Physics 228 - Exam 1
19 February 2009
Profs. Rabe and Coleman

$\Longrightarrow$ Your name sticker with **exam code** $\Longrightarrow$

SIGNATURE _____

Turn off and put away cell phones now!

1. The exam will last from 9:40pm to 11:00pm.
2. Use a #2 pencil to make entries on the answer sheet. Enter the following ID information now, before the exam starts.
3. In the section labelled NAME (Last, First, M.I.) enter your last name, then fill in the empty circle for a blank, then enter your first name, another blank, and finally your middle initial.
4. Under STUDENT # enter your 9-digit student ID.
5. Enter 228 under COURSE, and your section number (see label above) under SEC.
6. Under CODE enter the exam code given above.
7. During the exam, you may use pencils, a calculator, and one **handwritten** 8.5 x 11 inch sheet with formulas and notes, without attachments.
8. There are 15 multiple-choice questions on the exam. For each question, mark only one answer on the answer sheet. There is no deduction of points for an incorrect answer, so even if you cannot work out the answer to a question, you should make an educated guess. At the ened of the exam, **hand in the answer sheet and the cover page.** Retain this question paper for future reference and study.
9. When you are asked to open the exam, make sure that your copy contains all 15 questions. Raise your hand if this is not the case, and a proctor will help you. Also raise your hand during the exam if you have a question.
10. Please SIGN the cover sheet under your name sticker and have your student ID ready to show to the proctor during the exam.

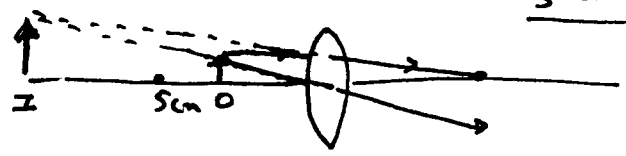
Useful information

c = speed of light = 3.00×10^8 m/s
1 nm = 10^{-9}m
1 μm = 10^{-6}m

1. An object placed in front of a thin lens of focal length +5 cm produces an image 10 cm from the lens on the same side as the object. How far is the object from the lens?

a) 2.8 cm b) 5 cm (c) 3.3 cm d) 20 cm e) 10 cm

$s' = -10\,cm$

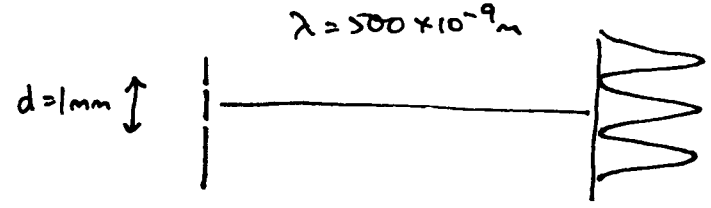


$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$ $\frac{1}{s} - \frac{1}{10} = \frac{1}{5} \Rightarrow \frac{1}{s} = \frac{1}{5} + \frac{1}{10} = \frac{3}{10}$

$\Rightarrow s = 10/3 = 3.33\,cm$

2. In a Young's double-slit experiment, light of wavelength 500 nm illuminates two slits which are separated by 1 mm. The separation between adjacent bright fringes on a screen that is 5 m from the slits is:

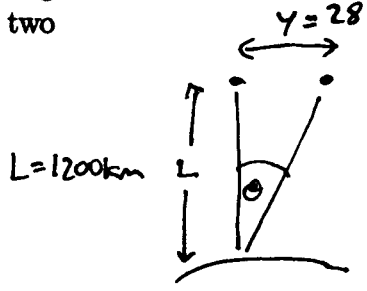
a) 1.0 cm
b) 0.10 cm
c) none of the other answers
(d) 0.25 cm
e) 0.50 cm



$y = \frac{5 \times 500 \times 10^{-9}}{10^{-3}} = 2.5 \times 10^{-3}\,m = 0.25\,cm$

3. Two satellites at an altitude of 1200 km are separated by 28km. If they broadcast 3.6-cm microwaves, what minimum receiving dish diameter is need to resolve (by Rayleigh's criterion) the two transmissions?

