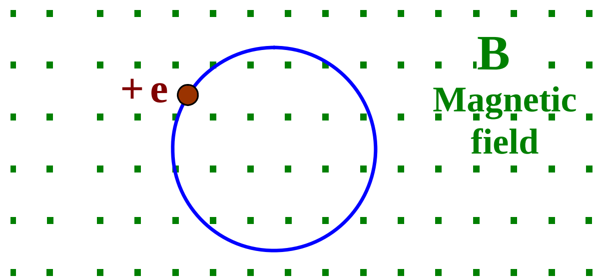
**Final Exam** # Physics 212

**08/07/08** NAME ____________________

**1.** A proton with kinetic energy 1.5 x $10^3$ eV circles in a plane perpendicular to a uniform magnetic field. The orbit radius is R=25 cm.




**1A** An approximate value of the proton's speed, and the direction it is circling, are:

**a)** 1.5 x $10^9$ m/s, counterclockwise **b)** 7.5 x $10^3$ m/s, clockwise

**c)** 5.3 x $10^5$ m/s, clockwise **d)** 2.1 x $10^7$ m/s, counterclockwise

**e)** NA

**1B** The magnitude of the magnetic field is (approximately):

**a)** 2.5 x $10^{-9}$ T **b)** 1.7 x $10^{-6}$ T **c)** 2.2 x $10^{-2}$ T

**d)** 5 x$10^{-4}$ T **e)** NA

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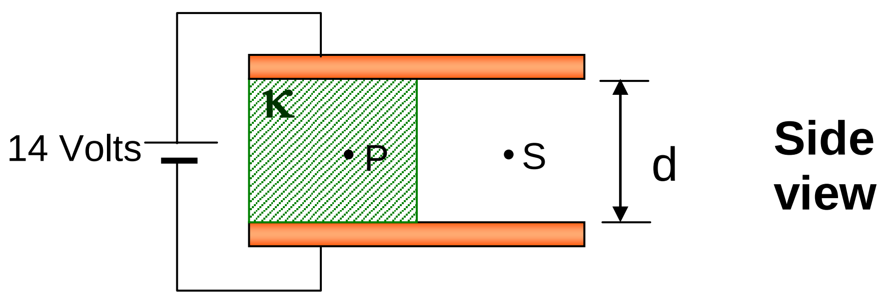
**2.** A parallel plate capacitor is 50% filled with a dielectric of dielectric constant $\kappa$= 2.5, while the remaining volume is empty (see figure below.) The area of the plates is A= 3 $cm^2$ and the separation distance between the parallel plates is d = 3.5 mm.



**2A** The capacitance of the capacitor is equal to (in units of $10^{-12}$ F)

**a)** 3.9 **b)** $4.2 \times 10^{-3}$ **c)** 22 **d)** $6.1 \times 10^{3}$ **e)** NA

**2B** The figure above also shows a couple of point "P" and "S" where we want to evaluate the corresponding electric filed. Which of the following expression(s) is(are) correct?

**a)** The magnitude of the electric field at P is greater than at S

**b)** The magnitude of the electric field at P is weaker than at S

**c)** The magnitude of the electric field at S is equal to $4x\ 10^{3}$ N/C

**d)** The electric field magnitude at P is equal to $1.6 \times 10^{3}$ N/C

**e)** All the expressions above are incorrect

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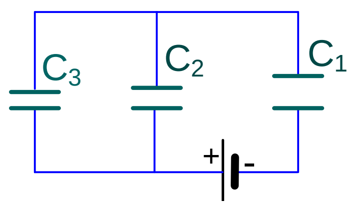
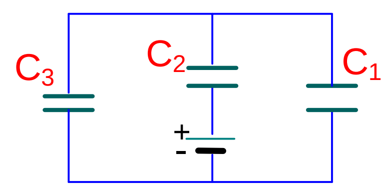
**3 3A** Find the equivalent capacitance of the 2 circuits shown below, where $C_1 = 1\ \mu F$, $C_2 = 2\ \mu F$ and $C_3 = 3\ \mu F$:

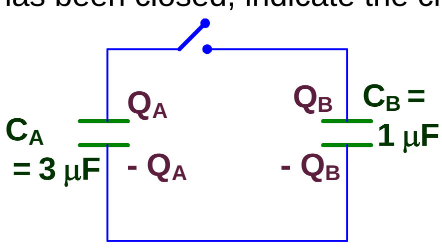


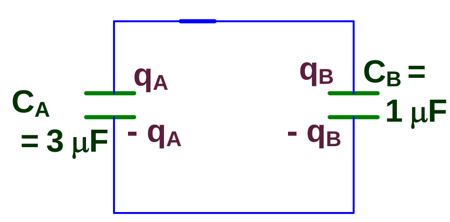




ANSWER 5/6 µF

ANSWER 4/3 µF

**3B** The figure below shows a circuit consisting of a switch and two capacitors initially charged as indicated (left side figure). After the switch has been closed, indicate the charges stored in each capacitor.




