Instructor(s): Mueller/Woodard

PHYSICS DEPARTMENT

PHY 2049, Fall 2017 Final Exam December 12, 2017

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

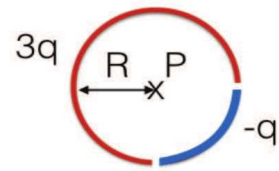
(1) **Code your test number on your answer sheet (use 76–80 for the 5-digit number)**. Code your name on your answer sheet. **Darken circles completely (errors can occur if too light)**. Code your student number on your answer sheet.
(2) Print your name on this sheet and sign it also.
(3) Do all scratch 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.

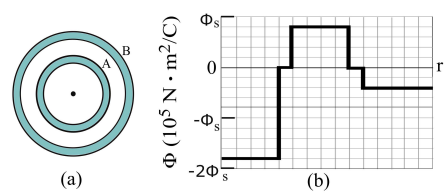
Constants		
$\mu_B = 9.27 \times 10^{-24}$ J/T	$m_p = 1.67 \times 10^{-27}$ kg	$m_e = 9.11 \times 10^{-31}$ kg
$e = 1.6 \times 10^{-19}$ C	$k = 9 \times 10^9$ N m^2/C^2	$\epsilon_0 = 8.85 \times 10^{-12}$ F/m
$\mu_0 = 4\pi \times 10^{-7}\ T \cdot m/A$	$c = 3 \times 10^8$ m/s	$g = 9.8$ m/s^2
f = femto = 10^{-15}	p = pico = 10^{-12}	n = nano = 10^{-9}
μ = micro = 10^{-6}	M = Mega = 10^6	G = Giga = 10^9

1. In the figure two curved plastic rods, one of charge +3q and the other of charge -q, form a circle of radius R in an xy plane. Note that the positively charged rod is 3 times longer! The charge is distributed uniformly on both rods. What is the magnitude of the y-component of the electric field produced at P, the center of the circle?



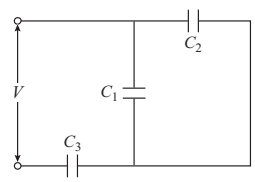
(1) $4k\dfrac{q}{\pi R^2}$ (2) $k\dfrac{q}{R}$ (3) $k\dfrac{q}{R^2}$ (4) $k\dfrac{q}{\pi R^2}$ (5) $4kq$

2. A charged particle is held at the center of two concentric conducting spherical shells as shown in Figure a. Figure b gives the net flux Φ through a Gaussian sphere centered on the particle, as a function of the radius r of the sphere. The scale of the vertical axis is set by $\Phi_s = 5.0 \times 10^5$ N m^2/C. What is the magnitude of the net charge (in μC) of shell B?



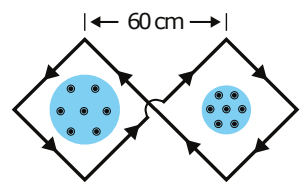
(1) 5.3 (2) 8.0 (3) 11.5 (4) 4.4 (5) 1.8

3. In the figure a potential difference of $V = 100$ V is applied across a capacitor arrangement with capacitances $C_1 = 10$ μF, $C_2 = 5$ μF and $C_3 = 15$ μF. What is the energy U_2 stored in capacitor 2?



(1) 6.3 mJ (2) 13 mJ (3) 19 mJ (4) 38 mJ (5) 25 mJ

4. The figure shows two circular regions region 1 of radius $r_1 = 15$cm and region 2 of radius $r_2 = 10$cm separated by 60 cm. The magnetic fields in both regions point out of the page and increase at a rate of 10mT/s in region 1 and a rate of 20mT/s in region 2. Calculate the magnitude of the path integral $\oint \vec{E} \cdot d\vec{s}$ in μV along the path drawn in the figure; ignore the bending of the path at the crossing.



(1) 79 (2) 34 (3) 6.2 (4) 20 (5) 11

5. A capacitor is connected to a 10 V EMF source long enough to reach its maximum charge of 30μC. It is then disconnected from the EMF source and connected across a 1.2 kΩ resistor. How long does it take for the charge on the capacitor to drop to 25% of its maximum value?

(1) 0.5 s (2) 0.35 s (3) 0.75 s (4) 0.025 s (5) 0.15 s

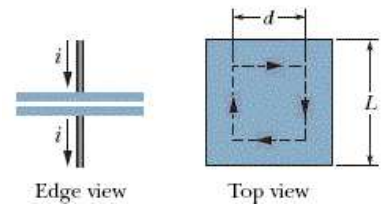
6. Suppose a charged particle moves with velocity $5\hat{\imath}$ m/s in a magnetic field of $\left(3\hat{\jmath} - 4\hat{k}\right)$ nT. What must be the electric field in nV/m in order for the particle to move freely with constant velocity?

(1) $-20\hat{\jmath} - 15\hat{k}$ (2) $+20\hat{\imath} - 15\hat{k}$ (3) $+20\hat{\jmath} + 15\hat{\imath}$ (4) $-20\hat{\jmath} + 15\hat{k}$ (5) Need to know the charge

7. Consider an serial RLC circuit with $R = 16\Omega$, $L = 0.4$H, and $C = 0.1\,\mu$F. It is connected to a voltage source which produces $V_0 = 8\,\text{V}\sin\omega_0 t$ where ω_0 is the resonance frequency of the circuit. Find the amplitude of the voltage across the inductor.

