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PHYSICS DEPARTMENT

PHY 2049 Final exam December 13, 2014

Name (print, last first): _____ 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**. 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 most questions demand.
(4) **Blacken the circle of your intended answer completely, using a #2 pencil or <u>blue</u> or <u>black</u> ink**. Do not make any stray marks or the answer sheet may not read properly.
(5) The answers are rounded off. Choose the closest to exact. There is no penalty for guessing.

>>>>>>>>**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. Two isolated conducting spheres are separated by a large distance. Sphere 1 has a radius of $2R$ and an initial charge $6Q$ while sphere 2 has a radius of $3R$ and an initial charge $4Q$. A very thin copper wire is now connected to the spheres to allow charge to flow between the spheres. How much charge will be transferred from sphere 2 to sphere 1? (Note that the charge transferred can be positive, negative or zero.)

(1) $-2Q$ (2) $+Q/2$ (3) $-4Q$ (4) $+3Q$ (5) none of these

2. A proton located at $x = 1$ m is projected along the positive x direction in a electric potential of the form $V(x) = x - 4/x$, where x is measured in meters and $V(x)$ is measured in volts. What is the x component of the force acting on the proton at $x = 2$?

(1) -3.2×10^{-19} N (2) $+3.2 \times 10^{-19}$ N (3) -4.8×10^{-19} N (4) $+4.8 \times 10^{-19}$ N (5) 0

3. Positive charge $3Q$ is distributed uniformly throughout an insulating sphere of radius R, centered at the origin. A particle with a positive charge $4Q$ is placed at $x = 2R$ on the x axis. The magnitude of the electric field at $x = 2R/3$ on the x axis is:

(1) $kQ/4R^2$ (2) $17kQ/4R^2$ (3) kQ/R^2 (4) $11kQ/4R^2$ (5) none of these

4. A 3-A current is used to charge a parallel plate capacitor. A large square piece of paper is placed between the plates and parallel to them so it sticks out on all sides. The value of the integral $\oint \vec{B} \cdot d\vec{l}$ around the perimeter of the paper (in T·m) is:

(1) 3.77×10^{-6} (2) 6 (3) 2.66×10^{-11} (4) 3×10^{-7} (5) not determined from the given quantities

5. A 0.70-m radius cylindrical region contains a uniform electric field that is parallel to the axis and is increasing at the rate 2.5×10^{12} V/m·s. The magnetic field at a point 1.2 m from the axis has a magnitude of:

(1) 5.5×10^{-6} T (2) 3.5×10^{-6} T (3) 0 (4) 1.2×10^{-5} T (5) 1.4×10^{-5} T

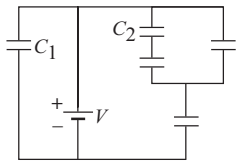
6. The magnetic field in a sinusoidal light wave has an amplitude of 3.3×10^{-7} T. The intensity of the wave is:

(1) 13 W/m^2 (2) 1.7×10^{-4} W/m^2 (3) 26 W/m^2 (4) 1.0×10^{5} W/m^2 (5) 4.0×10^{10} W/m^2

7. An unpolarized beam of light has intensity I_0. It is incident on two ideal polarizing sheets. The angle between the axes of polarization of these sheets is θ. Find θ if the emerging light has intensity $I_0/6$:

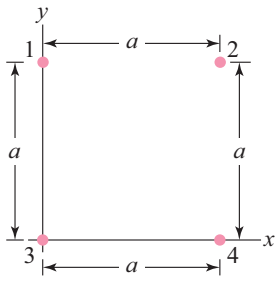
(1) $\cos^{-1}(1/\sqrt{3})$ (2) $\sin^{-1}(1/\sqrt{2})$ (3) $\cos^{-1}(1/3)$ (4) $\sin^{-1}(1/3)$ (5) $\tan^{-1}(1/4)$

8. In the figure, the battery has a potential difference of $V = 15.0$ V, and the five capacitors each of have a capacitance of 3.0 μF. What is the charge on capacitor 2? (in μC)



(1) 9.0 (2) 18.0 (3) 27.0 (4) 45.0 (5) 4.5

9. In the figure, the particles have charges $q_1 = 3.0\mu$C, $q_2 = -8.0\mu$C, $q_3 = 2.0\mu$C and $q_4 = 3.0\mu$C, and distance $a = 5.0$ cm. What is the magnitude of the net electrostatic force on particle 3?

