



**PART I.** Use the scantron sheet to answer all questions below. Best 6 out of 7 count towards 48% of your test grade.

- 1 Two charges  $+\frac{1}{2}Q$  and  $+2Q$  are separated by a distance  $r$ .  
At what distance from the greater charge, would a third test charge experience no net electrical force? ?  
/It has to be placed between the two charges/  
a)  $\frac{4}{5}r$       b)  $\frac{3}{4}r$       c)  $\frac{2}{3}r$       d)  $\frac{1}{2}r$       e) none of these answers
- 2 The current in a loop circuit that has a resistance of  $R_1$  is 2.00 A. The current is reduced to 1.60 A when an additional resistor  $R_2 = 3.00\Omega$  is added in series with  $R_1$ . What is the value of  $R_1$ ?  
a) 12  $\Omega$       b) 8  $\Omega$       c) 7  $\Omega$       d) 6  $\Omega$       e) none of these answers
- 3 A fully charged capacitor stores energy  $U_0$ . How much energy remains when its charge has decreased to half its original value?  
A)  $\frac{1}{16}U_0$       b)  $\frac{1}{9}U_0$       c)  $\frac{1}{4}U_0$       d)  $\frac{1}{2}U_0$       e) none of these answers
- 4 A particle ( $q = -4.0 \mu\text{C}$ ,  $m = 5.0 \text{ mg}$ ) moves in a uniform magnetic field with a velocity having a magnitude of 2.0 km/s and a direction that is  $50^\circ$  away from that of the magnetic field. The particle is observed to have an acceleration with a magnitude of  $5.8 \text{ m/s}^2$ . What is the magnitude of the magnetic field?  
a) 5.4 mT      b) 4.9 mT      c) 5.1 mT      d) 4.7 mT      e) 3.6 mT
- 5 The electric field inside a charged solid spherical conductor in equilibrium  
a) is always zero.  
b) is constant and equal to its value at the surface.  
c) decreases from its value at the surface to a value of zero at the center.  
d) increases from its value at the surface to a value at the center that is a multiple of the potential at the surface.  
e) is equal to the charge passing through the surface per unit time divided by the resistance.
- 6 Two charges of 15 pC and  $-40 \text{ pC}$  are inside a cube with sides that are of 0.50-m length. Determine the net electric flux through the surface of the cube.  
a)  $+2.8 \text{ N} \cdot \text{m}^2/\text{C}$       b)  $-1.1 \text{ N} \cdot \text{m}^2/\text{C}$       c)  $+1.1 \text{ N} \cdot \text{m}^2/\text{C}$   
d)  $-2.8 \text{ N} \cdot \text{m}^2/\text{C}$       e)  $-0.47 \text{ N} \cdot \text{m}^2/\text{C}$
- 7 Find the approximate value flux through the square of side  $a=5 \text{ cm}$  which is placed at distance 5 m from the single point charge  $Q=1\text{mC}$ . /Yes, the point charge is on the axis perpendicular to the square passing through its centre./  
a)  $90 \frac{\text{N}}{\text{C}} \text{m}^2$       b)  $400 \frac{\text{N}}{\text{C}} \text{m}^2$       c)  $900 \frac{\text{N}}{\text{C}} \text{m}^2$       d)  $2800 \frac{\text{N}}{\text{C}} \text{m}^2$       e) none of the these answers

