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PHYSICS DEPARTMENT

PHY 2049

Exam 2

October 21, 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}

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

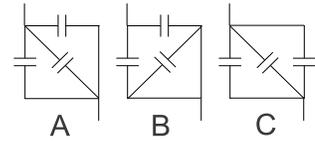
$q = CV(1 - e^{-t/RC})$ (charging) $q = q_o e^{-t/RC}$ (discharging) $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$ (parallel)

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

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

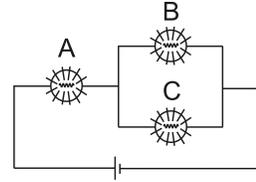
1. How are the three circuits at right related?

- (1) They are all different.
- (2) A and B are equivalent, but not C.
- (3) B and C are equivalent, but not A.
- (4) They are all equivalent.
- (5) A and C are equivalent, but not B.



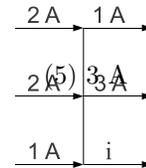
2. Three identical light bulbs are placed in a circuit as shown at right. Light bulb C is removed, resulting in an open circuit where C was originally. What happens to the brightness of light bulbs A and B?

- (1) Bulb A becomes dimmer, and bulb B becomes brighter.
- (2) Bulbs A and B both become brighter.
- (3) The brightness of the bulbs does not change.
- (4) Bulb B becomes dimmer, and bulb A becomes brighter.
- (5) Bulbs A and B both become dimmer.



3. A network of wires is shown at right. The currents in some of the wires are labelled. Based on this information, what is the current labeled i ?

- (1) 1 A
- (2) 2 A
- (3) 4 A
- (4) 0 A



4. An electron travels with velocity $v_o(\cos 30\hat{i} + \sin 30\hat{j})$ in a uniform magnetic field $B_o\hat{j}$, where $v_o = 5\text{ km/s}$ and $B_o = 2\text{ T}$. What is the force on the electron?

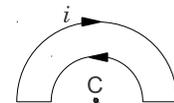
- (1) $-0.8 \times 10^{-15} N\hat{k}$
- (2) $-1.4 \times 10^{-15} N\hat{k}$
- (3) $+0.8 \times 10^{-15} N\hat{k}$
- (4) $+1.4 \times 10^{-15} N\hat{k}$
- (5) $-1.1 \times 10^{-15} N\hat{j}$

5. A circular current carrying loop with a single turn has radius 0.5 cm and is placed in the plane of the page. The current initially flows clockwise around the loop with magnitude 5 mA, and there is a uniform magnetic field coming out of the plane of the page of magnitude 3 T. The direction of the current flow is changed from clockwise to counterclockwise, still with magnitude 5 mA. What is the change in the potential energy, $U_f - U_i$?

- (1) $-1.2\mu J$
- (2) 0
- (3) $+1.2\mu J$
- (4) $-2.4\mu J$
- (5) $+2.4\mu J$

6. A closed current path consists of two semicircular arcs having radii 3 cm and 6 cm and two straight wire segments. If current $i = 1.25\text{ A}$, what is the magnitude and direction of the magnetic field at the center of curvature, C?

- (1) $1.2 \times 10^{-5} T$, into page
- (2) $2.0 \times 10^{-5} T$, out of page
- (3) $6.5 \times 10^{-6} T$, into page
- (4) $6.5 \times 10^{-6} T$, out of page
- (5) $2.0 \times 10^{-5} T$, into page



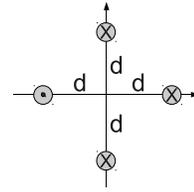
7. A $3\text{ k}\Omega$ resistor and a $2\text{ }\mu F$ capacitor are connected across a 12 V battery at $t = 0$. The capacitor is initially uncharged. What is the voltage across the capacitor at $t = 10\text{ ms}$? (A millisecond is 10^{-3} seconds.)

- (1) 12 V
- (2) 11.5 V
- (3) 9.7 V
- (4) 2.3 V
- (5) 4.9 V

8. A copper wire with circular cross section has resistance of $5\text{ }\Omega$. It is reformed into a wire that is twice as long without the addition or removal of any material. What is the resistance of this new wire?

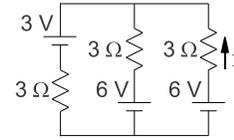
- (1) $40\text{ }\Omega$
- (2) $10\text{ }\Omega$
- (3) $20\text{ }\Omega$
- (4) $5\text{ }\Omega$
- (5) $25\text{ }\Omega$

9. Four long straight wires carry identical currents of $i = 2A$ perpendicular to the plane of the page as shown in the figure. If $d = 8\text{ m}$, what is the magnetic field at the origin?



- (1) $+1.0 \times 10^{-7}T\hat{j}$ (2) $+0.5 \times 10^{-7}T\hat{j}$ (3) $-1.0 \times 10^{-7}T\hat{j}$ (4) $+1.0 \times 10^{-7}T\hat{i}$ (5) $-0.5 \times 10^{-7}T\hat{j}$

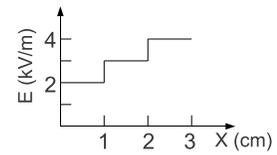
10. What is the current labelled i in the circuit at right?



