Physics 121 Midterm Exam 1 — Special Code 1111

Name Answer Student No.

2010 February 5

Make sure you fill in the bubbles for your name and student number on the bubble sheet, as well as the "Special Code." Use a soft pencil to mark the bubble sheets. Complete the problems on this paper clearly showing your work and reasoning

Do not tear this sheet off!

$$v_n = \frac{c}{n} = \lambda_n f$$
$$c = 2.998 \times 10^8 m/s$$
$$y(x,t) = A\sin[kx \pm \omega t + \phi_0]$$

Material	n
Air	1.00
Water	1.33
Oil	1.46
Glass	1.55
Diamond	2.41

Interference phenomena

$$\Delta\phi = 2\pi\frac{\Delta x}{\lambda} + \phi_0 = (m)2\pi$$
$$\Delta\phi = 2\pi\frac{\Delta x}{\lambda} + \phi_0 = (m+\frac{1}{2})2\pi$$
$$a\sin\theta_m = m\lambda \quad \text{(single slit)}$$
$$a\sin\theta_1 = 1.220\lambda \quad \text{(circular aperture)}$$
$$d\sin\theta_m = m\lambda \quad \text{(double-slit)}$$
$$d\sin\theta_m = \left(m+\frac{1}{2}\right)\lambda \quad \text{(double-slit)}$$
$$d\sin\theta_m = m\lambda \quad \text{(diffraction grating)}$$
$$2\theta_{\min} = 2\sin^{-1}\left(\frac{\lambda}{Nd}\right) \quad \text{(peak-width)}$$

Refraction, Lenses, etc.

$$n_1\sin\theta_1 = n_2\sin\theta_2$$
$$\sin\theta_c = \frac{n_2}{n_1}$$
$$\frac{1}{s}+\frac{1}{s'} = \frac{1}{f}$$
$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$
$$P = \frac{1}{f}$$
$$\frac{n_1}{s}+\frac{n_2}{s'} = \frac{n_2-n_1}{R}$$

Other formulæ

$\lambda = h/p$

$E_{\text{kin}} = p^2/2m$

$f = R/2$

Problem	11a	11b	11c	12a	12b	13a	13b
Score							
Maximum	5	3	4	5	5	3	5

Problems Total: _____/30

2010 February 5

Make sure you fill in the bubbles for your name and student number on the bubble sheet, as well as the "Special Code." Use a soft pencil to mark the bubble sheets. Complete the problems on this paper clearly showing your work and reasoning.

[Point values are in square brackets. Multiple choice questions are 2 pts each]

1. **Which of the following equations expresses a wave travelling in the positive y direction.**

   a) $y(x,t) = A\sin(kx - \omega t + \phi)$

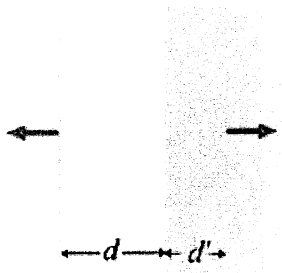
   b) $x(y,t) = A\sin(ky - \omega t + \phi)$

   c) $y(x,t) = A\sin(kx + \omega t - \phi)$

   d) $x(y,t) = A\sin(ky + \omega t - \phi)$

   e) none of the above

2. **A plane wave is incident on a flat piece of material with an index of refraction n. At time t=0, the wavefront is a distance d away from the surface of the material. At time t=t1, the wavefront is at the position of the material interface. How far into the material (d') the wavefront has the wavefront propagated by time t=2t1?**



$t = 2t_1$

   a) $d' = ct_1/n$

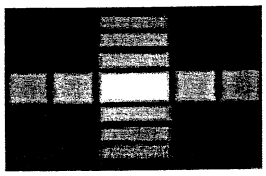
   b) $d' = 2ct_1/n$

   c) $d' = ct_1/(2n)$

   d) $d' = ct_1 n$

   e) None of the above

3. **Shown is the diffraction pattern of light intensity formed by light passing through a rectangular opening in a screen. Which is the shape of the opening?**



   a) b) c)

4. **The magnification of a refracting telescope is given as $M = -f_{eye}/f_{obj}$. Which of the following is NOT an assumption required for this to be true?**

   a) The object is at infinity

   b) The distance between objective and eyepiece is $f_{eye}+f_{obj}$

   c) the eye is placed at the focal point of the eyepiece.

   d) the lenses can be approximated as thin lenses

   e) all of the above are required.

5. **A person is 1.6 m tall and views herself in a flat wall mirror. What is the minimum height of the mirror which will allow her to see her entire body from head to toe?**

   a) 0.8 m

   b) 1.6 m

   c) 3.2 m

   d) it depends on her distance from the mirror

   e) none of the above

6. **You are directly facing the centre of a rainbow. Your shadow is on the ground. The shadow is**

   a) behind you

   b) in front of you

   c) on your left side

   d) on your right side

   e) any of the above depending on the time of day.

