Dawson College

Physics 203-SN2-RE Electricity & Magnetism

(New Science Program)

Sample Final Exam

Part 1: Multiple Choice Questions (30 x 2 marks each = 60points)

Part 2: Long answer problems (4 x 10 marks each = 40 points)

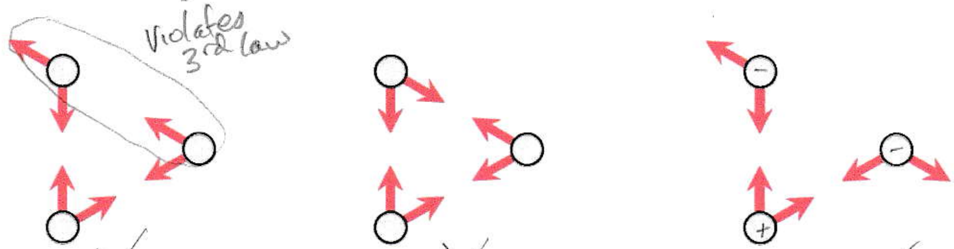
NOTE: It is suggested that you simulate an actual exam by setting aside 3 hours to do this exam without interruptions, using only the formula sheet and your calculator. Once you have finished then check your answers (see end of this file).

IMPORTANT: This sample final is only meant as an approximation of what a typical 203SN2 final could be like. The exact content of your exam will follow the course outline for the course and the distribution of grades may vary from year to year. Your teacher will inform you of the specifics regarding your particular exam.

Part 1: Multiple choice questions (2 points each – total points = 60)

1) Which of the following diagrams represent the forces that three charged objects might exert on each other?

violates 3rd law



~~(Fig.1)~~ ~~(Fig.2)~~ (Fig.3) ✓

would require existance of 3 diff kinds of charge

(a) Fig.1.

(b) Fig.2.

(c) Fig.3.

(d) Fig.1 and Fig.3, but not Fig.2.

(e) All three.

2) The force acting on an electron is 4.337×10^{-16} N along the $+y$-axis. What is the magnitude and direction of the electric field vector at the electron's position?:

(a) 6.95×10^{-35} N/C along the $-y$-axis.

(b) $4.76 \times 10^{+14}$ N/C along the $-y$-axis.

(c) $2.71 \times 10^{+3}$ N/C along the $-y$-axis.

(d) $2.71 \times 10^{+3}$ N/C along the $+y$-axis.

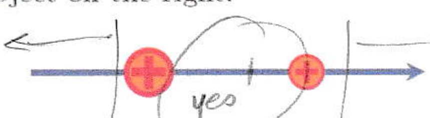
(e) Defined only for a positive charge.

$\vec{E} = \frac{\vec{F}}{q}$ ∴ since $q<0$ $\vec{F}$ and $\vec{E}$ are opposite

$|\vec{E}| = \frac{4.337\times10^{-16}}{1.6\times10^{-19}} = 2710$ N/C

3) Two positively charged objects are on the x-axis, as shown below. The object on the left has a larger charge than the object on the right.

both charges push/pull so no place for $F_{net}=0$



both charges push/pull so no possibility of $F_{net}=0$

On the x-axis there is a position where $\vec{E} = \vec{0}$ N/C. This position is

(a) ~~to the left of the larger charge.~~

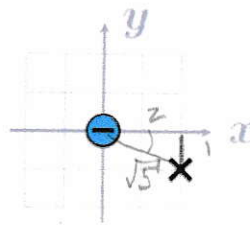
(b) between the two charges, but closer to the larger charge.

(c) between the two charges, exactly in the middle.

(d) between the two charges, but closer to the smaller charge. ✓

(e) ~~to the right of the smaller charge.~~

4) A -3 nC charge is at the origin. as shown below. (Each square is 10x10cm)



What are the components (E_x, E_y) of the electric field at the position "X", measured in N/C?

(a) ($\cancel{+}$241, $\cancel{+}$482).

(b) (-241, $+482$). X

(c) ($\cancel{+}$482, $+241$).

(d) (-482, $\cancel{+}$241).

(e) (-482, $+241$).

$$E_x = -K\frac{q}{r^2}\left(\frac{2}{\sqrt{5}}\right) = -K\frac{q}{5}\left(\frac{2}{\sqrt{5}}\right)$$

$$E_y = +K\frac{q}{r^2}\left(\frac{1}{\sqrt{5}}\right) = +K\frac{q}{5}\left(\frac{1}{\sqrt{5}}\right)$$

$|E_x| > |E_y|$

note: don't actually need to know the scale of the grid (only that it is the same for x and y-dir)

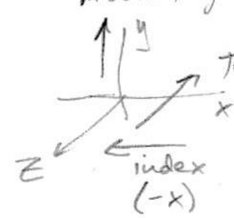
5) A positively charged particle is in a uniform magnetic field. As it moves along the $-x$-axis ($\vec{v} = -v\hat{\imath}$) the magnetic force it experiences points along the $-z$-axis ($\vec{F}_m = -F\hat{k}$). The magnetic field vector points along

$\vec{F} = q\vec{v} \times \vec{B}$

neg. z-axis

neg. x-axis

middle finger needs to be +y



(a) the $+x$-axis ($+\hat{\imath}$).

