

Sample Physics 130-2 Placement Exam

A. Multiple Choice Questions:

1. A negatively charged ball is brought close to a neutral isolated conductor. The conductor is then grounded while the ball is kept close. Then the ground connection is removed. After that the ball is taken away. How is the conductor charged at the end of this process?

- A) positively B) negatively C) neutral

2. Two point charges, q_1 and q_2 , are placed a distance r apart. The electric field is zero at a point P between the particles on the line segment connecting them. From this, we can conclude that:

- A) q_1 & q_2 must have the same magnitude & sign.
B) P must be midway between the particles.
C) q_1 & q_2 must have the same sign but may have different magnitudes.
D) q_1 & q_2 must have equal magnitudes & opposite signs.
E) q_1 & q_2 must have opposite signs & may have different magnitudes.

3. A hollow conductor is positively charged. A small uncharged metal ball is lowered by a silk thread through a small opening in the top of the conductor and allowed to touch its inner surface. After the ball is removed, it will have:

- A) a positive charge.
B) a negative charge.
C) no appreciable charge.
D) a charge whose sign depends on what part of the inner surface it touched.
E) a charge whose sign depends on where the small hole is located in the conductor.

4. The equi-potential surfaces associated with a charged point particle are:

- A) radially outward from the particle.
B) vertical planes.
C) horizontal planes.
D) concentric spheres centered at the particle.
E) concentric cylinders with the particle on the axis.

5. A battery is used to charge a parallel-plate capacitor constructed from circular plates. Then the battery is disconnected and the plates are pulled apart to twice their original separation without discharging the plates. The final plate separation is small compared to the radius of the plates. This process will double the:

- A) surface charge density on each plate.
B) charge on each plate.
C) electric field between the two plates.
D) energy stored in the field between the plates.

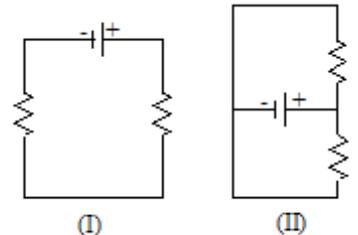
6. For the circuits in the figure at right, are the resistors connected in series, in parallel, or neither? Circle one answer for each circuit.

Circuit I

- A) series
B) parallel
C) neither

Circuit II

- D) series
E) parallel
F) neither

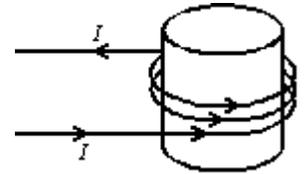


7. A beam of electrons is sent horizontally down the axis of a tube to strike a fluorescent screen at the end of the tube. On the way, the electrons encounter a magnetic field directed vertically downward. The spot on the screen will therefore be deflected:

- A) upward.
- B) downward.
- C) to the right as seen from the electron source.
- D) to the left as seen from the electron source.
- E) not at all.

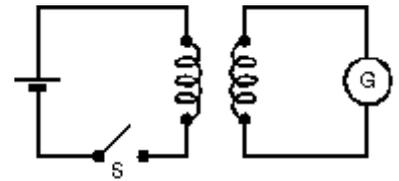
8. Magnetic field lines inside the solenoid shown at right are:

- A) clockwise circles as one looks down the axis from the top of the page
- B) counterclockwise circles as one looks down the axis from the top of the page
- C) toward the top of the page
- D) toward the bottom of the page
- E) in no direction since $B = 0$



9. In the circuit shown, there will be a non-zero reading in galvanometer G:

- A) only just after S is closed.
- B) only just after S is opened.
- C) only while S is kept closed.
- D) never.
- E) only just after S is opened or closed.



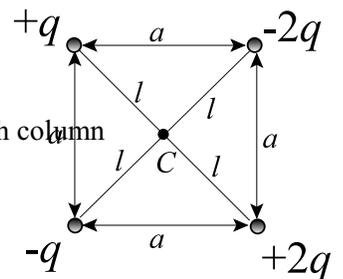
10. A light bulb is in a single loop circuit with a battery of constant strength. If we remove the light bulb and replace it with a new light bulb having twice the resistance of the original light bulb, how will the power output of the new bulb compare to the power output of the old bulb?

- A) The new bulb will have 1/4 the power output of the old bulb.
- B) The new bulb will have 1/2 the power output of the old bulb.
- C) The new bulb will have twice the power output of the old bulb.
- D) The new bulb will have 4 times the power output of the old bulb.

