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 PHYSICS DEPARTMENT

PHY 2049

Exam 2

March 3, 2010

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 blue or black 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: $e = 1.6 \times 10^{-19} \text{ C}$ $m_p = 1.67 \times 10^{-27} \text{ kg}$ $m_e = 9.1 \times 10^{-31} \text{ kg}$ $g = 9.8 \text{ m/s}^2$ micro = 10^{-6}

$\epsilon_o = 8.85 \times 10^{-12} \text{ C}^2/\text{N} \cdot \text{m}^2$ $k = 1/(4\pi\epsilon_o) = 9 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$ $\mu_o = 4\pi \times 10^{-7} \text{ T} \cdot \text{m}/\text{A}$ nano = 10^{-9}

Coulomb's Law: $|\vec{F}| = \frac{|q_1||q_2|}{4\pi\epsilon_o r^2}$ (point charge) pico = 10^{-12}

Electric field: $\vec{E} = \frac{\vec{F}}{q}$ $\vec{E} = \frac{q}{4\pi\epsilon_o r^2} \hat{r}$ (point charge) $\vec{E} = \int \frac{dq}{4\pi\epsilon_o r^2} \hat{r}$ (general) $E = \frac{\sigma}{2\epsilon_o}$ (plane)

Gauss' law: $\Phi = \hat{n} \cdot \vec{E} A = \oint \hat{n} \cdot \vec{E} dA = \frac{q_{enc}}{\epsilon_o}$

Energy: $W = \int \vec{F} \cdot d\vec{s} = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = K_f - K_i$ $P = \vec{F} \cdot \vec{v}$ (mechanical power)

For conservative forces $U_f - U_i = - \int \vec{F} \cdot d\vec{s} \rightarrow K_i + U_i = K_f + U_f$

Electric potential: $V = \frac{U}{q}$ $V = \frac{q}{4\pi\epsilon_o r}$ (point charge) $V = \int \frac{dq}{4\pi\epsilon_o r}$ (general)

$V_b - V_a = - \int_a^b E_x dx = - \int_a^b \vec{E} \cdot d\vec{s}$ $E_x = -\frac{\partial V}{\partial x}$, $E_y = -\frac{\partial V}{\partial y}$, $E_z = -\frac{\partial V}{\partial z}$

Capacitors: $q = CV$ $C = \frac{K\epsilon_o A}{d}$ (parallel-plate) $C = C_1 + C_2$ (parallel)

$U = \frac{q^2}{2C}$ $u = \frac{1}{2}\epsilon_o E^2$ $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$ (series)

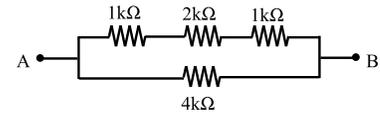
Resistors: $i = \frac{dq}{dt} = jA$ $R = \frac{V}{i}$ $R = \frac{\rho L}{A}$ (wire) $P = iV$ $R = R_1 + R_2$ (series)

$q = CV(1 - e^{-t/RC})$ (charging) $q = q_o e^{-t/RC}$ (discharging) $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$ (parallel)

Magnetism: $\vec{F} = q\vec{v} \times \vec{B}$ $\vec{F} = i\vec{L} \times \vec{B}$ $\mu = NiA$ $\vec{\tau} = \vec{\mu} \times \vec{B}$ $U = -\vec{\mu} \cdot \vec{B}$ $\frac{F}{l} = \frac{\mu_o i_1 i_2}{2\pi r}$

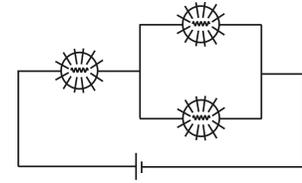
$d\vec{B} = \frac{\mu_o}{4\pi} \frac{i d\vec{s} \times \hat{r}}{r^2}$ $\oint \vec{B} \cdot d\vec{s} = \mu_o i_{enc}$ $B = \frac{\mu_o i}{2\pi R}$, (wire) $\frac{\mu_o i}{2R}$ (loop center), $\frac{\mu_o i N}{L}$ (solenoid)

1. The resistor network in the diagram has 12V across its end terminals labeled A and B. The current through, and voltage drop across, the 2kΩ resistor are, respectively:



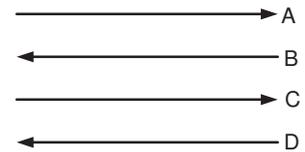
- (1) 10mA, 6V (2) 3mA, 2V (3) 6mA, 2V (4) 3mA, 6V (5) 2mA, 3V