PHY1322 Winter 2018  
Midterm I  
Prof. A. Czajkowski



**PART I.** Use the scantron sheet to answer all questions below. Best 6 out of 7 count towards 48% of your test grade.

- Two charges  $+\frac{1}{3}Q$  and  $+3Q$  are separated by a distance  $r$ . At what distance from the greater charge, would a third test charge experience no net electrical force? /It has to be placed between the two charges/  
a)  $\frac{4}{5}r$       b)  $\frac{3}{4}r$       c)  $\frac{2}{3}r$       d)  $\frac{1}{2}r$       e) none of these answers
- The current in a loop circuit that has a resistance of  $R_1$  is 2.00 A. The current is reduced to 1.40A when an additional resistor  $R_2 = 3.00 \Omega$  is added in series with  $R_1$ . What is the value of  $R_1$ ?  
a)  $12 \Omega$       b)  $8 \Omega$       c)  $7 \Omega$       d)  $4 \Omega$       e) none of these answers
- A fully charged capacitor stores energy  $U_0$ . How much energy remains when its charge has decreased to one quarter of its original value?  
A)  $\frac{1}{16}U_0$       b)  $\frac{1}{9}U_0$       c)  $\frac{1}{4}U_0$       d)  $\frac{1}{2}U_0$       e) none of these answers
- A particle ( $q = -4.0 \mu\text{C}$ ,  $m = 5.0 \text{ mg}$ ) moves in a uniform magnetic field with a velocity having a magnitude of 2.3 km/s and a direction that is  $60^\circ$  away from that of the magnetic field. The particle is observed to have an acceleration with a magnitude of  $5.8 \text{ m/s}^2$ . What is the magnitude of the magnetic field?  
a) 5.4 mT      b) 4.9 mT      c) 5.1 mT      d) 4.7 mT      e) 3.6 mT
- The electric field inside a charged solid spherical conductor in equilibrium  
a) is constant and equal to its value at the surface.  
b) is always zero.  
c) decreases from its value at the surface to a value of zero at the center.  
d) increases from its value at the surface to a value at the center that is a multiple of the potential at the surface.  
e) is equal to the charge passing through the surface per unit time divided by the resistance.
- Two charges of 20 pC and  $-30 \text{ pC}$  are inside a cube with sides that are of 0.40-m length. Determine the net electric flux through the surface of the cube.  
a)  $+2.8 \text{ N} \cdot \text{m}^2/\text{C}$       b)  $-1.1 \text{ N} \cdot \text{m}^2/\text{C}$       c)  $+1.1 \text{ N} \cdot \text{m}^2/\text{C}$   
d)  $-2.8 \text{ N} \cdot \text{m}^2/\text{C}$       e)  $-0.47 \text{ N} \cdot \text{m}^2/\text{C}$
- Find the approximate value flux through the square of side  $a=5 \text{ cm}$  which is placed at distance 5 m from the single point charge  $Q=3.1\text{mC}$ . /Yes, the point charge is on the axis perpendicular to the square passing through its centre./  
a)  $90 \frac{\text{N}}{\text{C}} \text{m}^2$       b)  $400 \frac{\text{N}}{\text{C}} \text{m}^2$       c)  $900 \frac{\text{N}}{\text{C}} \text{m}^2$       d)  $2800 \frac{\text{N}}{\text{C}} \text{m}^2$       e) none of these answers

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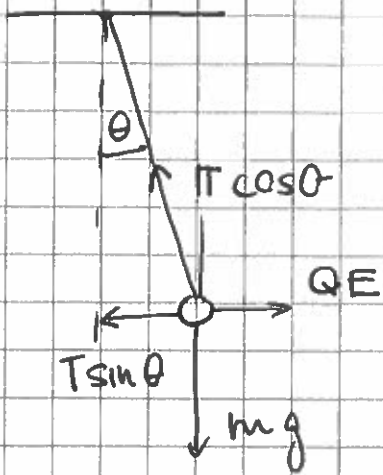
ver C