(b) the $+y$-axis ($+\hat{\jmath}$).

(c) the $+z$-axis ($+\hat{k}$).

(d) the $-y$-axis ($-\hat{\jmath}$).

(e) some other direction, not listed.

6) A proton + has velocity $\vec{v} = (-300 \text{ m/s})\hat{\imath} + (+400 \text{ m/s})\hat{\jmath}$. It is moving through a uniform magnetic field $\vec{B} = (0.5 \text{ T})\hat{\imath} + (+0.5 \text{ T})\hat{\jmath}$. The magnetic force acting on the proton is:

(a) $+8.01 \times 10^{-18}$ N $\hat{k}$.

(b) -8.01×10^{-18} N $\hat{k}$.

(c) $+5.61 \times 10^{-17}$ N $\hat{k}$.

(d) -5.61×10^{-17} N $\hat{k}$.

(e) zero.

$\vec{F} = q\vec{v} \times \vec{B}$

use component form of cross product (given on formula sheet).

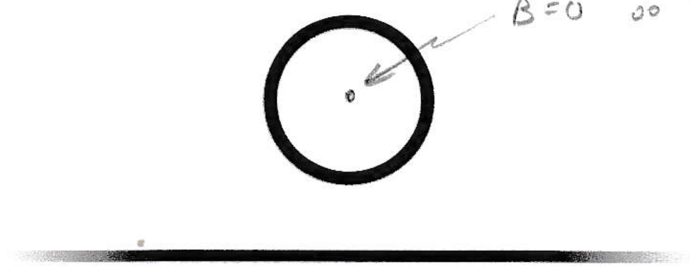
$$\vec{F} = \Big[\underbrace{0\hat{\imath} + 0\hat{\jmath}}_{\text{because } A_z = 0} + (A_x B_y - A_y B_x)\hat{k}\Big](1.6\times10^{-19})$$

$$= \big[(-300)(0.5) - (+400)(+0.5)\big]\hat{k}$$

$$= (-350)(1.6\times10^{-19}) = -5.6\times10^{-17} \text{ N } \hat{k}$$

7) A conducting loop and a long straight wire are shown.

$\vec{B}=0 \;\therefore\; \vec{B}_{TOT} = \underbrace{\vec{B}_{wire} + \vec{B}_{loop}}_{\text{must be opposite}}$



There is a current along the wire and a current around the loop. If the magnetic field is zero at the center of the loop then direction of current flow in the wire and in the loop must be:

(a) right; clockwise. $\Rightarrow$ outward ; inward. ✓

(b) right; counter-clockwise. $\Rightarrow$ outward ; outward ×

(c) left; clockwise. $\Rightarrow$ inward ; inward. ×

(d) left; counter-clockwise. inward ; outward ✓

(e) two of the the above are correct.

8) If a proton is in a uniform magnetic field 37.3 mT (perpendicular to the proton's velocity), how many orbits will the proton have completed after 20.0 μs?

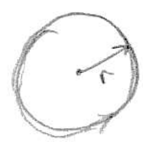
(a) 12

(b) 75

(c) 22 thousand

(d) 137 thousand

(e) 3.6 million



$F = qvB = \frac{mv^2}{r}$

$v = \frac{qBr}{m} \Rightarrow \omega = \frac{qB}{m} = 2\pi f$

$\therefore f = \frac{qB}{2\pi m} = \frac{(1.6\times10^{-19})(37.3\times10^{-3})}{2\pi(1.67\times10^{-27})} = \underbrace{5.7\times10^{5}}_{\text{rot. per second}}$

9) In a uniform electric field $\vec{E} = (+32\ \mathrm{N/C})\hat{\imath} + (-45\ \mathrm{N/C})\hat{\jmath}$ what is the difference in electric potential $V_B - V_A$ if A is at $x = -0.050$ m, $y = -0.200$ m and B is at $x = -0.050$ m, $y = +0.200$ m?

$\Delta V = -\int E\cdot ds = (-E_x\cancel{\Delta x})^0 + (-E_y \Delta y)$

$= -(32(0)) + (-(-45)(+.2-(-0.2)))$

$= +18V$

(a) -22 V

(b) -18 V

(c) 0 V

(d) $+18$ V

(e) $+22$ V

10) An electron between the oppositely charged plates of a capacitor is launched towards the negative plate. As it moves closer to the negative plate (ignore gravity)

(a) $\Delta V > 0$ V and $\Delta U_e > 0$ J.
(b) $\Delta V > 0$ V and $\Delta U_e < 0$ J.
(c) $\Delta V < 0$ V and $\Delta U_e > 0$ J.
(d) $\Delta V < 0$ V and $\Delta U_e < 0$ J.

+ + + + + V_A
V_0 $q<0$ $\vec{E}$
− − − − V_B

$V_A > V_B$

$\Delta V < 0$ so $\Delta U = q\Delta V > 0$

11) What is the speed of an electron after it has crossed a potential difference of $\Delta V = +9$ V if its initial speed was $4.2 \times 10^{+6}$ m/s?

(a) $1.8 \times 10^{+6}$ m/s.
(b) $3.8 \times 10^{+6}$ m/s.
(c) $4.2 \times 10^{+6}$ m/s.
(d) $4.6 \times 10^{+6}$ m/s.

