Physics 1520, Spring 2011

Quiz 2, Form: $\boxed{\text{A}}$

Name: Key

Date: ____________

Section 1. Exercises

1. A pair of narrow slits, separated 1.8 mm, is illuminated by a monochromatic light source. Light waves arrive at the two slits in phase. A fringe pattern is observed on a screen 4.8 m from the slits. The distance from the central maximum to the fifth bright fringe is 1 cm. The wavelength of the monochromatic light is closest to:

(a) 550 nm
(b) 600 nm
(c) 650 nm
(d) 700 nm
[✓ (e)] 750 nm

$d = 1.8\,\text{mm}$
$L = 4.8\,\text{m}$
$y_5 = 1\,\text{cm}$
$m = 5$

$$y = \frac{m\lambda L}{d}$$

$$\lambda = \frac{yd}{mL} = \frac{(1\times10^{-2}\,\text{m})(1.8\times10^{-3}\,\text{m})}{5(4.8\,\text{m})}$$

$$\lambda = 7.5\times10^{-7}\,\text{m} = 750\,\text{nm}$$

2. For the previous question, if you instead use light of a shorter wavelength, then the distance from the central maximum to the fifth bright fringe will be

(a) larger than 1 cm.
[✓ (b)] smaller than 1 cm.
(c) 1 cm, just as before.

$y \propto \lambda$

so smaller λ, smaller y.

3. Light having a frequency in vacuum of 6.0×10^{14} Hz enters a liquid of refractive index 2.0. In this liquid, its frequency is:

(a) 12×10^{14} Hz
[✓ (b)] 6.0×10^{14} Hz
(c) 3.0×10^{14} Hz
(d) 1.5×10^{14} Hz

f does not depend on n.

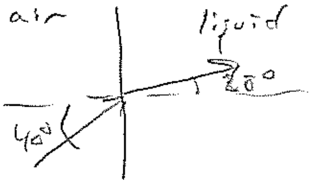
4. Light in a vacuum enters a liquid of refractive index 2.0. In this liquid, its speed is:

(a) 6.0×10^{8} m/
(b) 3.0×10^{8} m/s
[✓ (c)] 1.5×10^{8} m/s
(d) 0.75×10^{8} m/s

$$V = \frac{c}{n} = \frac{3\times10^{8}\,\frac{\text{m}}{\text{s}}}{2} = 1.5\times10^{8}\,\frac{\text{m}}{\text{s}}$$

5. A ray of light passes from air (n=1.00) into an unknown substance. If the angle between the light ray and the normal in air is 40° and the angle between the light ray and the normal in the unknown substance is 28°, what is the index of refraction of the unknown substance?

(a) 1.62
(b) 1.21
(c) 1.45
[✓ (d)] 1.37

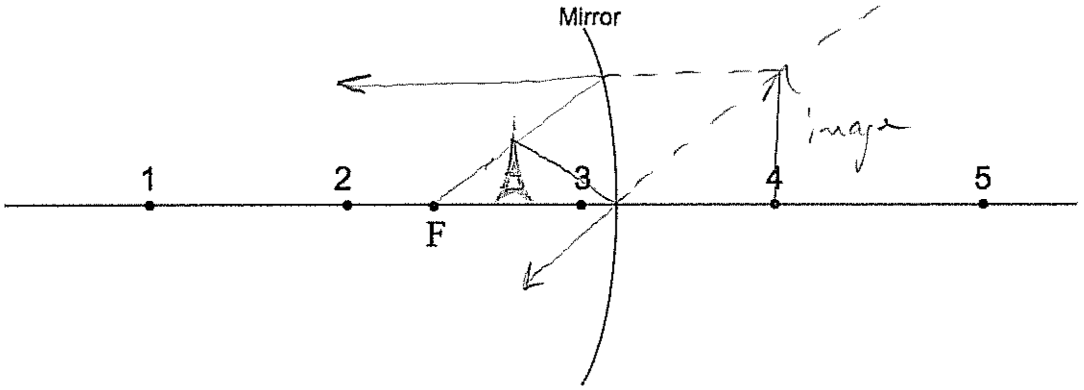


$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$1 \sin(40) = n_2 \sin(28)$

$n_2 = 1.37$

Questions 6–7: An object is shown in front of a mirror as shown below.