2. The Figure shows 3 identical light bulbs wired as shown. With all bulbs lit the power supply (potential difference V) sources current I . One of the parallel pair of light bulbs is unscrewed. Ignoring temperature dependent changes of the filament resistivity, the new current sourced by the power supply is:



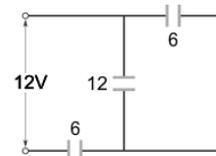
- (1) I (2) $0.75I$ (3) $0.25I$ (4) $2.0I$ (5) $0.5I$

3. Four long parallel wires are arranged on a plane, as shown in the attached figure, with 2.0 cm gaps between them. Each wire carries a 6.0 A current in the direction indicated by the arrow. On the wire labeled C, what is the magnetic force per meter in N/m?



- (1) 3.0×10^{-5} (2) 1.2×10^{-3} (3) 5.6×10^{-4} (4) 4.5×10^{-5} (5) 1.8×10^{-4}

4. In the Figure the capacitances are in micro-Farads (μF). The equivalent capacitance of the network of capacitors is:

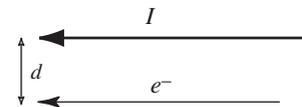


- (1) $10 \mu\text{F}$ (2) $12 \mu\text{F}$ (3) $4.5 \mu\text{F}$ (4) $15 \mu\text{F}$ (5) $24 \mu\text{F}$

5. In the previous problem, the charge on the positive plate of the **top** 6 μF capacitor is:

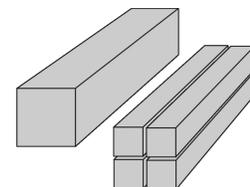
- (1) $40 \mu\text{C}$ (2) $9 \mu\text{C}$ (3) $18 \mu\text{C}$ (4) $54 \mu\text{C}$ (5) $27 \mu\text{C}$

6. An electron moves at a speed of $v = 3 \times 10^7$ m/s parallel to and a distance $d = 10$ cm from a conducting wire carrying a current of $I = 40$ A. If the directions of the electron and current are as shown in the figure, what is the magnitude (in N) and direction of the force experienced by the electron?



- (1) 1.7×10^{-16} toward the wire
 (2) 1.3×10^{-16} away from the wire
 (3) 3.8×10^{-16} away from the wire
 (4) 9.1×10^{-17} toward from the wire
 (5) 3.1×10^{-17} away from the wire

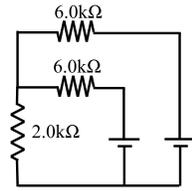
7. A copper wire has a length L , a square cross-section of side length W and an end to end resistance R . Without loss of material the wire is sliced along its long direction to make 4 equal length wires of equal square cross-sections (see Figure). These are then welded together end-to-end to make one wire that is 4 times the original length. The new resistance is:



- (1) $32R$ (2) $8R$ (3) $4R$ (4) $16R$ (5) R

8. In the circuit shown the ideal power supplies are each 12 V. The current through the $2.0\text{ k}\Omega$ resistor is

(1) 5 mA
 (2) 3 mA
 (3) 5.4 mA
 (4) 2.4 mA
 (5) 4.4 mA



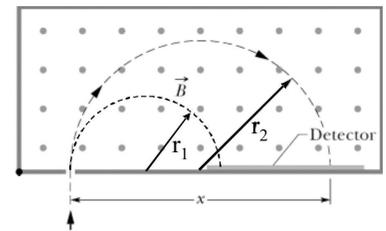
9. A particular wire has a circular cross-section. For the first $1/2$ meter of its one meter length its radius is 4 mm while for the second half it is 2 mm. 14 Coulombs of charge pass a point in the 4 mm section in 30 seconds. The current in the 2 mm section is:

(1) 933 mA (2) 467 mA (3) 233 mA (4) need the resistivity to solve. (5) 117 mA

10. A proton with velocity $\vec{v} = 56\text{ m/s } \hat{i}$ enters a region of space in which there is a magnetic field $\vec{B} = 0.5T\hat{j}$. The electric field that must permeate this region of space to keep the proton moving in the direction of its original velocity without deflection is (in N/C):

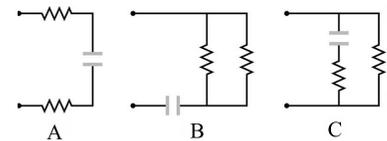
(1) $+112\hat{k}$ (2) $+112\hat{j}$ (3) $-28\hat{k}$ (4) $-28\hat{i}$ (5) $-112\hat{i}$