B. Multiple Choice Problems:

1. Four point charges are fixed at the corners of a square of sides of length $a = 5.0$ cm, as in the figure at right. What is the magnitude and direction of the net electric field at the center

(C) of the square if $q = 0.02 \mu\text{C}$? Note that $l = \frac{a}{\sqrt{2}}$. Circle an answer in each column for 2 pts each. (Recall that $k = 1/4\pi\epsilon_0 = 8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$)



Magnitude:

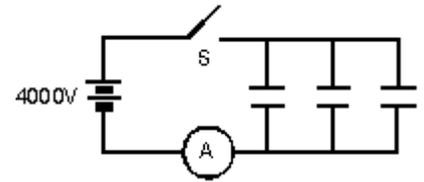
- a. zero
- b. $1.4 \times 10^5 \text{ N/C}$
- c. $2.0 \times 10^5 \text{ N/C}$
- d. $2.8 \times 10^5 \text{ N/C}$
- e. $6.1 \times 10^5 \text{ N/C}$
- f. $8.6 \times 10^5 \text{ N/C}$

Direction:

- g. up the page
- h. down the page
- i. left in the plane of the page
- j. right in the plane of the page
- k. out of the page
- l. into the page

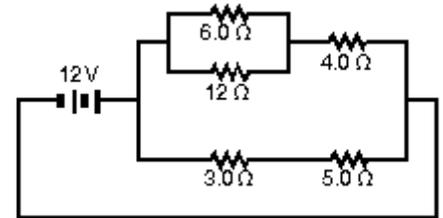
2. Each of the three 25- μF capacitors shown is initially uncharged. How many coulombs of charge pass through the ammeter A after the switch S is closed?

- A) 0.10 C B) 0.30 C C) 10 C D) 0.05 C
E) none of these

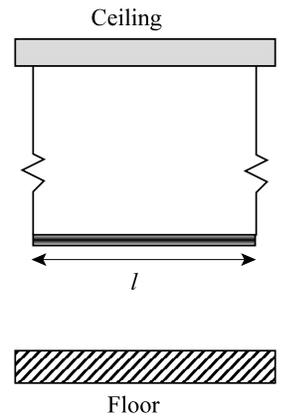


3. The current in the 5.0- Ω resistor in the circuit shown is:

- A) 0.42 A B) 0.67 A C) 1.5 A D) 2.4 A E) 3.0 A



4. A conducting rod of length $l = 72.0$ cm and mass $m = 14$ grams is suspended from the ceiling by a pair of flexible, conducting leads in a uniform magnetic field that is either into or out of the page in the figure at right. Electrons drift to the right through the wire with a speed of 5.0×10^{-5} m/s, leading to a current of 0.30 A in the wire. What is the magnitude and direction of the magnetic field that is required to remove the tension in the supporting leads? Circle an answer in each column for 2 pts. each. Recall that $g = 9.8$ m/s².



Magnitude:

- a. 0.084 μT c. 0.64 T
b. 1.1 μT d. 1.7×10^{22} T

Direction:

- e. into the page
f. out of the page

5. A car travels northward at 75 km/h along a straight road in a region where Earth's magnetic field has a vertical component of 0.50×10^{-4} T. The emf induced between the left and right side, separated by 1.7 m, is:

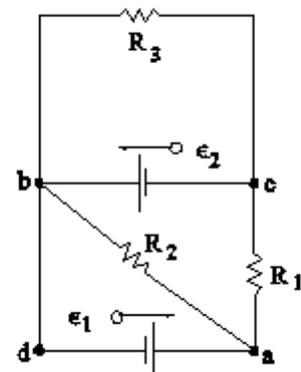
- A) 0 B) 1.8 mV C) 3.6 mV D) 6.4 mV E) 13 mV

C. Free Response Problems:

1. Calculate the current i_1 in R_1 , i_2 in R_2 , i_3 in R_3 , and i_0 in battery #2 for the circuit at right. Use the following values:

$$R_1 = 2 \Omega \quad R_2 = 4 \Omega \quad R_3 = 6 \Omega$$

$$\epsilon_1 = 3 \text{ V} \quad \epsilon_2 = 6 \text{ V}$$



2. You are given a copper wire of length 50.0 cm and resistance 0.0108 Ω . You join the ends and shape it into a circular loop, which you place in a uniform magnetic field face on to the field lines; i.e. the area enclosed by the loop is at right angles to the field lines. If the magnetic field is increasing in strength with time at a constant rate of 10.0×10^{-3} T/s, at what rate is thermal energy (power) generated in the loop?

