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PHY 2049, Spring 2013

PHYSICS DEPARTMENT

Final Exam 3

April 27, 2013

Name (print): \_\_\_\_\_

Signature: \_\_\_\_\_

*On my honor, I have neither given nor received unauthorized aid on this examination.***YOUR TEST NUMBER IS THE 5-DIGIT NUMBER AT THE TOP OF EACH PAGE.****DIRECTIONS**

- (1) **Code your test number** on your answer sheet (use **76-80** for the **5-digit number**). Code your name on your answer sheet. Darken circles completely (errors can occur if too light). Code your student number on your answer sheet.

- (2) Print your name on this sheet and sign it also.  
 (3) Do all scratch work anywhere on this exam that you like. At the end of the test, this exam printout is to be turned in.  
 (4) No credit will be given without both answer sheet and printout with scratch work.

- (4) Work the questions in any order. Incorrect answers are not taken into account in any way; you may guess at answers you don't know.

- (5) If you think that none of the answers is correct, please choose the answer given that is closest to your answer.  
 (6) Blacken the circle of your intended answer completely, using a **number 2 pencil**. Do not make any stray marks or the answer sheet may not read properly. Completely erase all incorrect answers, or take a new answer sheet.

- (7) As an aid to the examiner (and yourself), in case of poorly marked answer sheets, please circle your selected answer on the examination sheet. Please remember, however, that in the case of a disagreement, the answers on the bubble sheet count, **NOT** what you circle here. Good luck!!!

>>>>>**WHEN YOU FINISH** <<<<<<<<

Hand in the answer sheet separately.

Constants	
$\mu_B = 9.27 \times 10^{-24} \text{ J/T}$	$m_p = 1.67 \times 10^{-27} \text{ kg}$
$e = 1.6 \times 10^{-19} \text{ C}$	$k = 9 \times 10^9 \text{ N m}^2/\text{C}^2$
$\mu_0 = 4\pi \times 10^{-7} \text{ T} \cdot \text{A/m}$	$c = 3 \times 10^8 \text{ m/s}$
	$g = 9.8 \text{ m/s}^2$

1. An object is placed 5 cm from the first of a 2-lens system. The first lens has a focal distance of 10 cm, the second lens is 20 cm from the first and has a focal length of 20 cm. How far from the second lens does the image form?

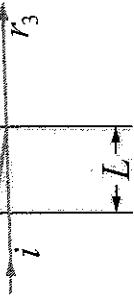
- (1) 30 cm      (2) 60 cm      (3) 40 cm      (4) 20 cm      (5) 50 cm

2. Light of wavelength 587 nm in air is normally incident from a region with index of refraction  $n_1 = 1.50$  to a thin layer of index of refraction  $n_2 = 1.34$  which is followed by a region of index of refraction  $n_3 = 1.42$ . What is the second thinnest layer that will result in the transmitted light being an interference minimum?

- (1) 294 nm  
 (2) 310 nm  
 (3) 329 nm  
 (4) 219 nm  
 (5) 438 nm

3. Suppose the magnetic field in a region of space has the form  $\mathbf{B}(x, y, z) = 5x \hat{i} + 6\hat{j} + f(x, z)\hat{k}$ , where  $f(x, z)$  is an unknown function. Which of the following choices for  $f(x, z)$  is allowed by Maxwell's equations?

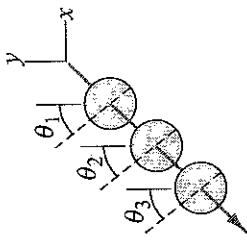
- (1)  $f(x, z) = +5x$       (2)  $f(x, z) = +5z$       (3)  $f(x, z) = -5x$       (4)  $f(x, z) = -11z$       (5)  $f(x, z) = -5z$



4. What is the solar radiation pressure in Pascals ( $\text{N/m}^2$ ) on a dark patch of the Earth's surface (perpendicular to the direction of the overhead sunlight) if the total power produced by the sun is  $3.8 \times 10^{26} \text{ W}$  and the distance between the sun and the Earth is  $1.5 \times 10^{11} \text{ m}$ ?