$\Delta U + \Delta K = 0$

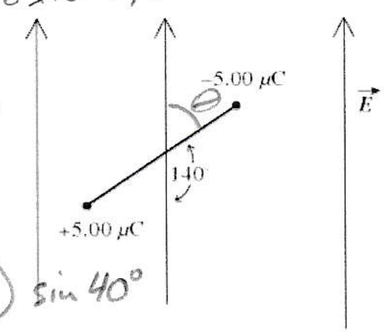
$q\Delta V + \Delta K = 0$

$K_f = \frac{1}{2}mv_f^2 = K_i - q\Delta V$

$v^2 = \frac{2}{m}\left(\frac{1}{2}m(4.2\times10^6)^2 - (-1.6\times10^{-19})(+9)\right)$

$v = 4.6\times10^6$ m/s

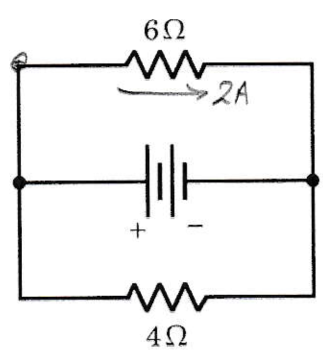
12) An electric dipole consists of charges ± 5.00 μC separated by 1.20 mm. It is placed in a vertical electric field of magnitude 525 N/C oriented as shown in the figure. The magnitude of the net torque this field exerts on the dipole is closest to



(a) 2.02×10^{-6} N·m
(b) 3.15×10^{-6} N·m
(c) 2.41×10^{-6} N·m
(d) 1.01×10^{-6} N·m
(e) 1.21×10^{-6} N·m

$\tau = pE\sin\theta$
$= qsE\sin(40°)$
$= (5\times10^{-6})(0.0012)(525)\sin 40°$
$= 2.02\times10^{-6}$

13) If the current through the 6Ω resistor is 2A, the power dissipated by the 4Ω resistor is

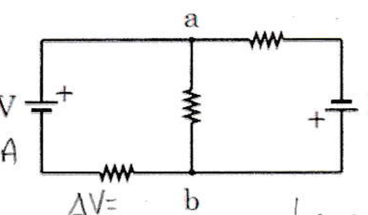


(a) 40W
(b) 36W
(c) 24W
(d) 16W
(e) 9.6W

$\Delta V_{6\Omega} = (6\Omega)(2A) = 12V = \Delta V_{4\Omega}$

$P = \frac{\Delta V^2}{R} = \frac{(12V)^2}{4} = 36W$

14) In the circuit shown below each resistor is 100 Ω. The current flowing through the 25 V battery is 200 mA, and the current flowing through the 10 V battery is 150 mA.



$\mathcal{E}_1 = 25$ V, (dir?) $|i_1| = 200$ mA

10 V $= \mathcal{E}_2$, $i_2 = 150$ mA (dir?)

$\Delta V =$

$|\Delta V_{ab}| = 100 i_3 = \pm(25-20) = \pm(+5)$
$= \pm(10-15) = \pm(-5)$

$\therefore |\Delta V_3| = 5V \quad \therefore i_3 = \frac{5}{100} = 50mA$

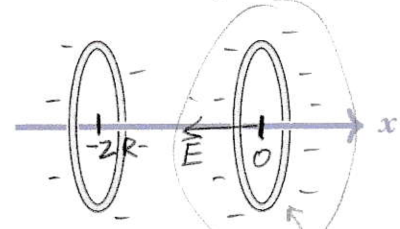
from outer loop: current must be CW for $\Delta V = 0$ $\therefore V_a > V_b$

$\therefore i_3 \downarrow$

The current through the resistor in the center is:

(a) 15~~0~~ mA from a towards b.
(b) 15~~0~~ mA from b towards a.
(c) 50 mA from a towards b.
(d) 50 mA from b ~~towards~~ a.
(e) 0 ~~m~~A.

15) Two uniformly charged rings are placed on the x-axis, as shown. Each ring has radius R and total charge $Q < 0$C. One ring is centered at $x = -2R$, and the other is centered at the origin. At the origin, what is the x-component of the net electric field?



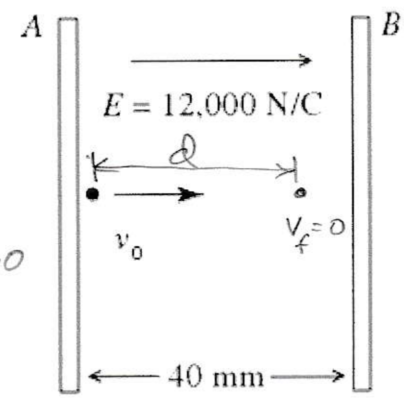
Causes no $\vec{E}$ field at $x=0$

Correct answer is missing (mistake)

(a) ~~$\frac{4}{\sqrt{5}} \frac{k_e|Q|}{R^2}$~~
(b) ~~$\frac{2}{\sqrt{5}} \frac{k_e|Q|}{R^2}$~~
(c) ~~0~~
(d) $-\frac{2}{\sqrt{5}} \frac{k_e|Q|}{R^2}$ Should be $-\frac{2}{\sqrt[3]{5}} \frac{K|Q|}{R^2}$
(e) $-\frac{4}{\sqrt{5}} \frac{k_e|Q|}{R^2}$

