_1 - \theta_2)$

$\Rightarrow \sin\theta = n[\sin\theta_1\cos\theta_2 - \sin\theta_2\cos\theta_1]$

Eliminate θ_2: $\cos\theta_2 = (1-\sin^2\theta_2)^{1/2}$, $\sin\theta_2 = \frac{1}{n}\sin\theta_1$

So: $\sin\theta = n\left[\sin\theta_1\left(1-\frac{1}{n^2}\sin^2\theta_1\right)^{1/2} - \frac{1}{n}\sin\theta_1\cos\theta_1\right]$

continued ↓

Sample Test 6, continued.

$$\Rightarrow \sin\theta = n\left[\frac{L}{R}\left(1-\frac{1}{n^2}\frac{L^2}{R^2}\right)^{1/2} - \frac{1}{n}\frac{L}{R}\frac{(R^2-L^2)^{1/2}}{R}\right]$$

$$* \cos\theta_1 = \frac{(R^2-L^2)^{1/2}}{R}$$

$$\Rightarrow \sin\theta = n\left[\frac{L}{R}\left(\frac{(n^2R^2-L^2)^{1/2}}{nR}\right) - \frac{L}{R}\frac{(R^2-L^2)^{1/2}}{nR}\right]$$

$$\boxed{\sin\theta = \frac{L}{R^2}\left[(n^2R^2-L^2)^{1/2} - (R^2-L^2)^{1/2}\right]}$$

hmm... I think that's as good as it gets.

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An overenthusiastic sports car nerd obsessively polishes the hubcaps of her McLaurin F1. The hubcap is a section of a sphere. When she looks into the concave side of the hubcap, she sees an image of her face 30cm behind the hubcap. When she looks into the convex side, she sees an image of her face 10cm behind the hubcap.

a) How far is her face from the hubcap?
b) What is the radius of curvature of the hubcap?

Given

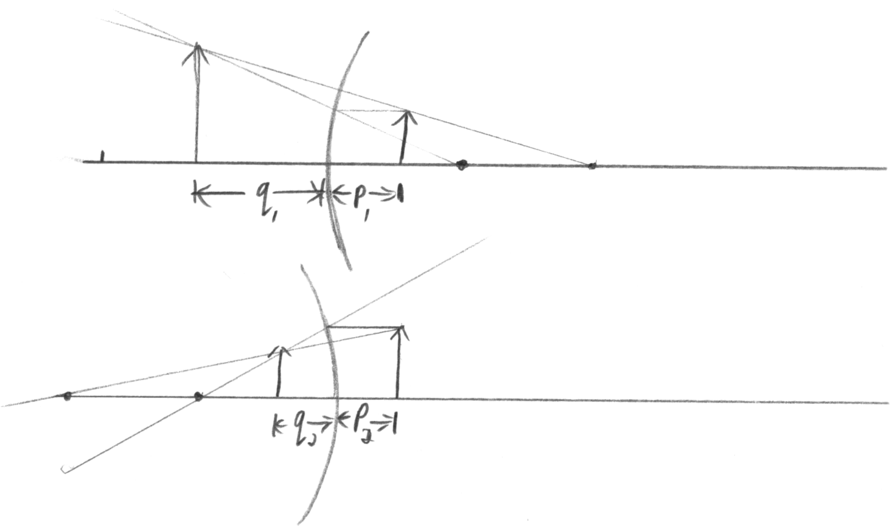
$p_2 = p_1 = p$

$q_1 = 30\text{cm}$

$q_2 = 10\text{cm}$

Want

p, f



$$\frac{1}{p_1} - \frac{1}{q_1} = \frac{1}{f_1}, \quad \frac{1}{p_2} - \frac{1}{q_2} = \frac{1}{f_2}, \quad f_1 = -f_2$$

$$\Rightarrow \frac{1}{p} - \frac{1}{q_1} = -\left[\frac{1}{p} - \frac{1}{q_2}\right] \Rightarrow \frac{2}{p} = \frac{1}{q_1} + \frac{1}{q_2}$$

$$\Rightarrow p = 2\left(\frac{1}{q_1} + \frac{1}{q_2}\right)^{-1} \Rightarrow \boxed{p = 15\text{cm}}$$

$$\text{Then: } f = \left(\frac{1}{p} - \frac{1}{q_1}\right)^{-1} \Rightarrow \boxed{f = 30\text{cm}}$$

