Physics 1520, Fall 2011
Quiz 2, Form: $\boxed{A}$

Name: Key

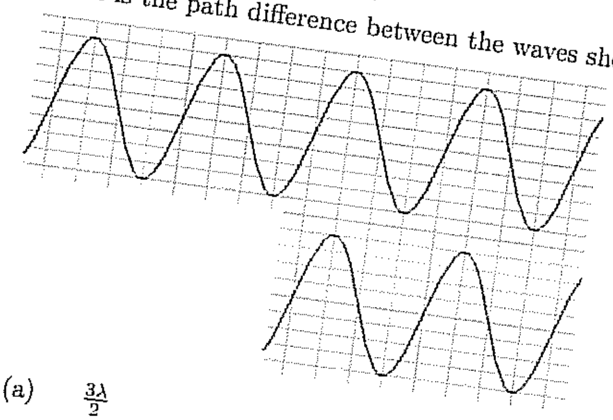
Date:

Numeric answers must include units. Sketches must be labeled. All short-answer questions must include your reasoning, for full credit. A correct answer with no reasoning will only receive partial credit.

Section 1. Multiple Choice

4 pts each for M.C.

1. What is the path difference between the waves shown?

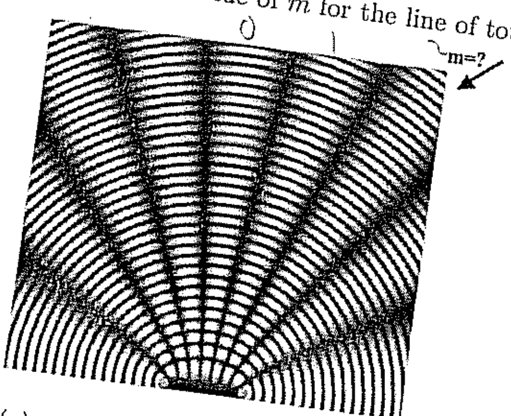


(a) $\frac{3\lambda}{2}$
(b) $\frac{5\lambda}{2}$
(c) λ
(d) 2λ
(e) 3λ

2. When the two waves in the previous question interfere, the result will be

(a) total constructive interference
(b) total destructive interference
(c) something in between total constructive and total destructive interference, with an amplitude between 0 and twice the amplitude of a single wave

3. What is the value of m for the line of total constructive interference indicated by the arrow?



(a) 0
(b) 1
(c) 2
(d) 3
(e) 4

4. A pair of slits (A) have a slit spacing d. Another pair of slits (B) are twice as far apart, $2d$. For which pair of slits will the spacing between bright fringes be the greatest?
   (a) Slits A
   (b) Slits B
   (c) Neither; the distance from the central maximum to the first bright fringe is independent of the slit spacing d

5. Light travels from air into a soap bubble. The wave that reflects off the front surface of the soap bubble (that is exposed to air) will be phase shifted
   (a) 0° (i.e. not phase shifted).
   (b) 180° (i.e. 1/2 a wavelength).

6. Looking straight downward into a rain puddle whose surface is covered with a thin film of gasoline, you notice a swirling pattern of colors caused by interference inside the gasoline film. The point directly beneath you is colored a beautiful iridescent green. You happen to remember that the index of refraction of gasoline is 1.38, the index of refraction of water is 1.33, and the wavelength of green light is about 540 nm. What is the minimum possible thickness of the gasoline layer directly beneath you?
   (a) 540 nm
   (b) 196 nm
   (c) 270 nm
   (d) 98 nm
   (e) 49 nm

air $n=1$ — phase shift
t thickness — gas $n=1.38$ — no phase shift
water $n=1.33$

constructive int. for
$p.d. = (m+\frac{1}{2})\frac{\lambda}{n}$
$2t = (m+\frac{1}{2})\frac{\lambda}{n}$

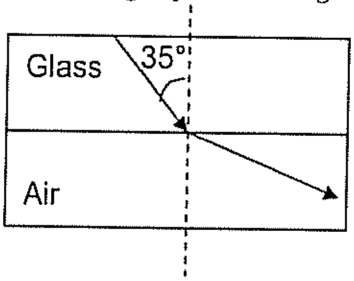
$m=0$ for min. thickness, so $t = \frac{\frac{1}{2}\lambda}{2n} = \frac{540\text{ nm}}{4(1.38)} = 98\text{ nm}$

7. The bending of waves around a barrier, such as what occurs with waves incident on a single slit, is called
   (a) diffraction
   (b) interference
   (c) reflection
   (d) refraction
   (e) scattering

8. The bending of light due to its speeding up or slowing down when it travels from one medium to another medium, such as what happens when light travels from air to glass, is called
   (a) diffraction
   (b) interference
   (c) reflection
   (d) refraction
   (e) scattering

9. As light travels from air to water, which of these quantities stays the same?
   (a) speed
   (b) wavelength
   (c) frequency
   (d) both speed and wavelength
   (e) none of the above

10. A ray of light passes from glass ($n = 1.50$) into air ($n = 1.00$) as shown below.



The incident light ray in the glass is at an angle of 35° with respect to the normal. What is the angle of the ray (with respect to the normal) as it travels through the air?