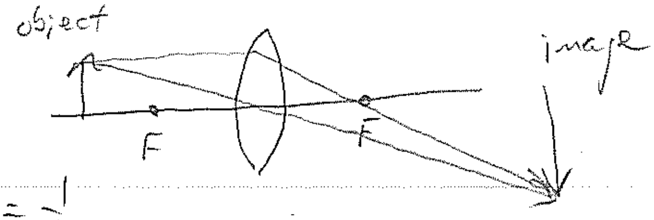
6. Sketch at least two "easy" rays to determine the point (1-5) that is closest to where the image is formed.

   (a) 1
   (b) 2
   (c) 3
   [✓ (d)] 4
   (e) 5

7. The image found in the previous question is

   (a) real and upright.
   (b) real and inverted.
   [✓ (c)] virtual and upright.
   (d) virtual and inverted.

Questions 8–10: An object is placed 15 cm in front of a converging lens which has a focal point that is 10 cm from the lens.



8. The resulting image will be at a distance

   (a) 0.033 cm from the lens.
   (b) 5 cm from the lens.
   (c) 25 cm from the lens.
   (d) 6 cm from the lens.
   [✓ (e)] 30 cm from the lens.

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

$$\frac{1}{s'} = \frac{1}{10\,cm} - \frac{1}{15\,cm}$$

$$\boxed{s' = 30\,cm}$$

9. The image is

   (a) on the same side of the lens as the object.
   [✓ (b)] on the opposite side of the lens from the object.

10. The image is

   (a) virtual and enlarged.
   (b) virtual and reduced.
   (c) real and reduced.
   [✓ (d)] real and enlarged.

$$M = \frac{-s'}{s} = -\frac{30\,cm}{15\,cm} = -2$$

11. An object is 6 cm in front of a convex mirror with a focal length of -10 cm. The magnification is

(a) 0.6
(b) -1.67
(c) 2.5
(d) -0.4
[✓ (e)] 0.625

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

$\frac{1}{s'} = \frac{1}{-10cm} - \frac{1}{6cm}$

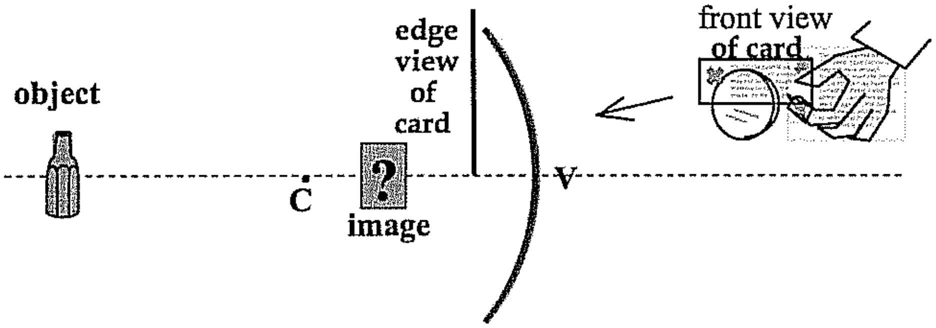
$s' = -3.75 cm$

$s' = -3.75 cm$

$m = \frac{-s'}{s} = \frac{3.75cm}{6 cm}$

$= 0.625$

12. A concave mirror forms an image of an object as shown.



Suppose the top half of the mirror is blocked by an opaque card. With the card in place, we see

(a) no image
[✓ (b)] an image of the entire object
(c) an image of just the top half of the object
(d) an image of just the bottom half of the object

13. Which statement about images is correct?

[✓ (a)] A virtual image cannot be formed on a screen.
(b) A virtual image cannot be viewed by the unaided eye.
(c) A virtual image cannot be photographed.
(d) A real image must be inverted.
(e) Mirrors always produce real images because they reflect light.