$Q_A = 6\ \mu C$ $Q_B = 2\ \mu C$

$q_A = ?$ $q_B = ?$

ANSWER: $q_A = 6\ \mu C$ $q_B = 2\ \mu C$

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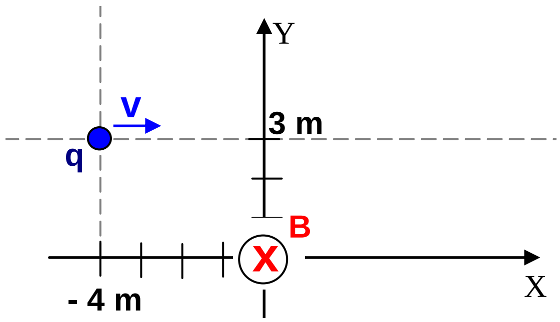
**4** A positive point charge of magnitude $q= 4.5x10^{-3}C$ is moving in the XY plane with speed $v= 3.6 \times 10^{4}$ m/s parallel to the x-axis along the line y = 3m.

**4A.** Find the magnitude of the magnetic field at the origin produced by this charge when the charge is at the point x = - 4m, y= 3m as shown in the figure.

**a)** $7.3x10^{-4}$ T **b)** $1.4 \times 10^{3}$ T **c)** $9.1 \times 10^{-10}$ T

**d)** $3.9 \times 10^{-7}$ T **e)** NA

**4B.** In the graph below, draw the magnetic field vector at the origin, produced by the charge. In addition, express that magnetic field in terms of the unit vectors $\hat{\imath}$, $\hat{\jmath}$, and $\hat{k}$.




$\vec{B}$ (at the origin) = ____________

$-|B|\hat{k}$

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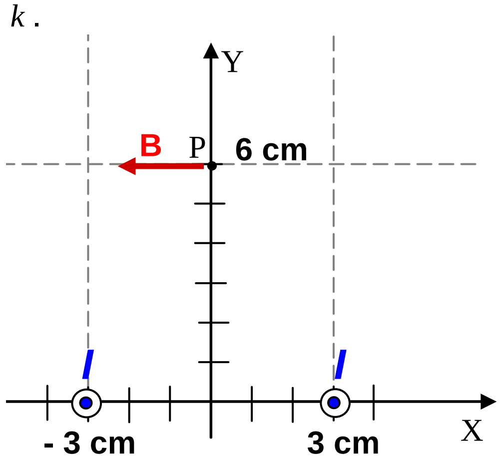
**5.** An infinite long straight wire carrying a current of 1.7 Amperes in the positive z direction lies along the line x = -3 cm, y=0. A similar wire carrying a current of 1.7 Amperes also in the positive z-direction lines along the line x = 3 cm, y=0 as shown in the figure.

**5A.** Draw the magnetic field vector at the point P on the Y-axis at y= 6 cm**.** In addition, express that magnetic field in terms of the unit vectors $\hat{\imath}$, $\hat{\jmath}$, and $\hat{k}$.




$\vec{B}$ (at P) = ____________

$-|B|\hat{\imath}$

**5B.** The magnitude of the magnetic field at the point P on the Y-axis at y= 6 cm is equal to

**a)** $8.2 \times 10^{-3}$ T　　**b)** $5.7 \times 10^{-7}$ T　　**c)** $9.1 \times 10^{-6}$ T

**d)** $3.1 \times 10^{-7}$ T　　**e)** NA

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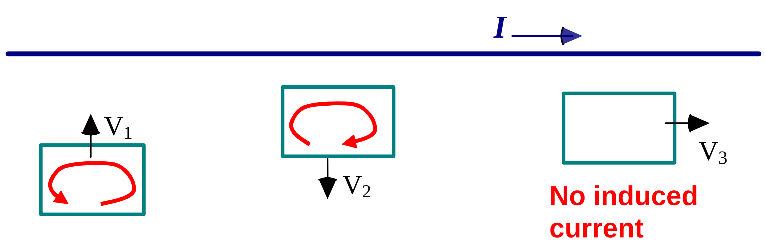
**6. 6.A** Three rectangular loops of wire with length "a" and width "b" are placed near an infinitely long wire carrying current I. The long wire stay at a fixed position, while the loops move with constant speed v ($v_1 = v_2 = v_3 = v$). All the loops and the long wire are in the plane XY.