$E_{\text{ring on axis}} = K \frac{z|Q|}{(z^2+R^2)^{3/2}}$
$= K \frac{(-2R)(Q)}{((2R)^2+R^2)^{3/2}} = K \frac{-2QR}{(5R^2)^{3/2}}$
$\boxed{= -\frac{2}{(5)^{3/2}} \frac{K|Q|}{R^2}}$

16) A pair of charged conducting plates produces a uniform field of 12,000 N/C, directed to the right, between the plates. The separation of the plates is 40 mm. An electron is projected from plate A, directly toward plate B, with an initial velocity of $v_0 = 1.0 \times 10^{+7}$ m/s, as shown in the figure. The distance of closest approach of the electron to plate B is nearest to



(a) 16 mm.
(b) 18 mm.
(c) 20 mm.
(d) 22 mm.
(e) 24 mm

when $V_f = 0$

use energy: $U_i + K_i = U_f + \cancel{K_f}^{0}$

$\Delta U = q\Delta V = qEd$

$\therefore qEd = \frac{1}{2} m v_i^2$

$d = \frac{m v_i^2}{2qE} = \frac{(9.11\times10^{-31})(1.0\times10^{7})^2}{2(1.6\times10^{-19})(12000)} = 0.0237\,m$
$= 24\,mm$

17) The charge on the square plates of a parallel-plate capacitor is Q. The potential across the plates is maintained with constant voltage by a battery as they are pulled apart to twice their original separation, which is small compared to the dimensions of the plates. The amount of charge on the plates is now equal to

(a) $4Q$.

(b) $2Q$.

(c) Q.

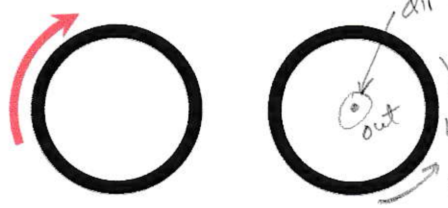
(d) $Q/2$.

(e) $Q/4$.

$$C_1 = \frac{Q_1}{\Delta V_1} \qquad C_2 = \frac{Q_2}{\Delta V_2} = \frac{Q_2}{\Delta V_1}$$

$$\therefore \frac{C_1}{C_2} = \frac{\varepsilon_0 A_1/d_1}{\varepsilon_0 A_2/d_2} = \frac{d_2}{d_1} = 2 = \frac{Q_1/\Delta V_1}{Q_2/\Delta V_2} \quad \therefore Q_2 = \frac{1}{2} Q_1$$

18) Two conducting loops are in the plane of the page, as shown.



dir of $\vec{B}$ due to left loop.

to counter flux increasing out of pg need CW current

to counter flux decreasing out of pg. need CCW current

The current around the loop on the left is initially zero, increases up to a large clockwise current, then decreases back down to zero. The current induced in the loop on the right is:

(a) initially clockwise, then counter-clockwise.

(b) initially clockwise, then clockwise again.

(c) initially counter-clockwise, then clockwise.

(d) initially counter-clockwise, then counter-clockwise again.

19) Current flowing through a 80 mH inductor increases from 400 mA to 1.2 A over 128 μs. If we cross the inductor in the direction of current flow, the difference in electric potential is

(a) +750 V

(b) +500 V

(c) −78 V

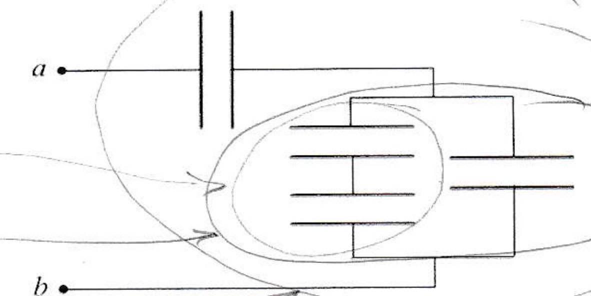
(d) −500 V

(e) −750 V

$$\Delta V = -L\frac{di}{dt} \qquad \frac{di}{dt} \approx \frac{\Delta I}{\Delta t} = \frac{1.2 - 0.4}{128\,\mu s} = 6250\ \text{A/s}$$

$$\Delta V = -(80\times10^{-3})(6250) = -500\,V$$

20) The capacitors in the network shown in the figure each have a capacitance of 5.0 μF. What is the equivalent capacitance, C_{ab}, of this capacitor network?



$C_{eq} = \left(\frac{1}{C} + \frac{1}{C}\right)^{-1} = \frac{C}{2}$

$C_{eq} = \frac{C}{2} + C = \frac{3C}{2}$

$C_{eq} = \left(\frac{1}{C} + \frac{2}{3C}\right)^{-1} = \frac{3C}{5}$

$= \frac{3}{5}(5.0\mu F) = 3.0\mu F$

(a) 20. μF

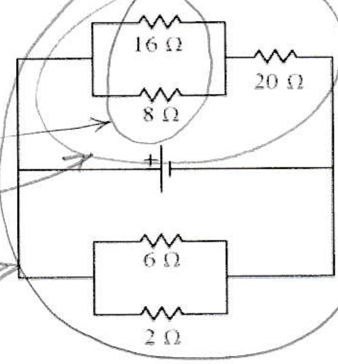
(b) 3.0 μF

(c) 10. μF

(d) 5.0 μF

(e) 1.0 μF

21) For the circuit shown in the figure, what is the equivalent resistance of the circuit?