2010 February 5

Make sure you fill in the bubbles for your name and student number on the bubble sheet, as well as the "Special Code." Use a soft pencil to mark the bubble sheets. Complete the problems on this paper clearly showing your work and reasoning.

7. **A thin lens is made in such a way that the object and its image are at equal distance from the lens. If the lens is not flat then it is**

   a) a diverging lens with the object at the focal point
   b) a diverging lens with the object at twice the focal length
   c) a converging lens with the object at the focal length
   (d) a converging lens with the object at twice the focal length
   e) none of the above

8. **In a Camera Obscura a small hole in the wall of a dark room allows an image of a well-lit object outside to be formed on a screen inside which is on the wall opposite the hole. If the distance between the screen and small hole is decreased, the size of the image**

   a) increases
   (b) decreases
   c) is unchanged

9. **If the kinetic energy of an electron is doubled, by what factor is the de Broglie wavelength multiplied?**

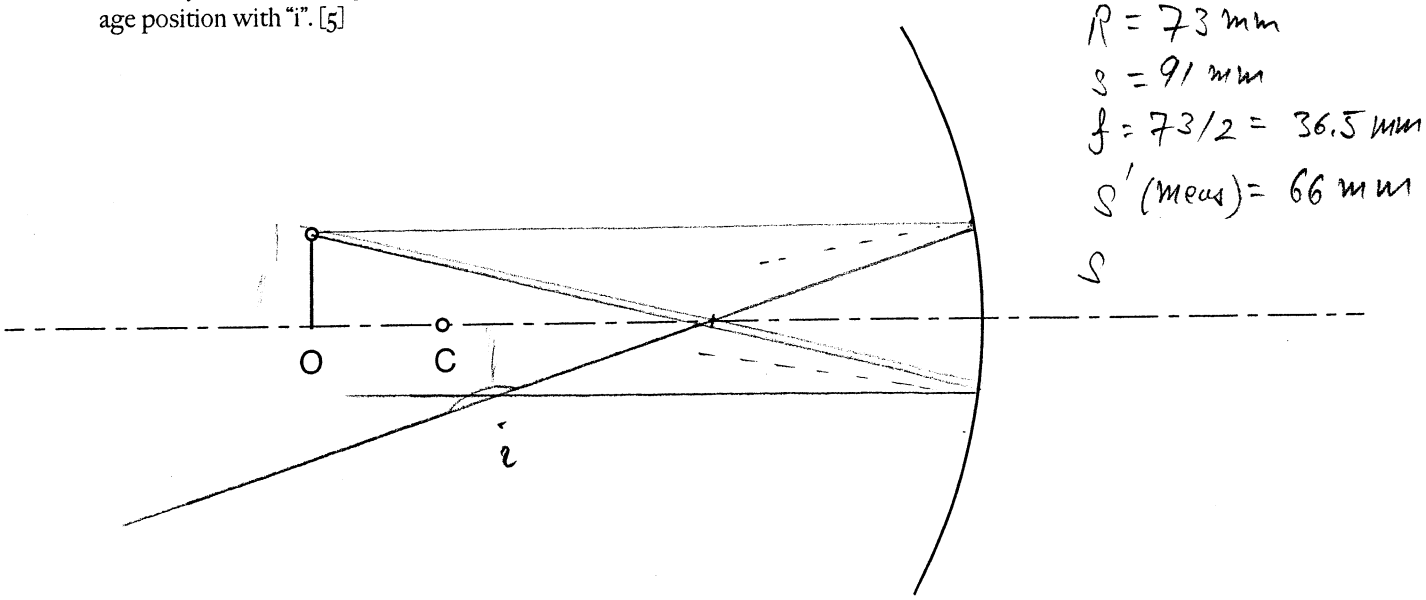
   a) 2
   b) $\sqrt{2}$
   c) 1
   d) 1/2
   (e) $1/\sqrt{2}$

10. **Annie Liebovitz takes a photograph at f/4 and then takes a second photo of the same person, with the same lighting, at f/8. In order for the brightness of both images to be the same, the exposure time of the second photo must be**

    a) twice the first
    b) one-half the first
    (c) four times the first
    d) one-fourth the first.
    e) none of the above

11. **The drawing shows a section of a spherical mirror. The centre of the circular section of the mirror is at C.**

    a) Carefully draw a ray diagram on the figure to locate the position of the image of the object O formed by the mirror. Label the image position with "i". [5]



R = 73 mm
s = 91 mm
f = 73/2 = 36.5 mm
s' (meas) = 66 mm
s

2010 February 5

Make sure you fill in the bubbles for your name and student number on the bubble sheet, as well as the "Special Code." Use a soft pencil to mark the bubble sheets. Complete the problems on this paper clearly showing your work and reasoning.