(a) 63.7°
(b) 39.6°
(c) 44.1°
(d) 48.6°
(e) 59.4°

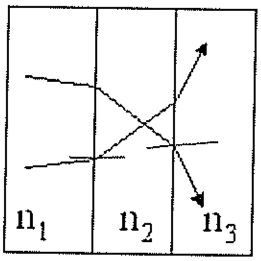
Snell's law

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

$1.5 \sin(35°) = 1 \sin\theta_2$

$\theta_2 = 59.4°$

11. Two rays start in Material #1 and pass through Material #2 into Material #3 as shown below.

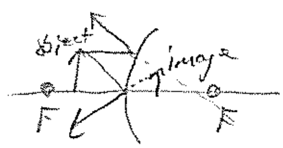


The correct relationship between the indices of refraction of the three materials is:

(a) $n_1 < n_2 < n_3$
(b) $n_1 > n_2 > n_3$
(c) $n_1 < n_2 > n_3$
(d) $n_1 > n_2 < n_3$

The ray bends away from the normal at both interfaces, so $n_2 < n_1$ and $n_3 < n_2$.

12. The image in a convex mirror is



(a) always real.
(b) always virtual.
(c) neither of the above because it depends on the object distance.

13. A concave makeup mirror is designed so that a person 0.30 m in front of it sees a virtual image at a distance of −1.2 m. What is the focal length of the mirror?

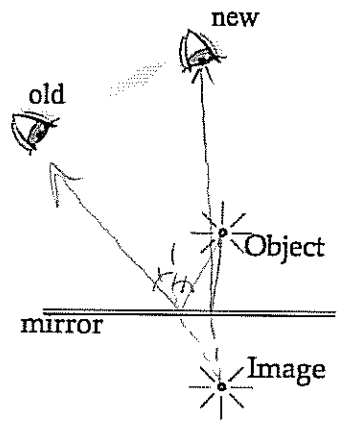
(a) 2.5 m
(b) 0.30 m
(c) 0.075 m
(d) 0.24 m
(e) 0.40 m

$$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$$

$$\frac{1}{0.3} + \frac{1}{-1.2} = \frac{1}{f}$$

$$\boxed{f = 0.4\text{m}}$$

14. If the observing eye is moved to the new position shown, the image it sees in the plane mirror will appear



$s' = s$ for a plane mirror

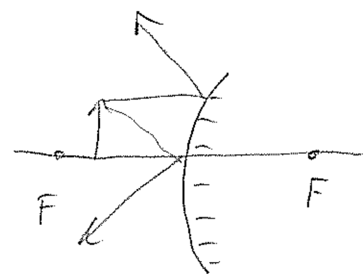
From both viewpoints, virtual rays converge at the image.

(a) closer to the mirrored surface.
(b) further from the mirrored surface.
(c) in the same place as before.
(d) further to the left.
(e) further to the right.

15. A mirror has a focal length $f = -0.3$ m. What is the radius of the mirror and what type of mirror is it?

(a) concave mirror, $R = 0.15$ m
(b) concave mirror, $R = 0.3$ m
(c) concave mirror, $R = 0.6$ m
(d) convex mirror, $R = 0.15$ m
(e) convex mirror, $R = 0.3$ m
(f) convex mirror, $R = 0.6$ m

