Instructor(s): *Acosta/Woodard*

PHYSICS DEPARTMENT

PHY 2049, Fall 2015 Final Exam December 12, 2015

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. 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			
$\epsilon_0 = 8.85 \times 10^{-12}$ F/m	$m_e = 9.11 \times 10^{-31}$ kg	$m_p = m_n = 1.67 \times 10^{-27}$ kg	$e = 1.6 \times 10^{-19}$ C
$k = 9 \times 10^9$ N m^2/C^2	$\mu_0 = 4\pi \times 10^{-7}$ T m/A	$N_A = 6.02 \times 10^{23}$ atoms/mole	$c = 3 \times 10^8$ m/s
m = milli = 10^{-3}	μ = micro = 10^{-6}	n = nano = 10^{-9}	p = pico = 10^{-12}

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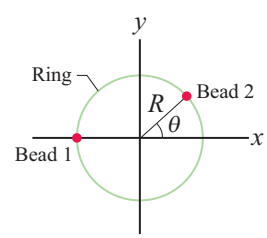
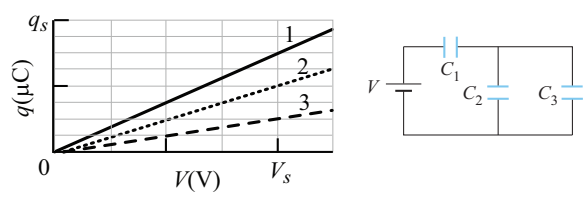
1. The figure shows a plastic ring of radius $R = 50.0$ cm. Two small charged beads are on the ring. Bead 1 of charge $+2.00\ \mu$C is fixed in place at the left side; bead 2 of charge $+4.00\ \mu$C can be moved along the ring. The two beads produce a net electric field of magnitude $E = 2.00 \times 10^5$ N/C at the center of the ring. What is the angle θ in degrees?



(1) 133 degrees (2) 67.8 degrees (3) 43.0 degrees (4) 34.3 degrees (5) 118 degrees

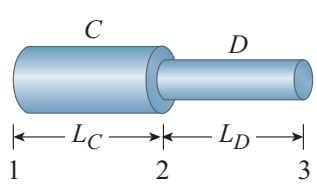
2. The line labelled 1 on figure (a) gives the charge q that can be stored on capacitor 1 versus the electric potential V set up across it. The vertical scale is set by $q_s = 16.0\ \mu C$, and the horizontal scale is set by $V_s = 2.0\ V$. The lines labelled 2 and 3 are similar plots for capacitors 2 and 3, respectively. Figure (b) shows a circuit with these three capacitors and a 6.0 V battery. What is the charge (in μC) stored on capacitor 3 in that circuit?



(a) (b)

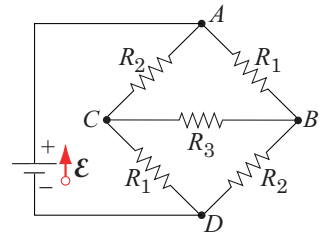
(1) 6 (2) 8 (3) 12 (4) 16 (5) 24

3. Wire C and D are made from different materials and have length $L_C = L_D = 1.0$ m. The resistivity and diameter of wire C are $2.0 \times 10^{-6}\ \Omega$m and 1.00 mm, and those of wire D are $1.0 \times 10^{-6}\ \Omega$m and 0.50 mm. The wires are joined as shown, and a current of 2.0 A is set up in them. What is the rate at which energy is dissipated in wire D?



(1) 20 W (2) 32 W (3) 8 W (4) 10 W (5) 16 W

4. In the figure $\varepsilon = 21$ V, $R_1 = R_3 = 1\,\Omega$, and $R_2 = 2\,\Omega$. What is the potential difference $V_A - V_B$?

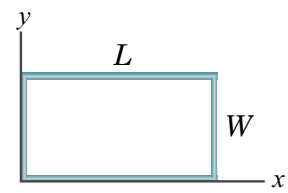


(1) 9 V
(2) 6 V
(3) 3 V
(4) 12 V
(5) 21 V

5. The current density $\vec{J}$ inside a long, solid, cylindrical wire of radius $a = 3.1$ mm is in the direction of the central axis, and its magnitude varies linearly with radial distance r from the axis according to $J = J_0 r/a$, where $J_0 = 155$ A/m^2. What is the magnitude of the magnetic field at $r = a/2$? You may need the Jacobian term $r\,dr\,d\theta$ for integration in polar coordinates.

