Instructor(s):

PHYSICS DEPARTMENT

PHY 2049, Spring 2012 | Final Exam | April 28, 2012

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		
$x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$	$m_p = 1.67 \times 10^{-27}$ 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
$\mu_0 = 4\pi \times 10^{-7}\ T \cdot A/m$	$c = 3 \times 10^8$ m/s	$g = 9.8$ m/s^2

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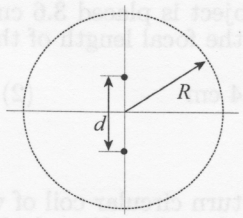
1. A small spaceship with a mass of only 1.0×10^3kg (including an astronaut) is at rest in outer space with negligible gravitational force acting on it. If the astronaut turns a 10 kW laser beam, what speed will the ship attain in 1 day because of the momentum carried away by the beam?

(1) 1 mm/s (2) 0.7 mm/s (3) 1.4 mm/s (4) 0.5 mm/s (5) 3 mm/s

2. Two identical converging lenses with a focal distance of $f = 8$ cm are separated by a distance 16 cm. An object of 1-cm size is placed 4 cm in front of the two-lens package. What is the absolute size of the image formed by the two lenses?

(1) 2 cm (2) 1.4 cm (3) 1 cm (4) 0.7 cm (5) 0.5 cm

3. Two coherent radio-frequency point sources separated by $d = 3$ m radiate in phase with a wavelength $\lambda = 1$ m. A 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. You may assume R is large compared to d.



(1) 16 (2) 32 (3) 8 (4) 12 (5) 4

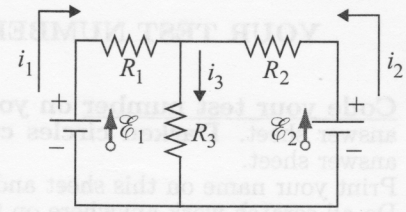
4. A parallel plate capacitor has circular plates of radius R and plate separation d. The potential difference between the plates is given by the time dependent function $V(t) = \mathcal{E}\sin(2\pi ft)$. What is the maximum value of the magnetic field induced between the plates at a radial distance $R/2$ from the axis of symmetry?

(1) $\frac{2\pi Rf\mathcal{E}}{c^2 d}$ (2) $\frac{\pi Rf\mathcal{E}}{2c^2 d}$ (3) $\frac{2Rf\mathcal{E}}{\pi c^2 d}$ (4) $\frac{Rf\mathcal{E}}{2\pi c^2 d}$ (5) $\frac{\pi Rf\mathcal{E}}{c^2 d}$

5. Initially unpolarized light is sent along the z-axis into a system of three polarizing sheets placed perpendicular to the z-axis and whose polarizing angles with respect to y-axis are 30° (first sheet on the way of light), 90° (second sheet on the way of light), and 45° (the last sheet). What percentage of the initial light intensity is transmitted by the system?

(1) 36% (2) 6% (3) 24% (4) 48% (5) 12%

6. In the figure shown, the ideal batteries have EMFs $\varepsilon_1 = 9.0$ V and $\varepsilon_2 = 3.0$ V, and the resistances are each $4\,\Omega$. What is the magnitude of the current in resistor 3?



(1) 0.25 A (2) 0 A (3) 1.25 A (4) 1.0 A (5) 0.5 A

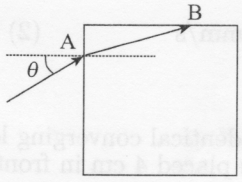
7. What is the smallest object on the Moon that can be resolved with the Hubble Space Telescope whose diameter is 2.4 m? The typical light wavelength is 500 nm. The distance between the Earth and the Moon is 400,000 km. Neglect the fact that the telescope is at 600 km above the Earth.

(1) 10 cm (2) 1 m (3) 1 cm (4) 10 m (5) 100 m

8. Two straight parallel power lines are separated by a distance of 2 m. Each carries a current of 5000 A, in opposite directions. What is the magnitude of the force per unit length on the wires, and is the force attractive or repulsive?

(1) 5×10^{-4} N/m, repulsive
(2) 2.5 N/m, repulsive
(3) 1.3×10^{7} N/m, repulsive
(4) 2.5 N/m, attractive
(5) 5×10^{-4} N/m, attractive

9. A ray of light enters from air into a glass cube at point A at an incident angle of $\theta = 30°$ and then undergoes total internal reflection at point B. What minimum value of the index of refraction n of glass can be inferred from this information?



(1) 1.12 (2) 1.39 (3) 1.41 (4) 1.22 (5) 1.32

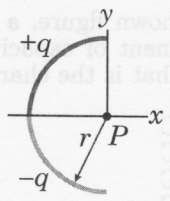
10. An object is placed 3.6 cm in front of a concave/convex mirror. Its image is virtual and four times tall as the object. Find the focal length of the mirror.