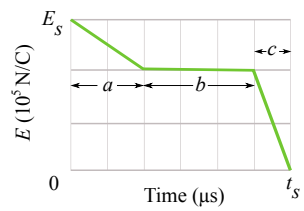
(1) 1000 (2) 400 (3) 1600 (4) 5000 (5) 16

8. In the figure, a parallel-plate capacitor has square plates of edge length $L = 2.2$ m. A current of 1.0 A charges the capacitor, producing a uniform electric field $\vec{E}$ between the plates, with $\vec{E}$ perpendicular to the plates. What is the value of $\oint \vec{B} \cdot d\vec{s}$ (in units of 10^{-6} Tm) around the square dashed path of side length $d = 0.70$ m?



(1) 0.13 (2) 0.21 (3) 0.27 (4) 0.33 (5) 0.39

9. In the figure, a uniform electric field $\vec{E}$ collapses. The vertical axis scale is set by $E_s = 1.5 \times 10^5$ N/C, and the horizontal axis scale is set by $t_s = 24$ μs. Calculate the magnitude of the displacement current through a 2.8 m^2 area perpendicular to the field during the time interval a.



(1) 0.15 A (2) 0.62 A (3) 0.31 A (4) 0.46 A (5) 0 A

10. A 150W laser beam has a uniform intensity distribution across an area with radius $r = 3$ mm. This beam is directed towards a semi-transparent mirror which reflects 75% of the intensity and transmits 25%. What is the radiation pressure in N/m^2 on this mirror in the area where the beam hits the mirror?

(1) 0.027 (2) 1.3 (3) 0.35 (4) 0.096 (5) 0.73

11. Initially unpolarized light is sent into a series of three polarizing sheets. The polarizing direction of the first sheet is parallel to the y-axis. The polarizing direction of the second sheet is rotated by 60° from the y-axis. The polarizing direction of the third sheet is then parallel to the x-axis. If the initial intensity of the light is I_0, what is the intensity of the light after the three polarizing sheets?

(1) $\frac{3}{32}I_0$ (2) $\frac{3}{8}I_0$ (3) $\frac{1}{2}I_0$ (4) $\frac{1}{32}I_0$ (5) 0

12. Any electromagnetic wave carries energy which is proportional to squares of the field amplitudes E^2 and B^2. The amplitudes of the fields are related via $E = cB$ where c is the speed of light. The energy density in an EM wave stored in the electric field is U_E while the energy density of the corresponding magnetic field is U_B. What is the ratio $U_E/U_B =$?

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

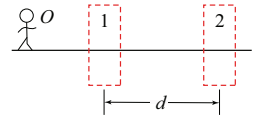
13. Object O stands on the central axis of a spherical mirror with focal length $f = +24$ cm. If the object is a distance $p = 34$ cm from the mirror, what is the magnification?

(1) -2.4 (2) $+2.4$ (3) -1.5 (4) $+1.5$ (5) $+1.0$

14. Which statement correctly describes the images formed by an object placed before a *converging* thin lens?

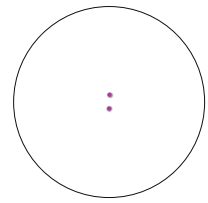
(1) Virtual images are always enlarged
(2) Virtual images are always inverted
(3) Real images are always enlarged
(4) Real images can be inverted or upright
(5) None are correct

15. In the figure O (the object) stands on the common central axis of two thin, symmetric lenses, which are mounted in the boxed regions 1 and 2. The object O is a distance $p_1 = 19$ cm from lens 1, which is a distance $d = 39$ cm from lens 2. Lens 1 is converging with focal length $f_1 = +8.9$ cm, and lens 2 is diverging with focal length $f_2 = -8.2$ cm. What is the distance i_2 of the final image from lens 2?



(1) -6.0 cm (2) 17 cm (3) 22 cm (4) -13 cm (5) 4.3 cm

16. Two coherent radio-frequency point sources separated by d = 1.5 m radiate in phase at a wavelength $\lambda = 0.75$ m. A radio wave detector moves in a circular path of some radius R around the mid-point between the two sources (see figure) and measures the radio-wave intensity of the signal. Find how many maxima it detects.



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

17. Two slits of width 4.0μm and separation 0.12 mm, cut on a thin metal plate, are illuminated with a beam of laser light of wavelength 600 nm. The beam is perpendicular to the plate. What is the separation of the bright interference fringes seen on a screen placed 3m behind the plate? The screen is parallel to the plate and we assume small angles: $\sin\theta = \tan\theta$.

(1) 15mm (2) 0.13mm (3) 3.2mm (4) 0.67mm (5) 41mm

18. You are asked to put a thin film on a lens substrate to reduce the reflection of light of $\lambda = 1064$ nm light. The thin film material has an index of refraction of 1.7 while the index of refraction of the lens material is 1.9. What is the minimum thickness in nm you would choose for the thin film.

(1) 156 (2) 253 (3) 112 (4) 418 (5) 297

19. A diffraction grating is illuminated with red light at normal incidence. This produces, on a screen behind the grating, three red spots - one at 0° (straight through) and one each at ±42.5°. Now yellow light of equal intensity is added, coming in the same direction as the red light. What will be seen on the screen?

(1) an orange spot at 0°, red spots at ±42.5°, and yellow spots slightly closer in
(2) an orange spot at 0°, red spots at ±42.5°, and yellow spots slightly further out
(3) orange spots at 0° and ±42.5°
(4) red spots at 0° and ±42.5°
(5) yellow spots at 0° and ±42.5°

20. When monochromatic light of an unknown wavelength passes through a single slit of width 0.21 mm the first diffraction minimum is observed to be .3 cm away from the central maximum on a screen that is 1 m from the slit. What is the wavelength of the light?

(1) 630nm (2) 410nm (3) 560nm (4) 720nm (5) 450nm