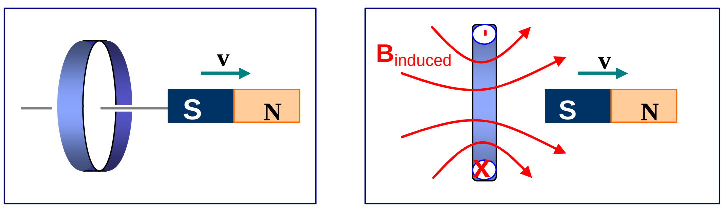
In each of the three cases shown below draw the induced current (if any) along the loop. (Consider that the three rectangular loops are very far apart each other.)




**6B** The figure shows two views of the same magnet moving away from a metallic ring (the latter is at a fixed position.)

On the right side figure: Indicate (using the conventional notation • and **x**) the induced current that circulates along the ring.

Draw also the <u>magnetic field lines established by the induced current</u>, indicating explicitly the direction of those lines.

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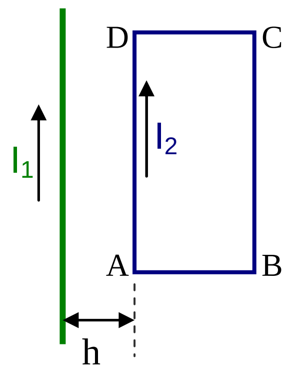
**7.** In the figure below, the current in the infinite long, straight wire is $I_1$ = 5 Amperes. The wire lies in the plane of the rectangular loop; the latter carries the current is $I_2$ = 10 Amperes. The dimensions are h = 0.1 m, AB = 0.15 m and BC= 0.45 m.




$I_1$ = 5 Amperes

$I_2$ = 10 Amperes

**7A.** Which of the following expression(s) is(are) correct?

**a)** The force on the segment AB due to the current $I_1$ is zero

**b)** The forces on the segments DA and BC have the same magnitude but opposite direction

**c)** The magnetic force acting on the segment DC point in the direction perpendicular to the plane of the loop

**d)** The net force on the loop is zero

**e)** All the expressions above are incorrect

**7B.** The magnitude of the net force acting on the loop by the magnetic field created by the infinite long wire is equal to (in units of μN),

**a)** 0.13 **b)** 27 **c)** 0 **d)** 6.6 **e)** NA

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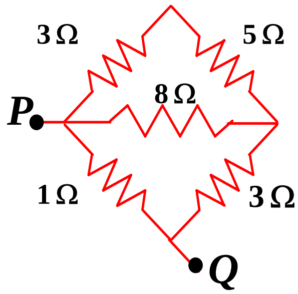
**8. 8A** A certain wire has a resistance R. What is the resistance of a second wire, made of the same material, that is half as long and has half the diameter.

**a)** (1/2)R **b)** 2R **c)** 4 Ω **d)** (1/4) R **e)** NA

**8B** Find the equivalent resistance between the points *P* and *Q* in the figure below




**a)** 2/7 Ω **b)** 1/3 Ω **c)** 1/12 Ω **d)** 7/8 Ω **e)** NA

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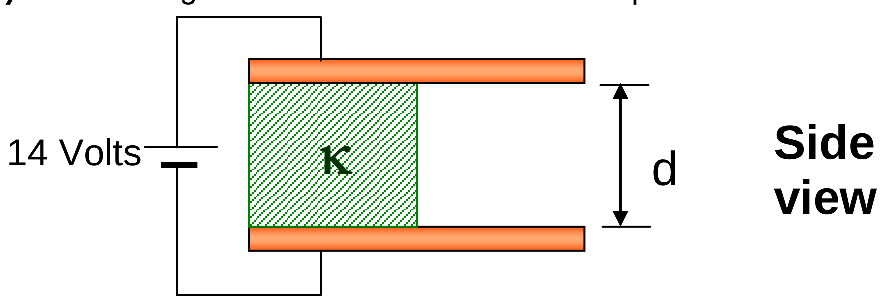
**BONUS QUESTIONS**

**B1. (5 points)** Consider again the situation described in question #2 above,




What is the total amount of charge deposited in each plate?