14. A screen and a converging lens of focal length f are arranged to have an image of the moon fall on the screen. What is the distance between the lens and the screen?

(a) ∞
(b) 0
(c) f/2
[✓ (d)] f
(e) 2f

$s = \infty$

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

$\cancel{\frac{1}{\infty}}^{\to 0} + \frac{1}{s'} = \frac{1}{f}$

so $\boxed{s' = f}$

15. As an object distance changes, a human eye keeps the image focused on the retina by adjusting its

(a) object distance.
(b) image distance.
[✓ (c)] focal length.

Section 2. Critical Thinking

16. A nearsighted person has a near point of 20 cm and a far point of 40 cm. What power lens is necessary to correct this person's vision to allow her to see distant objects? (Neglect the distance between the lens and the eye.)

An object at ∞ should have an image at the person's far point in order to see the distant object. $\frac{1}{s}+\frac{1}{s'}=\frac{1}{f}$ so $f = s' = -40$ cm

$\frac{1}{\infty}+\frac{1}{s'}=\frac{1}{f}$ $P=\frac{1}{f}=\frac{1}{-0.4\,m}=-2.5$

↑ virtual image

- (a) -5.0 D
- (b) +5.0 D
- [✓ (c)] -2.5 D
- (d) +2.5 D

17. If white light is incident on a pair of slits, the central maximum will be white. For angles greater than zero, interference results in a separation of white light into its component colors. Which color will have its next bright fringe (m=1) closest to the central maximum?

$\Delta y \propto \lambda$ so shorter λ has smaller fringe spacing.

- [✓ (a)] purple
- (b) green
- (c) yellow
- (d) red

18. For single slit diffraction, is the distance between the first dark fringe $p = 1$ and the second dark fringe $p = 2$ less than, greater than, or equal to the width of the central maximum? (Hint: look at the equations. This is not a fact that is memorized.)

$w = \frac{2\lambda L}{a}$ spacing ≈ $\Delta y = \frac{\lambda L}{a}$

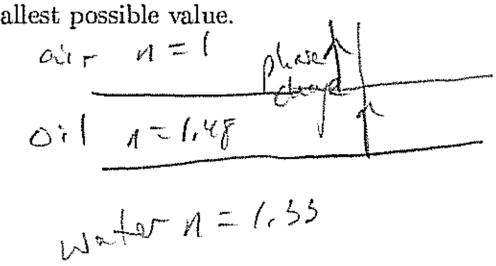
- [✓ (a)] less than
- (b) greater than
- (c) equal to

Questions 19–20: An oil film ($n = 1.48$) of thickness 290 nm floating on water (n=1.33) is illuminated with sunlight traveling perpendicular to the oil.

19. When a light wave in the oil reflects off the oil/water surface, it will undergo
- [✓ (a)] no phase change.
- (b) a 180° phase change.

20. What is the wavelength of the dominant color in the reflected light? (i.e. constructive interference) Hint: the smallest value of m results in constructive interference of a longer wavelength than visible light. Thus m is NOT the smallest possible value.

- (a) Green (541 nm)
- (b) Blue-green (493 nm)
- (c) Violet (404 nm)
- (d) Blue (470 nm)
- [✓ (e)] Yellow (572 nm)



1 phase change
const. int.

use $2t = \left(m+\frac{1}{2}\right)\frac{\lambda}{n}$ $\rightarrow$ $\lambda = \frac{2tn}{m+\frac{1}{2}}$

if $m = 0$: $\lambda = \frac{2tn}{\frac{1}{2}} = 4tn$

$= 4(290\,nm)(1.48)$

$= 1717\,nm$ this is not visible

if $m = 3$: $\lambda = \frac{2tn}{\frac{3}{2}} = \frac{4tn}{3} =$

$$\boxed{\lambda = 572\,nm}$$