**PART I.** Use the scantron sheet to answer all questions below. Best 6 out of 7 count towards 48% of your test grade.

- 1 Two charges  $+\frac{1}{4}Q$  and  $+4Q$  are separated by a distance  $r$ . At what distance from the greater charge, would a third test charge experience no net electrical force? /It has to be placed between the two charges/  
a)  $\frac{4}{5}r$       b)  $\frac{3}{4}r$       c)  $\frac{2}{3}r$       d)  $\frac{1}{2}r$       e) none of these answers
- 2 The current in a loop circuit that has a resistance of  $R_1$  is 2.00 A. The current is reduced to 1.20 A when an additional resistor  $R_2 = 2.00 \Omega$  is added in series with  $R_1$ . What is the value of  $R_1$ ?  
a)  $12 \Omega$       b)  $8 \Omega$       c)  $7 \Omega$       d)  $3 \Omega$       e) none of these answers
- 3 A fully charged capacitor stores energy  $U_0$ . How much energy remains when its charge has decreased to one third of its original value?  
A)  $\frac{1}{16}U_0$       b)  $\frac{1}{9}U_0$       c)  $\frac{1}{4}U_0$       d)  $\frac{1}{2}U_0$       e) none of these answers
- 4 A particle ( $q = -4.0 \mu\text{C}$ ,  $m = 5.0 \text{ mg}$ ) moves in a uniform magnetic field with a velocity having a magnitude of 2.1 km/s and a direction that is  $40^\circ$  away from that of the magnetic field. The particle is observed to have an acceleration with a magnitude of  $5.8 \text{ m/s}^2$ . What is the magnitude of the magnetic field?  
a) 5.4 mT      b) 4.9 mT      c) 5.1 mT      d) 4.7 mT      e) 3.6 mT
- 5 The electric field inside a charged solid spherical conductor in equilibrium  
a) is constant and equal to its value at the surface.  
b) decreases from its value at the surface to a value of zero at the center.  
c) is always zero.  
d) increases from its value at the surface to a value at the center that is a multiple of the potential at the surface.  
e) is equal to the charge passing through the surface per unit time divided by the resistance.
- 6 Two charges of 35 pC and  $-25 \text{ pC}$  are inside a cube with sides that are of 0.40-m length. Determine the net electric flux through the surface of the cube.  
a)  $+2.8 \text{ N} \cdot \text{m}^2/\text{C}$       b)  $-1.1 \text{ N} \cdot \text{m}^2/\text{C}$       c)  $+1.1 \text{ N} \cdot \text{m}^2/\text{C}$   
d)  $-2.8 \text{ N} \cdot \text{m}^2/\text{C}$       e)  $-0.47 \text{ N} \cdot \text{m}^2/\text{C}$
- 7 Find the approximate value flux through the square of side  $a=5 \text{ cm}$  which is placed at distance 5 m from the single point charge  $Q=0.44 \text{ mC}$ . /Yes, the point charge is on the axis perpendicular to the square passing through its centre./  
a)  $90 \frac{\text{N}}{\text{C}} \text{m}^2$       b)  $400 \frac{\text{N}}{\text{C}} \text{m}^2$       c)  $900 \frac{\text{N}}{\text{C}} \text{m}^2$       d)  $2800 \frac{\text{N}}{\text{C}} \text{m}^2$       e) none of these answers

1A



$$T \cos \theta - mg = 0$$

$$QE - T \sin \theta = 0$$

$$Q = \frac{T \sin \theta}{E}$$

$$Q = \frac{mg \sin \theta}{E \cos \theta}$$

$$Q = \frac{mg \tan \theta}{E}$$

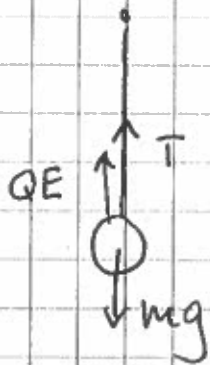
$$Q = 2.63 \mu\text{C}$$



1B

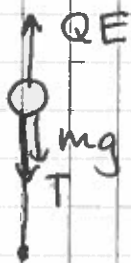
In the absence of E-field in the horizontal direction the ball experiences forces that are acting along the vertical direction only