**ANSWER: 54x $10^{-12}$ C**

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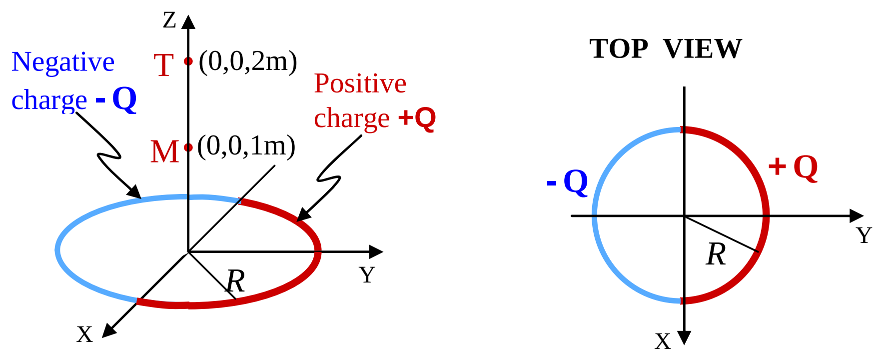
**B2. (5 points)** A ring of radius R= 0.8 m has charge distributed as shown in the figure. Assume that |Q| = 19 μC, and that the positive and negative charges are uniformly distributed over half of the ring, respectively.




**B2.A** Circle all the expression(s) that is(are) correct.

- **a)** The magnitude of the electric potential at T is greater than the magnitude of the electric potential at M.
- **b)** The electric field at T is zero.
- **c)** The electric potential at the origin is zero.
- **d)** The magnitude of the electric field at T is greater than the magnitude of the electric field at M.
- **e)** All the expressions above are incorrect.

**B2.B** The external work needed to take an electron from the origin to T is equal to:

**a)** 0 **b)** $15 \times 10^3$ J **c)** $7.1 \times 10^3$ J **d)** $2.3 \times 10^3$ J **e)** NA

# Some formulas:

- $\mu = 10^{-6}$ nano $= 10^{-9}$
- ln( ab ) = ln( a ) + ln ( b ) ln( a/b ) = ln( a ) - ln ( b )
- **Electron mass**: $9.1 \times 10^{-31}$ Kg **Proton mass** = $1.67 \times 10^{-27}$ Kg
- **1 Gauss = $10^{-4}$** Tesla
- Centripetal acceleration: $a_c = \frac{v^2}{R}$ 1eV = $1.6 \times 10^{-19}$ J

- Use $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N.m^2$ , $1/4\pi\varepsilon_0 = 9 \times 10^9$ $N.m^2/C^2$,

  $\mu_0/4\pi = 10^{-7}$ T m/A

## ELECTRICITY

- Coulomb's Law: $\vec{F} = \frac{1}{4\pi\varepsilon_0}\frac{q_2\ q_1}{r^2}\ \vec{u}$
- Electric field, along the z-axis, due to a charge Q distributed uniformly along a thin ring of radius R.: $\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{Q\ z}{\left(z^2 + R^2\right)^{3/2}}\ \hat{k}$
- For an infinite uniformly charged sheet: $E = \sigma / 2\varepsilon_o$
- Gauss' Law $\Phi = \int_S E \bullet d\vec{s} = q/\varepsilon_o$, where q is the net charge inside the gaussian surface S
- Definition of Electric Potential $V(r) = \frac{W_{ext}(\infty \xrightarrow{q_0} r)}{q_0}$
- Electric potential due to a point charge q: $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$
- Relationship between E and V: $E_x = -\,dV/dx$
- **About capacitance**
  $Q = C\ V$  $C = A\varepsilon_o / d$  $U = CV^2 / 2 = Q^2 / 2\ C$
- **RC circuit:** Time constant $\tau = RC$

## MAGNETISM

- **F** = q **v x B** F = force, q= charge, v = velocity, B = magnetic field
- Magnetic field produced by a charge q that moves with velocity $\vec{\mathbf{v}}$

  $$\vec{\mathbf{B}} = \frac{\mu_0}{4\pi}\frac{q}{r^3}\vec{\mathbf{v}} \times \vec{\mathbf{r}}$$

- $\Phi = L\ i$  $\Phi$ = Magnetic flux, L = inductance, i = current
- Hall effect $BI = nqtV_{Hall}$
- Inductive reactance $X_L = \omega L$

- $B = \frac{\mu_0 I}{4} \frac{1}{R}$ Magnetic field at the center of a semi-circle of radius "R"

- $B = \frac{\mu_0 I\phi}{4\pi R}$ Magnetic field at the center of an arc of angle f (in radians) and radius "R".

- $B = \frac{\mu_0 I}{2\pi r}$ Magnetic field produced by a infinitely long wire at a distance "r" from it.

- $\frac{F}{L} = \mu_0 \frac{I_a I_b}{2\pi d}$ Force per unit length between two parallel long wires, carrying currents $I_a$ and $I_b$ respectively, separated by a distance "d"

- Faraday's Law $\mathcal{E} = -\frac{\partial \Phi}{\partial t}$ ,
  where Φ = Magnetic flux and ε= electromotive force

- Definition of the magnetic dipole moment of a loop of area A, carrying a current I:
  **μ** = I A **n**
  where A = area, I current, **n** = unit vector perpendicular to the loop

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