(1) 50 nT (2) 4 nT (3) 150 nT (4) 12 nT (5) 200 nT

6. A wire loop of lengths $L = 40$ cm and $W = 25$ cm lies in a magnetic field $\vec{B} = (-0.16\ \text{T/m s})(y\,t)\ \hat{k}$. What are the magnitude and direction of the induced emf?



(1) 2 mV, counter-clockwise (2) 2 mV, clockwise (3) zero (4) 4 mV, clockwise (5) 4 mV, counter-clockwise

7. An LC circuit has a capacitance of 10 μF and an inductance of 20 mH. At time $t = 0$ the charge on the capacitor is 27 μC and the current is 80 mA. The maximum possible charge in μC is:

(1) 45 (2) 27 (3) 100 (4) 63 (5) 36

8. An LC circuit has a capacitance of 10 μF and an inductance of 20 mH. At time $t = 0$ the charge on the capacitor is 27 μC and the current is 80 mA. The maximum possible current in mA is:

(1) 100 (2) 27 (3) 45 (4) 63 (5) 36

9. A parallel-plate, air-filled capacitor is being charged. The circular plates have radius 3.0 cm, and at a particular instant, the conduction current in the wires is 0.45 A. What is the induced magnetic field between the plates at a distance of 1.0 cm from the central axis?

(1) 1 μT (2) 9 μT (3) 3 μT (4) 0.5 μT (5) 0.1 μT

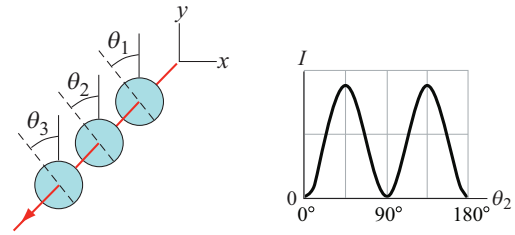
10. The magnetic susceptibility of a substance is positive and equal to $\chi = 2 \times 10^{-6}$. When placed in an external magnetic field, the field inside the substance is $B = (1 + \chi)B_{\text{ext}}$. The magnetic property of this substance is best classified as:

(1) paramagnetic (2) diamagnetic (3) ferromagnetic (4) hysteresis (5) unmagnetized

11. A plane electromagnetic wave in vacuum has $\vec{E} = (2\ \text{V/m})\cos[\omega(t - x/c)]\hat{k}$. What is the associated magnetic field?

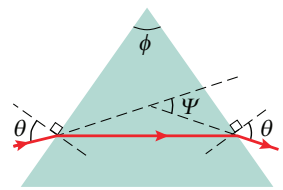
(1) $\vec{B} \approx -7\ \text{nT}\cos[\omega(t - x/c)]\hat{j}$
(2) $\vec{B} \approx +7\ \text{nT}\cos[\omega(t - x/c)]\hat{j}$
(3) $\vec{B} \approx -2\ \text{T}\cos[\omega(t - x/c)]\hat{j}$
(4) $\vec{B} \approx +2\ \text{T}\cos[\omega(t - x/c)]\hat{j}$
(5) Insufficient information

12. Initially unpolarized light is sent through three polarized sheets as shown. The angles θ_1, θ_2 and θ_3 are measured counterclockwise from the positive y axis (they are not drawn to scale). Angles θ_1 and θ_3 are fixed, but the angle θ_2 can be varied. The graph gives the intensity of the light emerging from sheet 3 as a function of θ_2. What percentage of the light's initial intensity is transmitted by the system when $\theta_2 = 30°$?



(1) 9 % (2) 3 % (3) 30 % (4) 20 % (5) 50 %

13. Suppose the prism shown in the figure has apex angle $\phi = 60°$ and index of refraction $n = 1.6$. What angle of incidence θ (from air, with index of refraction 1) is required for the ray to exit the prism with the same angle of refraction θ, as shown in the figure?