$R = 2|f| = 0.6$m

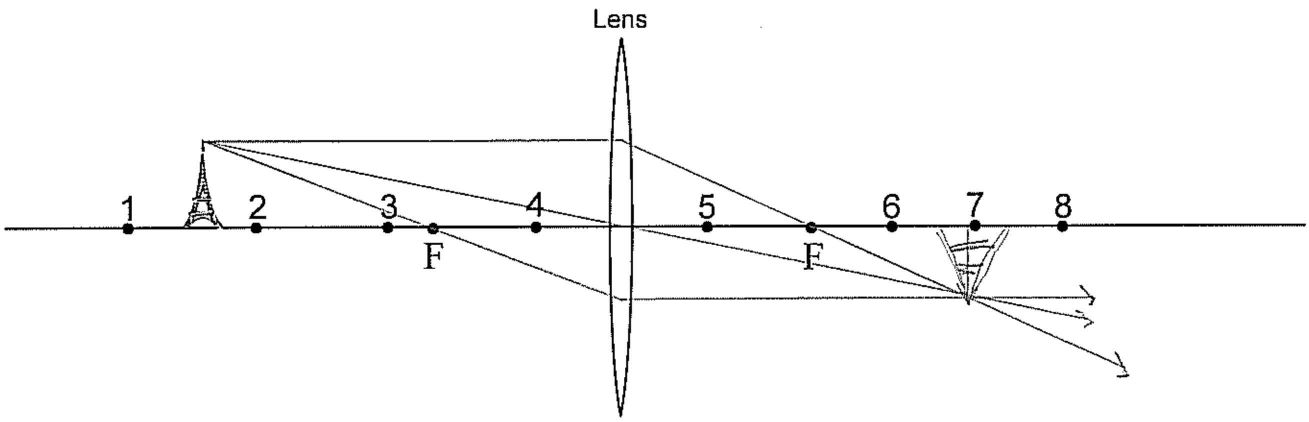


diverging reflected rays

convex mirror has neg. focal length.

Section 2. Problem Solving

16. A converging lens of focal length $f = +40$ cm is shown below. The object, a toy Eiffel Tower, is 100 cm from the vertex of the mirror.



(a) Sketch a ray emanating from the top of the object that is parallel to the optic axis. Show both the incident and refracted rays. Your sketch should be neat and clear. (1)

(b) Sketch a ray emanating from the top of the object that passes through the center of the lens. Show both the incident and refracted rays. Your sketch should be neat and clear. (1)

(c) Sketch a ray emanating from the top of the object that passes through the focal point before passing through the lens. Sketch both the incident and refracted rays. Your sketch should be neat and clear. (1)

(d) Sketch the image of the object. (Hint: it occurs near one of the number points in the image.) (1)

(e) Calculate the image distance.

$$\frac{1}{s'} + \frac{1}{s} = \frac{1}{f}$$ (5)

$$\frac{1}{s'} = \frac{1}{f} - \frac{1}{s} = \frac{1}{40\text{cm}} - \frac{1}{100\text{cm}}$$

$$\boxed{s' = 66.7\text{ cm}}$$

(f) Calculate the height of the image. (if $h = 5$ cm)

$$m = \frac{-s'}{s} = \frac{h'}{h} \quad \text{so } h' = -0.667(5\text{cm}) = \boxed{-3.33\text{ cm}}$$

$$= -\frac{66.7\text{cm}}{100\text{cm}} = -0.667$$ (5)

(g) Is the image real or virtual (circle one); is it inverted or upright (circle one), reduced or enlarged (circle one). Explain your reasoning for each of your answers. (6)

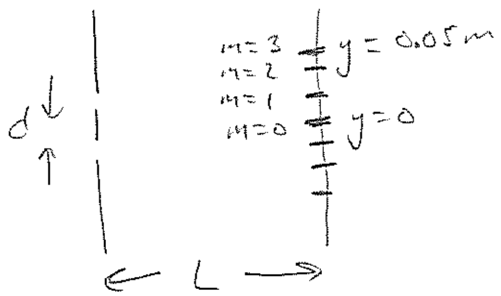
It is real because the image is formed on the opposite side of the lens as the object.

It is inverted because M is negative, and the image is upside down.

It is reduced because $|m| < 1$ and so $|h'| < h$.

17. A double-slit arrangement is used to determine the wavelength of light from a laser. The pattern of fringes is viewed on a screen 2.50 m from the slits. The slits are 6.0×10^{-5} m apart. The distance from the center fringe to the third bright fringe away from the center is 0.050 m. (10)

(a) What is the wavelength of the light?



$L = 2.5\,m$

$d = 6\times10^{-5}\,m$

$$d \sin\theta_m = m\lambda$$

$$\frac{d y_m}{L} \approx m\lambda$$

$$\lambda \approx \frac{d y_m}{mL} = \frac{(6\times10^{-5}\,m)(0.05\,m)}{3\,(2.5\,m)}$$

$$\lambda = 4\times10^{-7}\,m$$

$$\boxed{\lambda = 400\ nm}$$

(b) If the screen is brought closer, will the fringes get closer together or farther apart? For full credit, you must explain your reasoning using a picture or an equation. (10)

$$y_m = \frac{m\lambda L}{d} \quad \text{so} \quad y_m \propto L$$

If L decreases, then y_1 (the distance from the central maximum to the first fringe) will also decrease. Thus, all fringes will get closer together.