$\left(\frac{1}{16} + \frac{1}{8}\right)^{-1} = \frac{16}{3}\Omega$

$\frac{16}{3} + 20 = \frac{76}{3}\Omega$

$\left(\frac{3}{76} + \frac{1}{6} + \frac{1}{2}\right)^{-1} = 1.416\Omega$

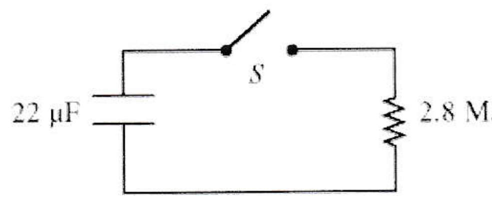
(a) 52 Ω

(b) 19 Ω

(c) 1.4 Ω

(d) 33 Ω

22) For the circuit shown in the figure, the switch S is initially open and the capacitor voltage is 80 V. The switch is then closed at time $t = 0$. How long after closing the switch will the current in the resistor be 7.0 μA?



$I_o = \frac{\Delta V_o}{R} = \frac{80V}{2.80\times10^6} = 28.57\mu A$

$I(t) = I_o e^{-t/\tau}$ where $\tau = RC = (22)(2.8) = 61.6$

$7.0\mu A = 28.57\mu A\left(e^{-t/61.6}\right) \Rightarrow t = 86.6s$

(a) 95 s

(b) 78 s

(c) 69 s

(d) 42 s

(e) 87 s

23) A proton is initially moving with a velocity $\vec{v_i} = +(700km/s)\hat{\imath}$ through an electric field $\vec{E} = -(0.370N/C)\hat{\imath}$. How much time does it take for the proton to have the same speed but in the opposite direction? (Gravity is completely negligible)

$V_{fy} = V_{iy} + a_y \Delta t$ (const accel.)

$a_y = \frac{qE}{m} = \frac{2V_i}{\Delta t}$

$\therefore \Delta t = \frac{2mV_i}{qE} = \frac{2(1.67\times10^{-27})(700,000)}{(1.6\times10^{-19})(0.370)} = 39.49ms$

(a) 199 ms

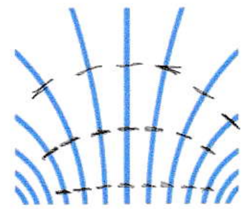
(b) 39.5 ms

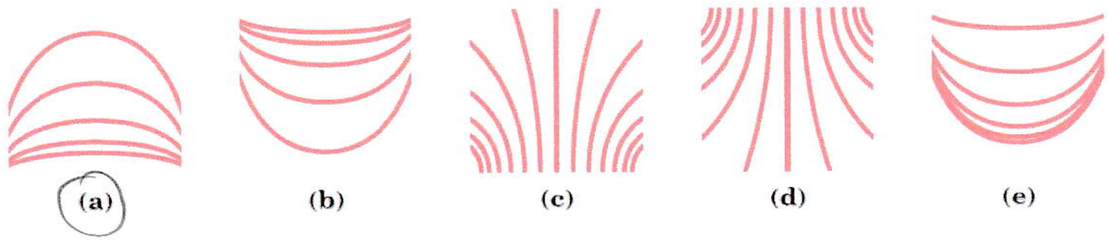
(c) 19.8 ms

(d) 141 ms

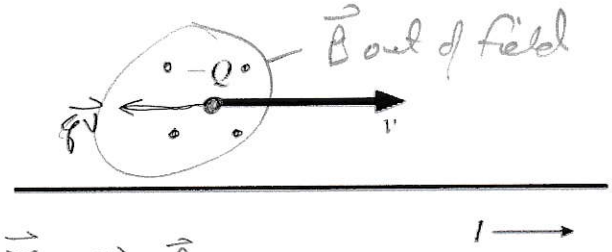
(e) 72.3 ms

24) Given the equipotential surfaces shown on the right, which of the following choices best depicts the corresponding electric field lines?





25) A negatively charged particle is moving to the right, directly above a wire having a current flowing to the right, as shown in the figure. In which direction is the magnetic force exerted on the particle?



$\vec{F}_B = q\vec{v} \times \vec{B}$

(a) into the page

(b) out of the page

(c) downward

(d) upward

(e). The magnetic force is zero since the velocity is parallel to the current.

26) Which of the following statements about the net force $\vec{F}_{\text{net}}$ and net torque $\vec{\tau}_{\text{net}}$ acting on the wire rectangle is true?:

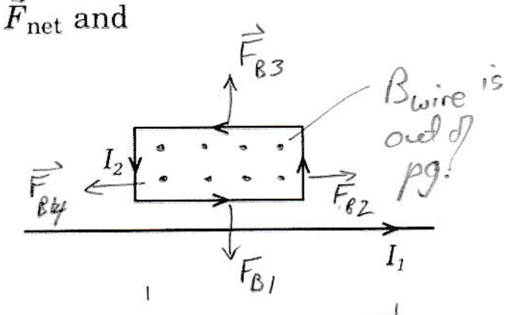
(a) $\vec{F}_{\text{net}}$ is upwards, and $\vec{\tau}_{\text{net}}$ is not zero.