b) Measure the diagram and calculate the focal length of the mirror (in mm) from your measurements assuming small angles. [3]

$f =$ R/2 = 73/2 = 36.5 mm

give full credit for alternate solutions if correct.

c) Predict the position of the image based on your focal length and the object position. [4]

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

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

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

$$s' = \frac{sf}{s-f}$$

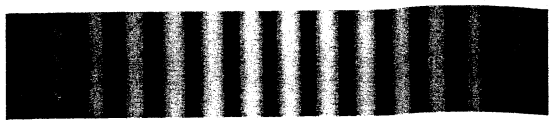
$$s' = \frac{(91)(36.5)}{91-36.5} = 61 \text{ mm}$$

2010 February 5

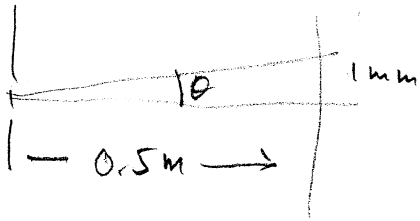
Make sure you fill in the bubbles for your name and student number on the bubble sheet, as well as the "Special Code." Use a soft pencil to mark the bubble sheets. Complete the problems on this paper clearly showing your work and reasoning.

---

12. The following is a two-slit interference pattern. Assume that the pattern is formed with 600 nm laser on a screen which is 0.5 m from the slits and that the bright fringes are 1 mm apart.



a) What is the separation of the slits? [5]



$\sin\theta \approx \frac{1\text{ mm}}{500\text{ mm}} = \frac{1}{500}$ small angle approx

$d\sin\theta = \lambda$

$d = \lambda/\sin\theta = \frac{600\text{ nm}}{1/500}$

$= (600\times10^{-9})(5\times10^{2})$

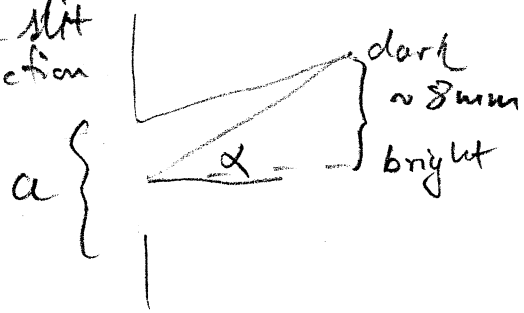
$= (3\times10^{3})(10^{-7})$

$= 3\times10^{-4}\text{ m}$

$d = 0.3\text{ mm}$

b) Calculate the width of each slit assuming both have equal widths [5].

Single slit diffraction



$\frac{a}{2}\sin\alpha = \frac{1}{2}\lambda$ for dark fringes

$\sin\alpha \approx 8/500$, became 8th fringe in dark

$a = \frac{\lambda}{\sin\alpha}$

$= d/8 = \frac{3}{8}\times10^{-4}\text{ m}$

$= 0.0375\text{ mm}$

2010 February 5

Make sure you fill in the bubbles for your name and student number on the bubble sheet, as well as the "Special Code." Use a soft pencil to mark the bubble sheets. Complete the problems on this paper clearly showing your work and reasoning.

---

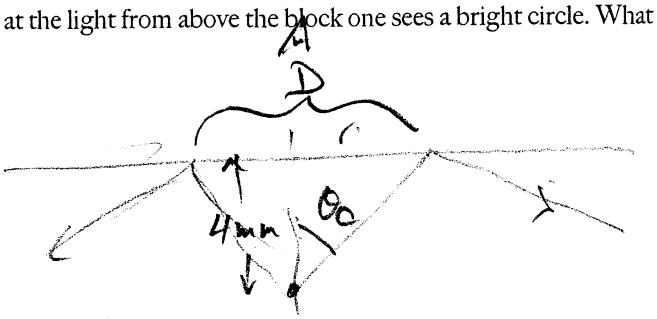
13. A light-emitting diode is embedded in a plastic block, 4 mm below the surface. The speed of light in the plastic is 0.67 times what it is in the air.

a) What is the index of refraction of the plastic relative to that of air, $n_{plastic}/n_{air}$? [3]

assume speed of light in air $v_a \approx c$

$$\frac{n_p}{n_a} = \frac{c}{v_p} = \frac{1}{0.67} = 1.5$$

b) When one looks at the light from above the block one sees a bright circle. What is the diameter of the illuminated circle that is seen? [5]



radius of illuminated circle is related to critical angle for T.I.R.

$$\sin\theta_c = \frac{1}{n_p} = 0.67$$

$$r = 4\text{mm} \sin^{-1}(0.67)$$

$$D = 2r = 8 \sin^{-1}(0.67) \text{ mm}$$

~~5.37 mm~~

$$D = 8\text{mm} \tan\left(\sin^{-1}(.067)\right)$$

$$= 7.22^{6}\text{mm}$$