(1) 53 degrees (2) 30 degrees (3) 37 degrees (4) 45 degrees (5) 60 degrees

14. An object is placed 40 cm in front of a converging lens with a focal length of magnitude 80 cm. What is the signed image distance from the lens' surface?

(1) −80 cm (2) 80 cm (3) 40 cm (4) −40 cm (5) −27 cm

15. An object is placed 40 cm in front of a diverging lens with a focal length of magnitude 80 cm. What is the signed image distance from the lens' surface?

(1) −27 cm (2) 80 cm (3) 40 cm (4) −40 cm (5) −80 cm

16. An object is 20 cm from the center of a spherical silvered-glass Christmas tree ornament 8 cm in diameter. What is the magnitude of the distance to the image (counting from the ornament surface), and is the image inverted or non-inverted?

(1) 1.8 cm, non-inverted (2) 1.8 cm, inverted (3) 2.2 cm, inverted (4) 2.2 cm, non-inverted (5) 3.3 cm, inverted

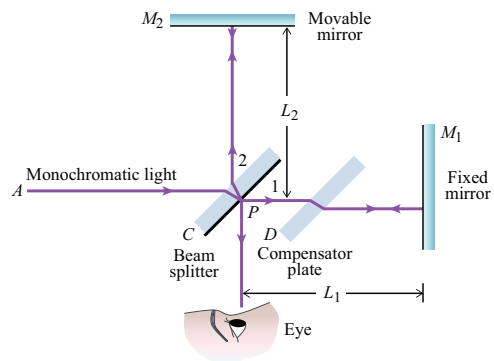
17. An object is 60 cm to the left of a diverging lens with a focal length of magnitude 60 cm. A second lens, this one converging with a focal length of magnitude 40 cm, is located 100 cm to the right of the first lens along the same optic axis. Find the location of the image produced by the combination of lenses relative to the surface of the second lens.

(1) 58 cm (2) 93 cm (3) 67 cm (4) 40 cm (5) −15 cm

18. Sunlight is used in a double-slit interference experiment. The fourth-order maximum for a wavelength of 450 nm occurs at an angle of $\theta = 90°$. What least wavelength in the visible range (400 nm to 700 nm) is not present in the third-order maxima?

(1) 600 nm (2) 450 nm (3) 400 nm (4) 700 nm (5) 1800 nm

19. How far must the mirror M_2 (see the figure) of the Michelson interferometer be moved so that 1600 fringes of laser light (600 nm) move across a line in the field of view?

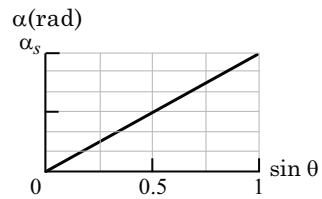


(1) 0.5 mm
(2) 1.0 mm
(3) 2.0 mm
(4) 0.25 mm
(5) 6×10^{-7} m

20. The walls of a soap bubble have about the same index of refraction as that of plain water, $n = 1.33$. There is air both inside and outside the bubble. What wavelength (in air) of visible light is most strongly reflected from a point on a soap bubble where its wall is 300 nm thick?

(1) 530 nm (2) 400 nm (3) 600 nm (4) 1600 nm (5) 800 nm

21. The figure shows $\alpha \equiv \frac{\pi a}{\lambda}\sin(\theta)$ as a function of $\sin(\theta)$ for single-slit diffraction through an aperture of width a with light of wavelength $\lambda = 610$ nm. The vertical scale is set by $\alpha_s = 12$ rad. What is the least angle θ for a diffraction minimum?



(1) 15 degrees (2) 20 degrees (3) 25 degrees (4) 30 degrees (5) 35 degrees

22. If Superman really had x-ray vision of 0.1 nm wavelength and a 4 mm pupil diameter, at what maximum altitude could he distinguish villains from heroes, assuming that he needs to resolve points separated by 5 cm to do this?

(1) 1600 km (2) 800 km (3) 400 km (4) 200 km (5) 100 km

FOLLOWING GROUPS OF QUESTIONS WILL BE SELECTED AS ONE GROUP FROM EACH TYPE
TYPE 1
Q# S 7
Q# S 8
TYPE 2
Q# S 14
Q# S 15