I Possibility



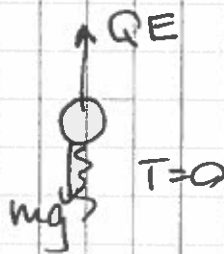
$$T + QE - mg = 0$$

II Possibility



$$QE - mg - T = 0$$

III Possibility



$$QE - mg = 0$$

Q2

$$Q(t) = \underbrace{EC}_{Q_{\text{Max}}} \left(1 - e^{-\frac{t}{RC}}\right)$$

at  $t = t_{1/n}$   $Q/n$  charge will be on the capacitor

$$\frac{Q_{\text{Max}}}{n} = Q_{\text{Max}} \left(1 - e^{-\frac{t}{RC}}\right)$$

$$\frac{1}{n} - 1 = -e^{-\frac{t_{1/n}}{RC}}$$

$$1 - \frac{1}{n} = e^{-\frac{t_{1/n}}{RC}}$$

$$\ln\left(\frac{n-1}{n}\right) = -\frac{t_{1/n}}{RC}$$

$$-\ln\frac{n}{n-1} = -\frac{t_{1/n}}{RC}$$

$$\ln\frac{n}{n-1} = \frac{t_{1/n}}{RC}$$

$$C = \frac{t_{1/n}}{R \ln\frac{n}{n-1}}$$

$$\underline{n=2} \quad C = \frac{t_{1/2}}{R \ln 2} = \frac{76 \times 10^{-6} \text{ s}}{50 \times 10^6 \ln 2 \ \Omega} = \frac{76}{50 \ln 2} \times 10^{-12} \text{ F}$$

$$C = 2.19 \times 10^{-12} \text{ F} = 2.19 \text{ pF}$$

This is equivalent capacitance for two capacitors

$$\frac{1}{C_{\text{EQ}}} = \frac{1}{C} + \frac{1}{C} = \frac{2}{C}$$

$$C_{\text{EQ}} = \frac{C}{2} \Rightarrow C = 2C_{\text{EQ}}$$

$$C = 4.39 \text{ pF}$$

$$C = \epsilon_0 \frac{A}{d}$$

$$4.39 \times 10^{-12} \text{ F} = 8.85 \times 10^{-12} \left(\frac{\text{F}}{\text{m}}\right) \frac{A}{d}$$

$$\frac{4.39}{8.85} \text{ m} = \frac{A}{d}$$

$$\frac{4.39}{8.85} \text{ m} \frac{1}{16 \times 10^{-6} \text{ m}^2} = \frac{1}{d}$$

$$0.031 \times 10^6 = \frac{1}{d}$$

$$d = 32 \times 10^{-6} \text{ m} = 32 \mu\text{m}$$

PROBLEM 3

We name the currents  $I_1$ ,  $I_2$ , and  $I_3$  as shown.

[1]  $70.0 - 60.0 - I_2(3.00 \text{ k}\Omega) - I_1(2.00 \text{ k}\Omega) = 0$

[2]  $80.0 - I_3(4.00 \text{ k}\Omega) - 60.0 - I_2(3.00 \text{ k}\Omega) = 0$

[3]  $I_2 = I_1 + I_3$

(b) Substituting for  $I_2$  and solving the resulting simultaneous equations yields

$I_1 =$   (through  $R_1$ )

$I_3 =$   (through  $R_3$ )

$I_2 =$   (through  $R_2$ )

(c)  $\Delta V_{cf} = -60.0 \text{ V} - (3.08 \text{ mA})(3.00 \text{ k}\Omega) =$

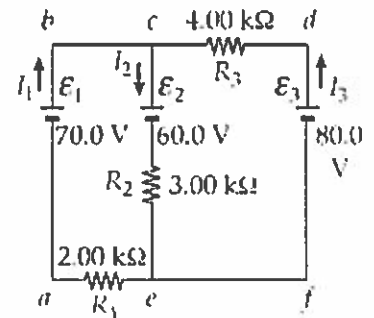
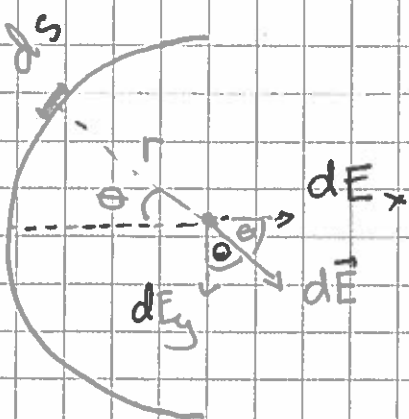