a) 3.76 m
b) 154 m
(c) 1.88 m
d) 1.54 m
e) 188 m



$\sin\theta \approx \theta = \frac{1.22\lambda}{D} = \frac{y}{L} = \frac{28\,km}{1200\,km}$

$\Rightarrow D = \frac{1.22 \lambda L}{y}$

$= \frac{1.22 \times 3.6 \times 10^{-2} \times 1200\,km}{28\,km}$

$= 1.88\,m$

4. When a diffraction grating is illuminated by light of wavelength 500 nm, it is found that of the principal maxima, two consecutive ones lie at 30° and 36.87°. What is the slit spacing? (Choose the answer that is closest to your calculation).

a) 2 μm
b) 1.66 μm
(c) 5 μm
d) 1 μm
e) 0.83 μm

$d \sin\theta_1 = n\lambda$

$d \sin\theta_2 = n+1\lambda$

$\Rightarrow d(\sin\theta_2 - \sin\theta_1) = \lambda$

$\Rightarrow d = \frac{\lambda}{\sin\theta_2 - \sin\theta_1} = \frac{500 \times 10^{-9}}{\sin(36.87) - \sin(30)} = 5 \times 10^{-6}\,m$

$= 5\,\mu m$

$\lambda_0 = \frac{c}{f}$ $\quad \lambda = \frac{\lambda_0}{n} = \frac{c}{fn} = \frac{3\times10^8}{4.7\times10^{14}\times1.33}$

$= 4.79\times10^{-7}\,m$

$= 479\,nm$

5. The frequency in air of light from a laser is (4.7×10^{14}) Hz. Its wavelength in water ($n = 1.33$) is:

a) 320 nm
b) 240 nm
c) 960 nm
d) 638 nm
(e) 480 nm

$s = f/2$ $\quad \frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$

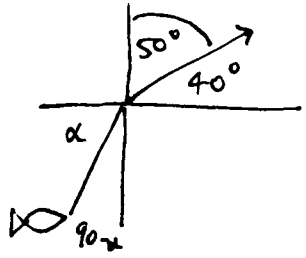
$\frac{1}{s} + \frac{2}{f} = \frac{1}{f} \Rightarrow \frac{1}{s'} = -\frac{1}{f}$

$s' = -f \Rightarrow$ other side of mirror

$\frac{y'}{y} = \frac{-s'}{s} = \frac{f}{f/2} = 2 \Rightarrow$ enlarged + erect

6. If an object is at a distance of one-half the focal length from a concave spherical mirror, the object's image is:

a) inverted, reduced, and on the other side of the mirror.
(b) erect, enlarged, and on the other side of the mirror.
c) inverted, reduced, and on the same side of the mirror.
d) inverted, enlarged, and on the other side of the mirror.
e) erect, enlarged, and on the same side of the mirror.



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

$\sin 50° = 1.33 \sin(90-\alpha)$

$\Rightarrow 90-\alpha = 35.16°$

$\Rightarrow \alpha = 54.8°$

7. A person in a boat sees a fish in the water (n=1.33), the light rays making an angle of 40° in the air relative to the water's surface. What is the angle under water relative to the water's surface of the same rays?

(a) 55°
b) 40°
c) 50°
d) 61°
e) 35°

$\frac{y'}{y} = \frac{-s'}{s}$ $\quad f = 3$ ins $\quad s = 90\times12$ ins $\quad y = 6\times12$

$\frac{1}{s'} = \frac{1}{f} - \frac{1}{s}$ $\quad s' =$

$\frac{1}{s'} = \frac{1}{3} - \frac{1}{90\times12} \Rightarrow 3.008$

$y' = \frac{-s'}{s} y = \frac{-3.008\times6\times12}{90\times12}$

$= -0.2$ in

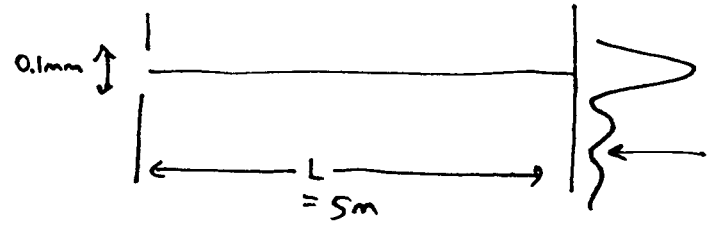
$|y'| = 0.2$ in

8. A camera with a lens of focal length 3 inches takes a picture of a 6 foot man standing 90 feet away. The height of the image is about:

a) 0.60 in
b) 0.50 in
c) 0.30 in
(d) 0.20 in
e) 0.10 in

9. A single slit of width 0.1 mm is illuminated by green light (λ = 500 nm). The resulting diffraction pattern is observed on a screen 5m from the slit. How far from the central maximum does the intensity on the screen go to zero for the *second* time?

(a) 5 cm
b) 7.25 cm
c) 3.75 cm
d) 6.25 cm
e) 10 cm

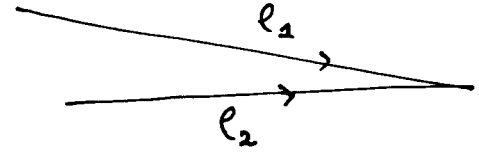


$$y = L\theta = \frac{L2\lambda}{d} = \frac{2\times 500\times10^{-9}\times 5m}{0.1\times10^{-3}} = 5\times10^{-2}m$$

$\equiv$ 5cm

10. Light of wavelength λ arrives at point P from two coherent point sources located at different distances l_1 and l_2 away. The sources have the same intensity and are in phase. Which of the following is true?

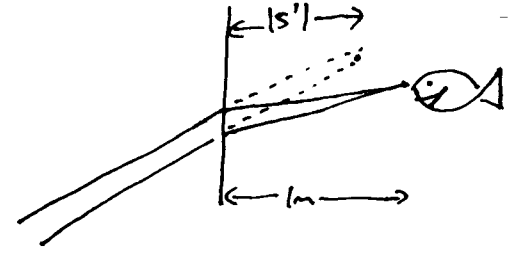
a) If P is a point of constructive interference and the wavelength is changed, it will always remain a point of constructive interference.
(b) The intensity is a maximum when $l_1 - l_2$ is an odd number of wavelengths λ.
c) If P is a point of constructive interference, the electric field field at P is never zero.
d) The intensity is zero if $l_1 - l_2$ is an even number of wavelengths λ.
e) The intensity is zero if $l_1 - l_2$ is an odd number of wavelengths λ



a) – Wrong because require $(l_2 - l_1) = m\lambda$
b) ok $(l_1 - l_2)$ = integer $\times\lambda$ odd $\therefore$ integer ✓
c) – wrong – E field oscillates $\therefore$ goes through zero.
d) $l_1 - l_2$ = even $\times\lambda$ $\therefore$ constructive – WRONG.
e) $l_1 - l_2$ = odd $\times\lambda$ $\therefore$ constructive – WRONG.

11. Nancy is standing 1 m in front of the large sealife tank at the Camden Aquarium. She sees a shark directly in front of her that is actually 1 m behind the glass wall of the tank. How far from the wall does the shark appear to Nancy? ($n_{water} = 1.33$. Neglect the effects of the glass wall itself.)

a) 2.33 m b) 0.67 m c) 1 m (d) 0.75 m
e) 1.33 m



$$\frac{1}{s'} + \frac{n}{s} = 0 \qquad s' = -\frac{s}{n} = \frac{-1}{1.33} = -0.75m$$

$|s'| = 0.75m$

CONVERGING LENS $\Rightarrow$ $f > 0$

$$\frac{1}{f} = \left(\frac{n_L}{n_m} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$n_L = 1.6$ $\quad R_1 = \infty$

$n_m = 1$ $\quad R_2 = -40$

$$\frac{1}{f} = (1.6-1)\left(\frac{1}{40}\right) = \frac{0.6}{40}$$

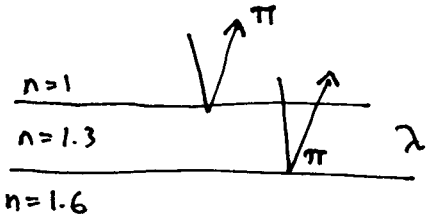
$\Rightarrow f = 40/0.6 = 66.7 \simeq 67\text{cm}$