(b) $\vec{F}_{\text{net}}$ is zero, and $\vec{\tau}_{\text{net}}$ is zero.

(c) $\vec{F}_{\text{net}}$ is downwards, and $\vec{\tau}_{\text{net}}$ is not zero.

(d) $\vec{F}_{\text{net}}$ is zero, and $\vec{\tau}_{\text{net}}$ is not zero.

(e) $\vec{F}_{\text{net}}$ is downwards, and $\vec{\tau}_{\text{net}}$ is zero.

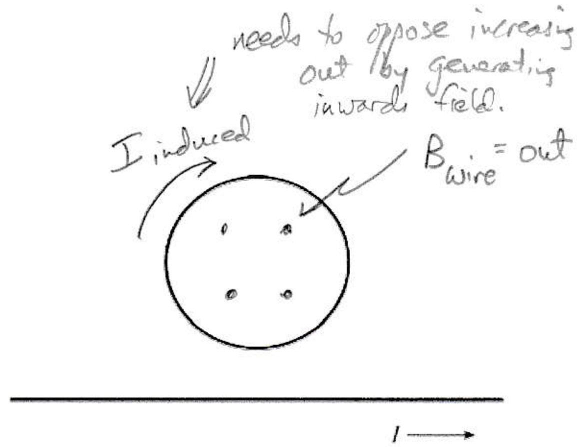


Note that $F_{B2} = F_{B4}$

and $F_{B1} > F_{B2} \Rightarrow \therefore F_{B,net} \downarrow$

and torque is zero.

27) A circular metal ring is situated above a long straight wire, as shown in the figure. The straight wire has a current flowing to the right, and the current is increasing in time at a constant rate. Which statement is true?



(a) There is an induced current in the metal ring, flowing in a clockwise direction.

(b) There is an induced current in the metal ring, flowing in a counter-clockwise direction.

(c) There is no induced current in the metal ring because the current in the wire is changing at a constant rate.

28) A 45-mH ideal inductor is connected in series with a 60-Ω resistor through an ideal 15-V DC power supply and an open switch. If the switch is closed at time t = 0 s, what is the current 7.0 ms later?

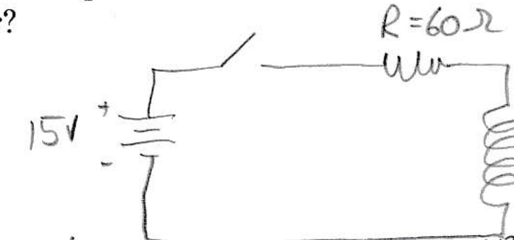
(a) 650 mA

(b) 250 mA

(c) 550 mA

(d) 280 mA

(e) 850 mA



$I_{max}(t \to \infty) = \frac{15V}{60\Omega} = 0.250\ A$

and $\tau = \frac{L}{R} = 7.5\times10^{-4}$

$I = I_{max}(1-e^{-t/\tau}) = (0.25)(1-e^{-7\times10^{-3}/7.5\times10^{-4}}) = 0.250A$

29) An insulated wire of diameter 1.0 mm and negligible resistance is wrapped tightly around a cylindrical core of radius 5.0 cm and length 30 cm to build a solenoid. What is the energy stored in this solenoid when a current I = 0.20 A flows through it?

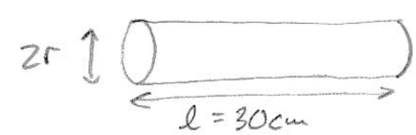
(a) 0.12 mJ

(b) 0.96 mJ

(c) 0.48 mJ

(d) 0.24 mJ

(e) 0.059 mJ



$= \pi(0.05)^2 = .$

$N = \frac{30cm}{0.1cm/coil} = 300$ coils

$U_L = \frac{1}{2}Li^2 = \frac{1}{2}\left(\mu_0 \frac{N^2}{l}A\right)i^2 = \frac{(4\pi\times10^{-7})(300)^2\pi(0.05)^2)(.20)^2}{2(0.30)} = 59\ \mu J$

30) An electron is orbiting a proton. If it is traveling in a circular path centered on the stationary proton with a speed 1.09x106m/s, what is the radius of its orbit?

(a) 20.7 μm

(b) 14.6 μm

(c) 0.426 nm

(d) 0.213 nm

(e) 0.107 nm

$v = 1.09\times10^6 m/s$

$\frac{mv^2}{r} = qE = K\frac{q_e^2}{r^2}$

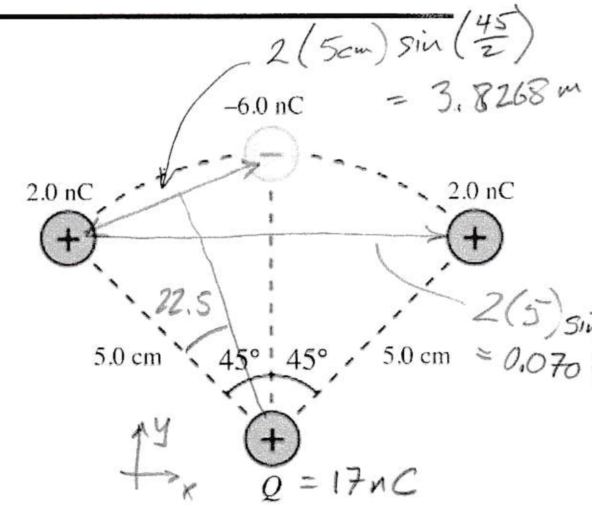
$\therefore r = \frac{Kq_e^2}{m_e v^2} = \frac{(8.99\times10^9)(1.6\times10^{-19})^2}{(9.11\times10^{-31})(1.09\times10^6)^2}$