(1)  $1.7 \times 10^4$       (2)  $1300$       (3)  $4.5 \times 10^{-6}$       (4)  $1.3 \times 10^{18}$       (5)  $9 \times 10^{-17}$

5. A beam of initially unpolarized light is sent along the  $z$ -axis into a stack of three polarizing sheets placed perpendicularly to the  $z$ -axis, as shown in the figure. The angles  $\theta_1$ ,  $\theta_2$ , and  $\theta_3$  of the polarizing directions are measured counterclockwise from the positive direction of the  $y$ -axis. What percentage of the light's initial intensity is transmitted by the system when  $\theta_1 = 30^\circ$ ,  $\theta_2 = -30^\circ$ , and  $\theta_3 = 0^\circ$ ?



(1) 9%      (2) 22%      (3) 28%      (4) 42%      (5) 38%

6. An LC circuit has a capacitance of  $20 \mu\text{F}$  and an inductance of  $10 \text{ mH}$ . At time  $t = 0$  the charge on the capacitor is  $27 \mu\text{C}$  and the current is  $80 \text{ mA}$ . The maximum possible charge is:

(1)  $45 \mu\text{C}$       (2)  $27 \mu\text{C}$       (3)  $100 \mu\text{C}$       (4)  $63 \mu\text{C}$       (5)  $36 \mu\text{C}$

7. The electric field of a plane electromagnetic wave is described by  $E_m \hat{i} \sin(kz + \omega t)$ . Which expression describes the magnetic field associated to this electromagnetic wave?

- (1)  $-(E_m/c) \hat{j} \sin(kz + \omega t)$   
 (2)  $(E_m/c) \hat{i} \sin(kz + \omega t)$   
 (3)  $cE_m \hat{k} \sin(kz + \omega t)$   
 (4)  $-cE_m \hat{j} \sin(kz + \omega t)$   
 (5)  $(E_m/c) \hat{j} \sin(kz + \omega t)$

8. A diverging lens is formed by joining together two identical concave surfaces whose radii of curvature have magnitude 10 cm. If the focal length of the lens is  $-15 \text{ cm}$ , what is the index of refraction of the material in the lens?

(1)  $4/3$       (2)  $3/2$       (3)  $5/3$       (4) 1      (5)  $5/4$

9. Consider a spherical glass ( $n = 1.5$ ) paperweight of diameter 5 cm that contains a grain of rice which appears (to an observer in air) to lie 1 cm from the edge of the glass. How far inside the glass is the grain actually located?

(1)  $1.75 \text{ cm}$       (2)  $0.57 \text{ cm}$       (3)  $1.50 \text{ cm}$       (4)  $1.25 \text{ cm}$       (5)  $1.00 \text{ cm}$

10. Two narrow slits are separated by a distance of 5 microns. Monochromatic light of wavelength 500 nm passes through the slits and goes on to hit a screen 2 meters behind them. What is the distance between the 1st intensity minimum and the 3rd maximum (counting the central peak as the 0th maximum)?

(1)  $53 \text{ cm}$       (2)  $50 \text{ cm}$       (3)  $63 \text{ cm}$       (4)  $10 \text{ cm}$       (5)  $73 \text{ cm}$

11. Recall the in-class demonstration in which liquid oxygen (LOX) was dribbled into the horizontal region between the two poles of a magnet. Which of the following statements explains why the LOX remained suspended between the poles of the magnet?

- (1) LOX is paramagnetic and magnetic dipoles stick together
- (2) LOX is diamagnetic
- (3) LOX is diamagnetic and magnetic dipoles stick together
- (4) Magnetic dipoles stick together
- (5) LOX is paramagnetic

12. A light ray traveling in a material with an index of refraction of  $n_1$  is incident onto a stack of two other materials with indices of refraction  $n_2$  and  $n_3$ , respectively, as shown in the diagram. What is the minimum angle of incidence  $\theta_1$  such that the light is totally reflected by the stack if  $n_1 = 1.48$ ,  $n_2 = 1.50$ , and  $n_3 = 1.43$ ?