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An observer to the right of the mirror-lens combination shown below sees two real images that are the same size and in the same location. One image is upright and the other is inverted. Both images are 1.5 times larger than the object. The lens has a focal length of 10.0cm. The lens and mirror are separated by 40.0cm.

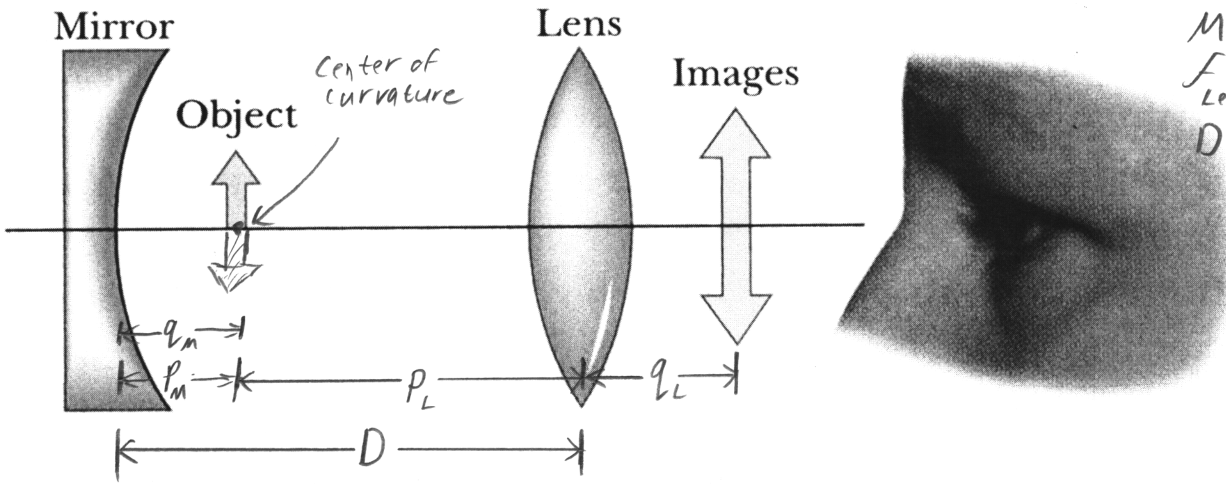
What is the focal length of the mirror? (do not assume that the figure is drawn to scale.)

Given

$M = 1.5$

$F_{Lens} = 10.0\,cm$

$D = 40.0\,cm$



$$P_M = q_M \Rightarrow \frac{2}{P_M} = \frac{1}{F_M}, \qquad \frac{1}{P_L} + \frac{1}{q_L} = \frac{1}{F_L}, \qquad M = -\frac{q_L}{P_L} \Rightarrow q_L = -P_L M$$

$$\Rightarrow F_M = \tfrac{1}{2} P_M, \qquad P_M = D - P_L$$

$$\frac{1}{P_L} - \frac{1}{M P_L} = \frac{1}{F_L}$$

$$\Rightarrow \frac{1}{P_L}\left(1 - \frac{1}{M}\right) = \frac{1}{F_L}$$

$$\Rightarrow P_L = F_L\left(\frac{M-1}{M}\right)$$

$$\Rightarrow F_M = \tfrac{1}{2}(D - P_L)$$

$$\Rightarrow F_M = \tfrac{1}{2}\left(D - F_L\left(\frac{M-1}{M}\right)\right)$$

$$\Rightarrow F_M = 11.8\,cm$$