$= 2.13\times10^{-10} m$

Part 2: Long answer questions (10 points each – total points = 40)

new

1) Four charged objects are arranged as shown. If the bottom-most object has charge $Q = +17\text{nC}$, and all objects have the same mass $m = 25\times10^{-6}\text{kg}$, determine the following:
   (a) What is the magnitude and direction of the net force on the bottom-most charge (Q)? (5 points)
   (b) If one of the +2.0nC charges was free to move, calculate its speed when it was a long way from the other charges. Assume none of the other charges move. (5 points)



a) $F_{net,Q,y} = K\left[-\left(\frac{2(17)}{.05^2}\cos 45^\circ\right)2 + \frac{6(17)}{.05^2}\right](10^{-9})^2 = +0.1941\times10^{-3}\,\text{N}\,\hat{j}$

$F_{net,Q,x} = 0$ (symmetry)

$\therefore$ $\boxed{F_{net,Q} = 194\,\mu\text{N in +y dir}}$

b) Use energy $\Delta U + \Delta K = 0$ and $K_i = 0$

$\therefore$ $K_f = -\Delta U$

↳ $\Delta U = -\Delta U$ to bring 2.0nC charge in as the last charge.

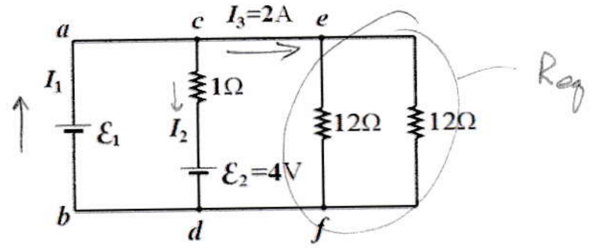
$\Delta U = K\left[\frac{2(17)}{0.05} + \frac{2(-6)}{0.03827} + \frac{(2)(2)}{.07071}\right](\times10^{-9})^2 = 3.807\,\mu\text{J}$

Convert nC → C

$\therefore$ $V = \sqrt{\frac{2(3.807\times10^{-6})}{25\times10^{-6}}} = 0.5519\,\text{m/s} = \boxed{55.2\,\text{cm/s}}$

2) Below is a circuit with four branches. The currents I_1 and I_2, and the emf $\mathcal{E}_1$ are unknown. The current flowing from c to e is 2 A.

Q3



(a) (2pt) What is the current flowing through each of the 12 Ω resistors?

(b) (2pt) What is the value of the emf $\mathcal{E}_1$?

(c) (4pt) What are the currents I_1 and I_2, and in what directions do they flow?

(d) (2pt) Is the emf $\mathcal{E}_2$ providing energy or is it absorbing energy? What is the power it is providing or absorbing?

a) $R_{eq} = \frac{1}{2}(12\Omega) = 6\Omega$ $\therefore$ $\Delta V_{ef} = 12\text{ V}$ (all of the 2A flows through R_{eq})

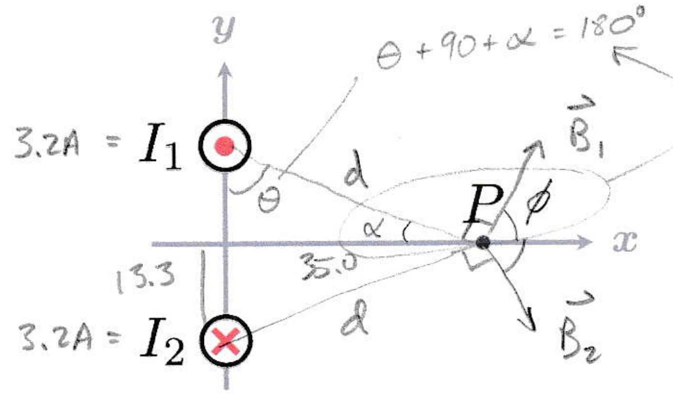
$\therefore$ $\boxed{I_{12} = 1\text{ A each}}$

b) $\Delta V_{ef} = \Delta V_{cd} = \Delta V_{ab} = \boxed{12\text{ V} = \mathcal{E}_1}$

c) $\Delta V_{cd} = +12V = -I_2(1\Omega) - 4V$ $\therefore$ $\boxed{I_2 = 8A \text{ dir} \downarrow}$

d) $\mathcal{E}_2$ is $\boxed{\text{absorbing}}$ energy @ $P = (8A)(4V) = \boxed{32W}$

3) Two long, straight, parallel current-carrying wires are shown below. The wires are parallel to the z-axis (the $+z$-axis points out of the page). The current in the wire above the origin is flowing in the $+z$-direction ($I_1 = 3.2\,\text{A}$, out of the page), while the current in the wire below the origin is flowing in the $-z$-direction ($I_2 = 3.2\,\text{A}$, into the page). The wire above the origin passes through $y = +13.3$ cm, the wire below the origin passes through $y = -13.3$ cm, and the point P is at $x = +35.0$ cm.