- (1) 75°
- (2) 80.5°
- (3) 72.5°
- (4) 90°
- (5) 18°



13. An air-filled capacitor is formed from two parallel, circular plates of radius 5 cm which are separated by a distance of 2 mm. The capacitor is connected in series with a  $5\ \Omega$  resistor and charged up from zero by a 12 volt battery. What is the magnitude of the magnetic field ( $\text{in } \mu\text{T}$ ) inside the capacitor at a distance of 2 cm from the center, when the charge on the capacitor has reached half of its maximum value?

- (1) .4
- (2) .2
- (3) 12
- (4) 2
- (5) 5

14. When monochromatic light of an unknown wavelength passes through a single slit of width 0.12 mm the first diffraction minimum is observed to be 0.5 cm away from the central maximum on a screen that is 1 m from the slit. What is the wavelength of the light?

- (1) 400 nm
- (2) 500 nm
- (3) 450 nm
- (4) 700 nm
- (5) 600 nm

15. What kind of image (real = R or virtual = V) and orientation (inverted = I or not inverted = NI) is produced by a spherical concave mirror?

- (1) V, I
- (2) R, NI
- (3) R, I
- (4) V, NI
- (5) Insufficient information

16. A  $5\ \mu\text{F}$  capacitor is connected to an AC generator with  $\varepsilon = 25.0\ \text{V}$ . What is the amplitude of the resulting alternating current if the frequency of the EMF in cycles/sec is  $f = 7\ \text{kHz}$ .

- (1) 0.9 A
- (2) 115 A
- (3)  $1.3 \times 10^{-4}\ \text{A}$
- (4)  $5 \times 10^{-3}\ \text{A}$
- (5) 5.5 A

17. How long does it take for the current in a resistor to reach one-third of its maximum value of 4 mA after it is connected in series with a  $0.3\ \text{H}$  inductor to a  $12\ \text{V}$  EMF source?

- (1)  $4 \times 10^{-5}\ \text{s}$
- (2)  $1 \times 10^{-4}\ \text{s}$
- (3)  $7 \times 10^{-5}\ \text{s}$
- (4)  $2 \times 10^{-5}\ \text{s}$
- (5)  $3 \times 10^{-5}\ \text{s}$

18. The famous 21 cm radiation of radio astronomy arises from flipping the spin of a Hydrogen atom electron in the presence of the magnetic field it perceives from the Hydrogen atom nucleus. The energy of this transition is about  $5.9 \mu\text{eV}$ . What must be the strength of the magnetic field (in Tesla) the electron perceives?

(1)  $6 \times 10^{17}$

(2)  $8 \times 10^8$

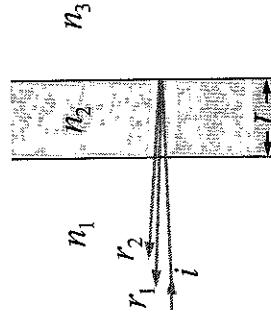
(3)  $3 \times 10^{17}$

(4) 0.05

(5) 0.10

19. Light is normally incident from a region with index of refraction  $n_1 = 1.40$  to a layer of thickness 210 nm and index of refraction  $n_2 = 1.46$  which is followed by a region of index of refraction  $n_3 = 1.75$ . Find the wavelength in air, in the visible range (400 nm to 700 nm), which results in the reflected wave being an interference minimum?

- (1) 613 nm
- (2) 588 nm
- (3) 409 nm
- (4) 420 nm
- (5) No visible light does this



20. A series RLC circuit is driven by a sinusoidally-varying EMF source. The current leads the EMF by  $30^\circ$ . What can be concluded about the driving frequency  $\omega$ ?

(1)  $\omega = 1/\sqrt{LC}$

(2)  $\omega > 1/\sqrt{LC}$

(3)  $\omega < 1/\sqrt{LC}$

(4)  $\omega = \infty$

(5)  $\omega = 0$