**Useful Facts
Placement Exam**

Kinematics: $v = v_o + at; \quad \Delta x = v_o t + (\frac{1}{2}) a t^2; \quad v^2 = v_o^2 + 2a(x - x_o)$

Kinetic Energy: $K = \frac{1}{2}mv^2$

Coulomb's law: $F = k \frac{|q_1||q_2|}{r^2} = \frac{1}{4\pi\epsilon_o} \frac{|q_1||q_2|}{r^2}$

Electric Field: $\vec{E} = \frac{\vec{F}}{q_o} \quad E = \frac{1}{4\pi\epsilon_o} \frac{|q|}{r^2}$

Gauss's Law for E: $\epsilon_o \Phi_E = q_{enc}$ where $\Phi_E = \vec{E} \cdot \vec{A}$

Gauss's Law for B: $\Phi_B = \vec{B} \cdot \vec{A} = 0$

Potential Difference: $\Delta V = \frac{\Delta U}{q} = -\frac{W}{q} = V_f - V_i = -\vec{E} \cdot \Delta \vec{s}$

Potential (point charge): $V = \frac{1}{4\pi\epsilon_o} \frac{q}{r}$

E from V: $\vec{E} = -\frac{\Delta V}{\Delta x} \hat{i} - \frac{\Delta V}{\Delta y} \hat{j} - \frac{\Delta V}{\Delta z} \hat{k}$

Electric Potential Energy: $U = \frac{1}{4\pi\epsilon_o} \frac{q_1 q_2}{r}$ (Pair of point charges)

Capacitors: $q = CV$ & $U_E = \frac{1}{2} CV^2 = \frac{q^2}{2C}$ (in general)

$C = \frac{\epsilon_o A}{d}$ (parallel-plate capacitor) $E = \frac{V}{d}$

$C_{eq} = \sum_{j=1}^n C_j$ (parallel) $\frac{1}{C_{eq}} = \sum_{j=1}^n \frac{1}{C_j}$ (series)

Current: $i = \frac{\Delta q}{\Delta t} = \vec{j} \cdot \Delta \vec{A}$ where $\vec{j} = (ne)\vec{v}_d$

Resistance:	$R = \frac{V}{i}$	$\rho = \frac{E}{j}$	$R = \rho \frac{l}{A}$
Power:	$P = iV = i^2 R = \frac{V^2}{R}$		
Resistors:	$R_{eq} = \sum_{j=1}^n R_j$	(series $\frac{1}{R_{eq}} = \sum_{j=1}^n \frac{1}{R_j}$	(parallel)
Magnetic Force/Torque:	$\vec{F}_B = q\vec{v} \times \vec{B}$	$\vec{F}_B = i\vec{l} \times \vec{B}$	$\vec{\tau} = \vec{\mu} \times \vec{B}$ $ \vec{\mu} = NiA$
Circulating Charge:	$qvB = \frac{mv^2}{r}$	$f = \frac{1}{T} = \frac{qB}{2\pi m}$	
Biot-Savart Law:	$\Delta\vec{B} = \frac{\mu_o}{4\pi} \frac{i\Delta\vec{l} \times \hat{r}}{r^2}$		
Ampere's Law:	$B_T C = \mu_o i_{enc}$		
Solenoid:	$B = \mu_o in$	$L = \mu_o \pi n^2 R^2 l$	$n = \frac{N}{l}$
Faraday's Law:	$\epsilon = E_T C = -N \frac{\Delta\Phi_B}{\Delta t}$	$\Phi_B = \vec{B} \cdot \vec{A}$	$\epsilon = vBL$
Inductors:	$L = \frac{N\Phi_B}{i}$	$\epsilon_L = -L \frac{\Delta i}{\Delta t}$	$U_B = \frac{1}{2} Li^2$ $u_B = \frac{B^2}{2\mu_o}$
RL Circuits:	$i = \frac{\epsilon}{R} (1 - e^{-(R/L)t})$	or	$i = I_o e^{-(R/L)t}$
LC Circuits:	$\omega = 2\pi f = \frac{2\pi}{T} = \frac{1}{\sqrt{LC}}$ $q = Q \cos(\omega t + \phi)$		

Constants:	$c = 3.00 \times 10^8$ m/s (speed of light)	$k = 1/4\pi\epsilon_o = 8.99 \times 10^9$ N · m ² /C ²	
	$\epsilon_o = 8.85 \times 10^{-12}$ C ² /N · m ²	$m_e = 9.11 \times 10^{-31}$ kg (electron mass)	
	$m_p = 1.67 \times 10^{-27}$ kg (proton mass)	$e = 1.6 \times 10^{-19}$ C (charge on electron)	
	$\mu_o = 4\pi \times 10^{-7}$ T · m/A	$g = 9.81$ m/s ²	
Conversions:	1 MΩ = 10 ⁶ Ω 1 gram = 10 ⁻³ kg 1 mT = 10 ⁻³ T 1 kV = 1000 V	1 m = 10 ² cm = 10 ³ mm = 10 ⁶ μm = 10 ⁹ nm 1 eV = 1.6 × 10 ⁻¹⁹ J	
Geometry:	S (cylinder) = $2\pi rL + 2\pi r^2$ V (cylinder) = $\pi r^2 L$	S (sphere) = $4\pi r^2$ V (sphere) = $(4/3)\pi r^3$	A (circle) = πr^2 C (circle) = $2\pi r$