$\phi + 90 + \alpha = 180$
so $\phi = \theta$ $= \tan^{-1}\left(\frac{35}{13.3}\right) = 69.193°$

$d = \sqrt{13.2^2 + 35^2} = 37.4\,\text{cm}$

(a) (5pt) Find all three components of the magnetic field vector at the point P on the x-axis.

(b) (2pt) If an electron were traveling in the $+z$-direction at 5200 m/s what would be the magnitude and direction of the magnetic force acting on it as it passed through P?

(c) (3pt) What electric field (state all three components) would we need to apply to the electron in part (b) so that the net force acting on it were zero?

a) Since $|\vec{B}_1| = |\vec{B}_2|$ at P $\Sigma B_y = 0$ (and $B_z = 0$)

$\therefore$ $B_x = \cancel{2}\left(\frac{\mu_0 I}{\cancel{2}\pi d}\right)\cos\phi = \frac{(4\cancel{\pi}\times10^{-7})(3.2)\cos(69.193°)}{\cancel{\pi}(0.374)} = 1.2157\,\mu\text{T}$

$\therefore$ $\boxed{\vec{B}_P = (1.22\,\mu\text{T})\hat{\imath}}$ $(B_{P,y} = 0,\ B_{P,z} = 0)$

b) $|\vec{F}_B| = |q\vec{v}\times\vec{B}| = qvB = (1.6\times10^{-19})(5200)(1.2157\times10^{-6}) = \boxed{1.01\times10^{-21}\,\text{N}}$

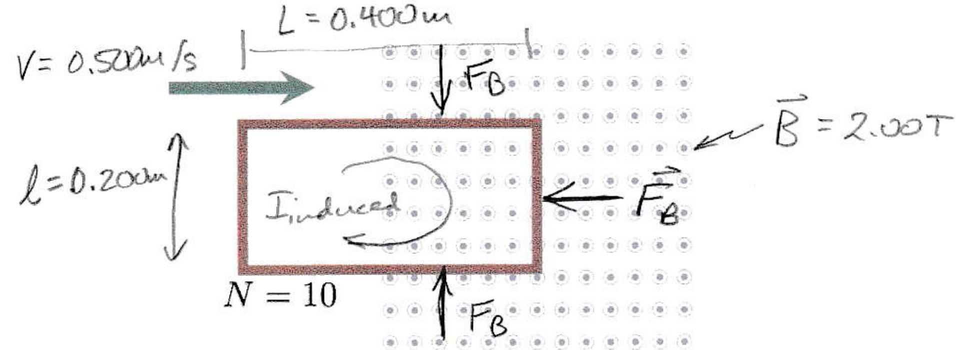
RHR: dir of $\vec{F}_{B,e}$ is $\boxed{-y\text{-dir}}$

c) $\vec{F}_E = q\vec{E}$ $\therefore$ $|\vec{E}| = \frac{F}{q} = \boxed{6.32\,\text{mC/m}}$ with $\vec{E}$ in $\boxed{-y\text{-dir}}$

$(E_x = E_z = 0)$

$\vec{F}_e \propto -\vec{E}_e$ because $q < 0$

4) There is a rectangular conducting coil, measuring 40.0 cm by 20.0 cm, with resistance 50.0 ohm has 10 turns, as shown below. The coil moves at a constant speed of 50.0 cm/s from a region where the magnetic field is zero and into a region where the field is 2.00 T pointed along the $+z$-axis.



While the coil is in the process of entering the magnetic field (and neither full in nor full out of the field):

(a) (4pt) Determine the magnitude and direction (as viewed from above) of the induced current in the coil.

(b) (2pt) Determine the magnitude and direction of the magnetic force that acts on the coil.

(c) (4pt) From the moment that the coil begins to enter the field until the moment that the coil has fully entered the field what will be the total amount of energy dissipated by the coil's resistance?

a) Mag. flux out of page ↑ so induced current must
The change in flux and produce field into page } $\boxed{I = 40.0\,mA \text{ in CW dir}}$
and $I = N\left|\frac{d\Phi_m}{dt}\right| = 10\left(\frac{B\ell V}{R}\right) = 40.0\,mA$

b) $\vec{F}_B = \vec{I}\vec{\ell} \times \vec{B}$
$\uparrow$ induced ; left-most end (upper and lower segments cancel)

$= (0.040)\underbrace{[10(0.20\,m)]}_{\text{total length of wire at right end}}(2.0) = \boxed{0.160\,N}$ and using RHR the net force on loop is to $\boxed{\text{left}}$

c) $P = I^2R$

$E_{diss} = P\Delta t = I^2R\Delta t$ where $\Delta t = \frac{L}{V} = \frac{0.40\,m}{0.50\,m/s} = 0.80\,s$

$= (0.040\,A)^2(50\,\Omega)(0.80) = \boxed{0.064\,J}$

or $P = \vec{F}\cdot\vec{v} = (0.160\,N)(0.50\,m/s)\cos 180 = \underbrace{-0.064\,J}_{\text{the pushing force has to put in the same amount of Energy as Resistance dissipates.}}$ ✓

END.