(1) 2.4 cm (2) −4.8 cm (3) 4.8 cm (4) 1.6 cm (5) −2.4 cm

11. A 25-turn circular coil of wire has a diameter of 2 m. It is placed with its axis aligned with a magnetic field of 10^{-4} T. Then the coil is flipped 180° in 0.2 s. An average EMF of what magnitude is generated in the coil?

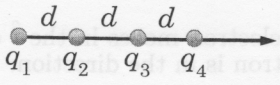
(1) 31 mV (2) 160 mV (3) 80 mV (4) 1.6 mV (5) 3.1 mV

12. A glass rod forms a semi-circle of radius $r = 7$ cm with a charge of $+q$ distributed uniformly along the upper quadrant and $-q$ distributed along the lower quadrant, where $q = 5$ pC. What is the magnitude and the direction (as the polar angle relative to the direction of the x-axis) of the electric field at the center P of the semi-circle?



(1) 18 N/C, $\theta = 0°$ (2) 12 N/C, $\theta = 90°$ (3) 12 N/C, $\theta = 270°$ (4) 18 N/C, $\theta = 180°$ (5) 0 N/C

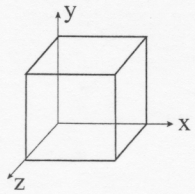
13. Four charges are evenly spaced along the x axis with a separation distance $d = 3$ cm. The values of the charges are: $q_1 = +4\,\mu$C, $q_2 = -2\,\mu$C, $q_3 = +2\,\mu$C, and $q_4 = +6\,\mu$C. What is the net electrostatic force along the x-axis acting on charge q_1 due to the other charges?



(1) $33\,\hat{i}$ N (2) $-27\,\hat{i}$ N (3) $130\,\hat{i}$ N (4) $-240\,\hat{i}$ N (5) $80\,\hat{i}$ N

14. What is the total flux leaving the surface of the shown cube if the electric field is given by $\vec{E} = 3x\hat{i} - 2y\hat{j}$ and the cube has a side length of 2?

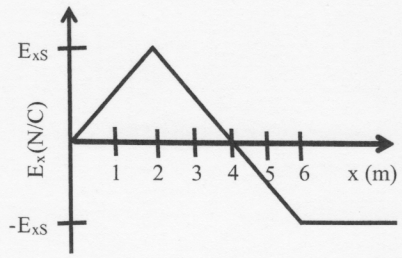
(1) -16
(2) 16
(3) -8
(4) 8
(5) 0



15. An oscillating current in an inductor-capacitor LC-circuit emits electromagnetic waves with a wavelength λ. What is this wavelength, if $L = 0.50\,\mu$ H and $C = 25$ pF?

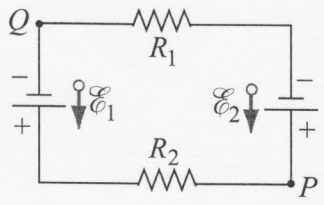
(1) 3.3 m (2) 4.7 m (3) 9.4 m (4) 6.7 m (5) 2.4 m

16. A graph of the x component of the electric field as a function of x in a region of space is shown in figure. The scale of the vertical axis is set by $E_{xs} = 40.0$ N/C. The y and z components of the electric field are zero in this region. If the electric potential at the origin is 60 V, what is the electric potential (in V) at $x = 4.0$ m,



(1) 140 (2) 60 (3) -20 (4) 0 (5) -80

17. In the circuit shown, the ideal batteries have EMFs of $\varepsilon_1 = 9$ V and $\varepsilon_2 = 4.5$ V and the resistances are $R_1 = 30\,\Omega$ and $R_2 = 15\,\Omega$. If the potential at Q is defined to be 3 V, what is the potential at P?

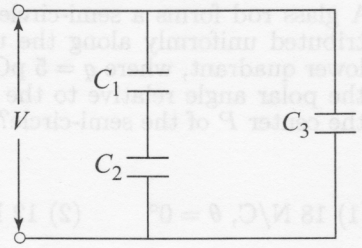


(1) 7.5 V (2) 10.5 V (3) 9.0 V (4) 4.5 V (5) -4.5 V

18. We wish to coat a glass lens ($n = 1.50$) with a transparent material ($n = 1.25$) so that the reflection of light at wavelength 500 nm (in air) is eliminated by interference. What minimum thickness can the coating have to do this?

(1) 100 nm (2) 80 nm (3) 120 nm (4) 110 nm (5) 90 nm

19. In the shown figure, a potential difference of $V = 12$ V is applied across the arrangement of capacitors with capacitances of $C_1 = C_2 = 2\,\mu$F, and $C_3 = 3\,\mu$F. What is the charge q_3 on capacitor C_3?



(1) $36\,\mu$C
(2) $48\,\mu$C
(3) $24\,\mu$C
(4) $12\,\mu$C
(5) $6\,\mu$C

20. An electron moves in the $\hat{i}$ direction, through a uniform magnetic field in the $-\hat{j}$ direction. The magnetic force on the electron is in the direction:

(1) $\hat{j}$ (2) $-\hat{k}$ (3) $-\hat{j}$ (4) $\hat{k}$ (5) $-\hat{i}$