12. A lens made of glass of refractive index 1.6 is flat on one side, and convex, with magnitude of the radius of curvature 40 cm on the other side. What is the focal length of this lens?

a) 25 cm b) 33 cm c) -25 cm d) -67 cm
(e) 67 cm

13. A glass (n = 1.6) lens is coated with a thin film (n = 1.3) to minimize reflection of certain incident light. If $\lambda_{air} = 500$ nm is the wavelength of the light in air, the least film thickness is:

a) 162 nm
b) 250 nm
c) 78 nm
(d) 96 nm
e) 200 nm



$\lambda = \lambda_0/n$

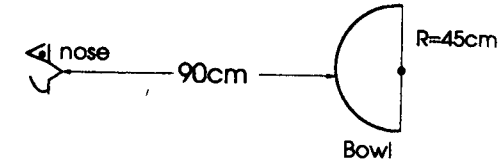
$\phi_2 = \pi + 2\pi\,(2d/\lambda)$ $\quad \phi_1 = \pi$ $\quad \Big\} \quad \phi_2 - \phi_1 = \frac{4\pi d}{\lambda} = \pi \times (\text{odd \#})$

$\Rightarrow d = \frac{\lambda}{4} \times (\text{odd \#})$

$d = \frac{\lambda_0}{4n} = \frac{500}{4\times 1.3} = 96.1\text{nm}$

14. You hold a reflecting spherical salad bowl 90cm in front of your nose, facing away from you to form a convex mirror. The salad bowl is made of polished metal with a 45-cm radius of curvature. Where is the image of the your nose located?

a) 30cm behind the salad bowl
b) 90cm behind the salad bowl
(c) 18cm behind the salad bowl
d) 18cm in front of the salad bowl
e) 30cm in front of the salad bowl



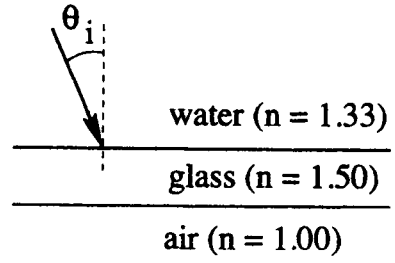
$$\frac{1}{S} + \frac{1}{S'} = \frac{2}{R} = -\frac{2}{45} \qquad \frac{1}{S'} = \frac{2}{R} - \frac{1}{S} = \frac{-2}{45} - \frac{1}{90}$$

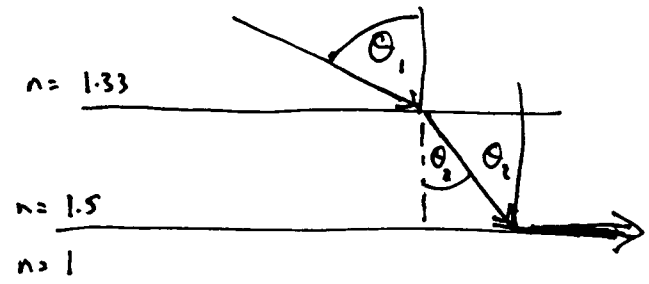
$S = 90\text{cm}$ $\quad \Rightarrow S' = -90/5 = -18\text{cm}$

$S' < 0$ $\quad \therefore$ behind bowl.

15. What is the minimum value for θ_i for which total internal reflection occurs at the glass-air interface?

a) 15.6°
b) 41.81°
c) 0°
(d) 48.59°
e) 36.25°





$1.33 \sin\theta_1 = 1.5 \sin\theta_2$

TOTAL INT REFLECTION AT GLASS-AIR

$1.5 \sin\theta_2 = 1 \times \sin(90°)$

$1.33 \sin\theta_1 = 1$

$\sin\theta_1 = \frac{1}{1.33} \Rightarrow \theta_1 = 48.59°$

If $\theta > \theta_1$ TIR occurs at glass-air interface.