11. The Figure shows a rudimentary mass spectrometer based on charged particles entering a region with a velocity that is perpendicular to a uniform magnetic field that permeates the region (the gray dots represent a uniform magnetic field pointing out of the page). Assume that two particles having the same charge enter the B-field region with the same velocity. If $r_2 = 2r_1$ then m_2 (the mass of particle 2), is:



(1) $\frac{1}{2}m_1$ (2) $4m_1$ (3) $\frac{1}{4}m_1$ (4) m_1 (5) $2m_1$

12. In the circuits shown all the capacitors have the same capacitance and all the resistors have the same resistance. The capacitors are all charged to the same initial charge Q_0 . At time $t = 0$ the terminals of each circuit are electrically connected together. Rank order the time taken for the capacitor in each circuit to reach 10% of Q_0 , *shortest* time first.



(1) A, C, B (2) B, A, C (3) C, A, B (4) B, C, A (5) A, B, C

13. A proton executes helical motion in a uniform B field at a frequency of 820 kHz. It moves at an angle of 30° relative to the direction of the field. What is the magnitude of the B field?

(1) 0.027 T (2) 0.054 T (3) 0.046 T (4) 0.108 T (5) 0.023 T

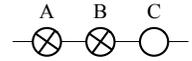
14. A parallel plate capacitor has a plate area of 45 cm^2 a plate separation of 30 micrometers and is filled with a dielectric material having a dielectric constant of 280. When charged to 6.0 V the potential energy stored in the device is:

(1) $1.3\ \mu\text{J}$ (2) $0.7\ \mu\text{J}$ (3) $2.7\ \mu\text{J}$ (4) $6.7\ \mu\text{J}$ (5) $4.8\ \mu\text{J}$

15. A 24.0V DC motor raises a 1.00 kg mass with a constant speed through 10.0 meters in 20.0 seconds. Assuming no other energy losses the current drawn by the motor must be:

(1) 204 mA (2) 88 mA (3) 220 mA (4) 334 mA (5) 128 mA

16. Three wires are equally spaced along a line (perpendicular to the page) as shown in the Figure. Wires A and B each carry current i into the page. When wire C carries no current, wire B experiences a force F . With no other currents changed, in order for wire B to experience a force $3F$ in the same direction as the original F , the current in wire C must be set equal to



- (1) $3i$, in (2) $i/4$, out (3) $2i$, in (4) $3i$, out (5) $2i$, out

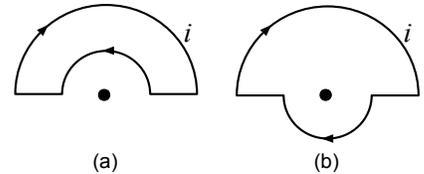
17. Three resistors A , B , and C are connected in parallel with a 12 V power supply. You feel each resistor in turn and B is hottest while C is coolest. The resistance values of the three resistors must be such that:

- (1) $A > B > C$ (2) $C > A > B$ (3) $B > A > C$ (4) $C > B > A$ (5) $B > C > A$

18. A 5-turn circular loop of wire of radius 23 cm carries a current of 15 A. Its magnetic moment is oriented at an angle 50° to a uniform magnetic field of 3.7 T. What energy is required to rotate the loop from its lowest energy position to this orientation?

- (1) 46 J (2) 10.8 J (3) 16 J (4) 30 J (5) 35 J

19. In the Figure two loop configurations are shown with identical currents. Each wire loop consists of a semicircle of radius 10 cm, a smaller concentric semicircle of radius 6.67 cm, and two radial straight lengths, all in the same plane. The magnitude of the magnetic field produced at the center marked by the dot is $10 \mu\text{T}$ in (a). What is the magnitude of the magnetic field at the dot in (b)?



- (1) $25 \mu\text{T}$ (2) $30 \mu\text{T}$ (3) $2.0 \mu\text{T}$ (4) $3.3 \mu\text{T}$ (5) $50 \mu\text{T}$

20. An ideal 6.00 V power supply is connected to a series RC circuit in which the resistor is 120Ω and the capacitor (initially uncharged) is 47.0 pF. The charge accumulated on the positive plate of the capacitor at a time $t = 10RC$ is approximately,

- (1) 5.64 nC (2) 0.282 nC (3) 2.35 pC (4) 56.4 nC (5) 2.68 μC