- (1) 1.33 A (2) 0.67 A (3) 1.67 A (4) 1 A

- (5) 0.33 A

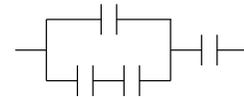
11. Current flows through a rod of length 3 cm. The rod with circular cross-section consists of three sections of the same material but with different radii. The electric field in the rod is shown in the figure. If the radius of the segment between $x = 1\text{ cm}$ and 2 cm is 1 mm, what is the radius of the segment between $x = 2\text{ cm}$ and 3 cm ?



- (1) 0.87 mm (2) 1.33 mm (3) 0.75 mm (4) 0.64 mm

- (5) 1.78 mm

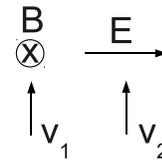
12. Each of the capacitors in the circuit at right has capacitance $1\ \mu\text{F}$. What is the effective capacitance of the network?



- (1) $1.7\ \mu\text{F}$ (2) $0.6\ \mu\text{F}$ (3) $0.4\ \mu\text{F}$ (4) $1.2\ \mu\text{F}$

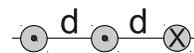
- (5) $2.5\ \mu\text{F}$

13. Charges $Q_1 > 0$ and $Q_2 < 0$ have velocities in the plane of the page as indicated in the figure. A uniform magnetic field with magnitude B is going into the plane of the page, and a uniform electric field with magnitude E is going to the right. If the speed of charge 1 satisfies $v_1 < E/B$ and the speed of charge 2 satisfies $v_2 > E/B$, what is the direction of the net force on charges 1 and 2?



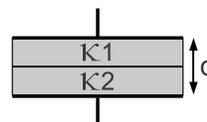
- (1) The net force on both particles is to the left.
 (2) The net force on both particles is to the right.
 (3) The net force is to the right on Q_2 and to the left on Q_1 .
 (4) The net force is to the right on Q_1 and to the left on Q_2 .
 (5) The net force on both particles is going into the page.

14. Three long straight wires carry identical currents of $i = 2A$ perpendicular to the plane of the page as shown in the figure. If $d = 4\text{ cm}$, what is the magnitude and direction of the force per unit length on the left most wire?



- (1) $2 \times 10^{-5}N/m$ to the left (2) $3 \times 10^{-5}N/m$ to the left (3) $2 \times 10^{-5}N/m$ to the right (4) $1 \times 10^{-5}N/m$ to the right
 (5) $1 \times 10^{-5}N/m$ to the left

15. A parallel plate capacitor with area 10 cm^2 and plate separation 1 mm is filled with two different dielectrics as shown in the figure. The top half has dielectric constant $\kappa_1 = 10$, and the bottom half has dielectric constant $\kappa_2 = 20$. What is the capacitance of this parallel plate capacitor?

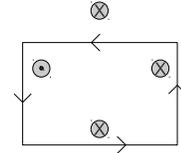


- (1) $2.4 \times 10^{-10}F$ (2) $1.2 \times 10^{-10}F$ (3) $0.6 \times 10^{-8}F$ (4) $0.6 \times 10^{-10}F$ (5) $1.2 \times 10^{-8}F$

16. A copper wire and a nichrome wire of the same length and cross-section are connected in series across a large battery. If the resistivity of the copper wire is $1.7 \times 10^{-8} \Omega \cdot m$ and the resistivity of the nichrome wire is $1.1 \times 10^{-6} \Omega \cdot m$, what is the power dissipated in the copper wire divided by the power dissipated in the nichrome wire?

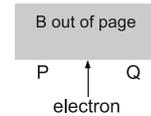
(1) 1 (2) 0.0024 (3) 65 (4) 0.015 (5) 4200

17. Each of the four conductors in the figure carries 2 A of current into or out of the page. What is the value of the line integral $\oint \vec{B} \cdot d\vec{s}$ for the indicated path of integration?



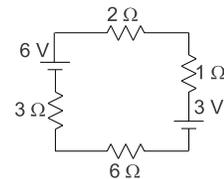
(1) $+2.5 \times 10^{-6} Tm$ (2) $+7.5 \times 10^{-6} Tm$ (3) $-2.5 \times 10^{-6} Tm$ (4) $-7.5 \times 10^{-6} Tm$ (5) $+5.0 \times 10^{-6} Tm$

18. An electron moves into a region of uniform magnetic field, $4 \times 10^{-5} T$, coming out of the page as shown in the figure. How long will it take for the electron to exit the magnetic field and at which point will it exit, P or Q?



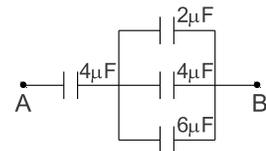
(1) $9.0 \times 10^{-7} s$, Q (2) $4.5 \times 10^{-7} s$, Q (3) $6.0 \times 10^{-7} s$, P (4) $9.0 \times 10^{-7} s$, P (5) $4.5 \times 10^{-7} s$, P

19. What is the current in the circuit at right?



(1) 0.75 A (2) 1 A (3) 1.5 A (4) 0.5 A (5) 0.25 A

20. If the voltage between points A and B in the circuit at right is 12 volts, what is the charge on the $2 \mu F$ capacitor?



(1) $36 \mu C$ (2) $12 \mu C$ (3) $18 \mu C$ (4) $6 \mu C$ (5) $24 \mu C$