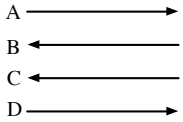


(1) 1.75 N
(2) 62.5 N
(3) 27 N
(4) 4.6 N
(5) 0.75 N

10. A capacitor charged to 700 μC begins discharging through a 500-Ω resistor at $t = 0$. After 15 msec the charge reaches 250 μC. What is the capacitance?

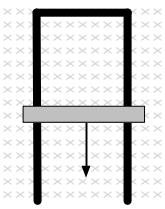
(1) 29 μF (2) 68 μF (3) 20 μF (4) 7.5 μF (5) 43 μF

11. In the figure, four long parallel wires of equal length are carrying identical currents in the directions shown. If the force per unit length on wire B is F what is the force per unit length on B if the currents in wires B and D reverse their directions?



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

12. A 14.0 g conducting rod with resistance 8.0 Ω and length L slides freely downward between two vertical conducting rails without friction, achieving a terminal velocity of 3.51 m/s. The entire apparatus is placed in a 0.43 T uniform magnetic field. What is the length L of the rod? ($g = 9.8$ m/s^2)



(1) 1.3 m
(2) 1.7 m
(3) 0.85 m
(4) 0.70 m
(5) 3.7 m

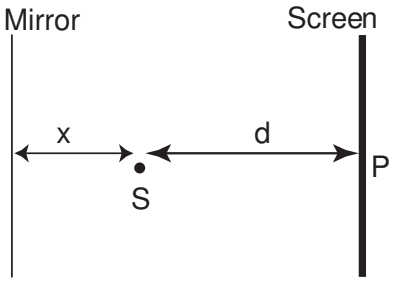
13. A proton moves in a circle of radius 0.54 m inside a cyclotron with magnetic field 0.98 T. What is the frequency of revolution?

(1) 15 MHz (2) 94 MHz (3) 590 MHz (4) 8.1 MHz (5) 45 MHz

14. A 60.0 mH inductor and a 500 Ω resistor are connected in series to an ac generator with an rms emf of 25.0 V. What is the rms current if the frequency of the emf source is 1.42 kHz?

(1) 34 mA (2) 48 mA (3) 24 mA (4) 47 mA (5) 50 mA

15. A point source S is placed a perpendicular distance d in front of a planar screen as shown in cross section in the drawing. The intensity of light reaching point P on the screen is I_0. A perfectly reflecting planar mirror, which is parallel to the screen, is now brought up a distance x from the point source. The value of x which causes I_0 to increase by 25% is:



(1) $d/2$ (2) d (3) $d/4$ (4) $1.08d$ (5) $3d$

16. You are required to project onto a screen an enlarged image of an object. Let f be the magnitude of the lens focal length. Which of the following would be an appropriate choice of lens and object distance?

(1) Convex lens, object between f and $2f$.
(2) Convex lens, object between lens and focal point.
(3) Concave lens, object between lens and focal point.
(4) Concave lens, object between f and $2f$.
(5) Convex lens, object beyond $2f$

17. An inverted image is formed 60 cm from an object by a thin lens located between the two. The image is 1/3 the height of the object. What is the distance from the object to the lens?

(1) 45 cm (2) 48 cm (3) 80 cm (4) 30 cm (5) 15 cm

18. Two slits of width 0.5 μm and separation 0.12 mm are illuminated by a coherent beam of light of wavelength 600 nm. What is the linear separation of the bright interference fringes observed on a screen that is a distance 5 m away?

(1) 25 mm (2) 0.04 mm (3) 2.0 mm (4) 10 mm (5) 5.0 mm

19. Two light waves travel in air with wavelength 520 nm, and they are initially in phase. Each passes through a block of length L before passing back into the air. One travels through glass with index of refraction $n_1 = 1.65$, and the other passes through ice with index of refraction $n_2 = 1.31$. What is the minimum value of L for which the waves will undergo full destructive interference?

(1) 765 nm (2) 2400 nm (3) 4800 nm (4) 400 nm (5) 1260 nm

20. A person holds several grains of red sand. When her eye is 26 cm from the sand she is barely able to resolve the individual grains. Assuming that the grains are spherical and all the same size (somewhat unrealistic, but OK from the point of view of the problem), what is their diameter? Assume that her pupil diameter is 1.9 mm and the light from the grains has wavelength 660 nm?

(1) 110 μm (2) 28 μm (3) 80 μm (4) 55 μm (5) 45 μm