FIG. P28.24

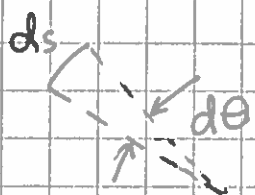
Q 4



$$|d\vec{E}_y| = |d\vec{E}| \cos \theta$$

$$|d\vec{E}| = k_e \frac{dq}{r^2}$$

$$dq = \lambda ds$$



$$ds = r d\theta$$

$$\lambda = \frac{Q}{L}$$

$$dq = \lambda r d\theta$$

$$dq = \frac{Q}{L} r d\theta$$

$$L = \pi r \Rightarrow r = \frac{L}{\pi}$$

$$E_x = \int dE_x = \int k_e \frac{dq}{r^2} \cos \theta = \int \left( k \frac{Q}{L} \frac{r d\theta}{r^2} \right) \cos \theta$$

semi  
circle

$$E_x = k \frac{Q}{L} \frac{1}{r} \int_{\theta = -90}^{+90} [\cos \theta] d\theta = 2k \frac{Q}{L} \frac{1}{r}$$

$$E_y = \int dE_y = 0 \leftarrow$$

due to cancellations  
(symmetry)

4B



Full sphere (with the hole plugged)

Will produce  $E = 0$  at the centre!

We need to take into account the effect of a disk  
(we added it - we need to subtract it)



$$r = 2 \text{ cm}$$

$$\bar{\sigma} = \frac{Q}{4\pi R^2}$$

$$E_{\text{disk}} = -2\pi k \bar{\sigma} \left( 1 - \frac{y}{\sqrt{R^2 + y^2}} \right)$$

$$E_{\text{disk}} = -2\pi k \bar{\sigma} \left( 1 - \frac{2}{\sqrt{4.0004}} \right)$$

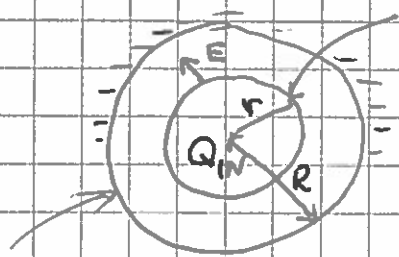
$$E_{\text{disk}} = -2\pi (8.99 \times 10^9) \frac{0.01}{4\pi (4)} \left( 4.9996 \times 10^{-5} \right) \frac{\text{N}}{\text{C}}$$

$$E_{\text{disk}} = 561.83 \frac{\text{N}}{\text{C}}$$

Q5

(A)

$r < R$



Charge on the surface

Gaussian Surface of radius  $r$

Since all the charge resides on the surface of the conductor

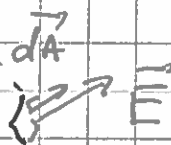
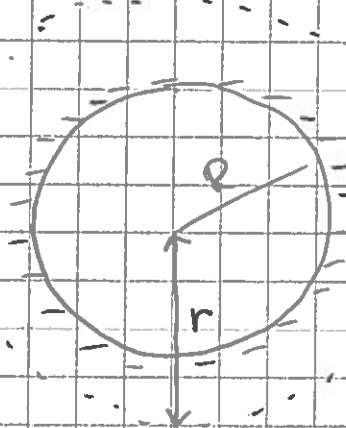
$$Q_{IN} = 0$$

for any surface (does not matter what is the shape)

$\vec{E} = 0$

(B)

$R < r$



$$\oint \vec{E} \cdot d\vec{A} = \frac{Q_0}{\epsilon_0}$$

$$\oint |\vec{E}| |dA| \cos\theta = \frac{Q}{\epsilon_0}$$

$$|\vec{E}| \oint dA = \frac{Q}{\epsilon_0}$$

$$|\vec{E}| 4\pi r^2 = \frac{Q}{\epsilon_0}$$

$$|\vec{E}| = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2}$$

$\vec{E} \parallel d\vec{A}$

at every point of this sphere due to the symmetry,