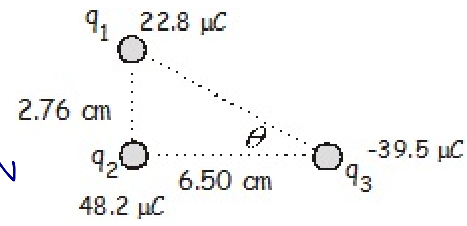
Circuits/Electromagnetics

WORKSHEET #10

Name: ______________________

1. Three charges are arranged as shown. What is the magnitude and direction of the force acting on q_3 the -39.5 μC charge, by the other two charges?



$d_{1\ to\ 3} = (2.76^2 + 6.50^2)^{\frac{1}{2}} = 7.0617$ cm
$\theta = \tan^{-1}(2.76/6.50) = 23.0°$
$F_2 = kq_2q_3/r^2$
$= 9.0\times10^9\ Nm^2/C^2 \cdot 48.2\ \mu C \cdot -39.5\ \mu C/(0.0650\ m)^2 = -4056$ N
$F_1 = 9.0\times10^9\ Nm^2/C^2 \cdot 22.8\ \mu C \cdot -39.5\mu C/(0.0706\ m)^2 = -1626$ N
$F_x = -1626\ N \cdot \cos(23.0°) + -4056\ N = -5553$ N
$F_y = -1626\ N \cdot \sin(23.0°) = -635$ N
$F_{TOTAL} = (635^2 + 5553^2)^{\frac{1}{2}}$ at $180° - \tan(635/5553)$
$= \boxed{5589\ N\ @\ 173.5°}$

2. The potential difference between two points is 15.0 V. What amount of work is needed to move a 25.0 mC charge within the field?

$W = \Delta U = qV = 25.0\ mC \cdot 15.0\ V = \boxed{0.375\ J\ or\ 375\ mJ}$

3. Two charged plates are 5.20 mm apart. The electric field between them is 485 N/C. (a) What is potential difference between plates and (b) what work is done moving an electron from one plate to another?

a. $V = E \cdot d = 485\ V/m \cdot 0.00520\ m = 2.522\ V = \boxed{2.52\ V}$
b. $W = \Delta U = qV = 1.6\times10^{-19}\ C \cdot 2.52\ V = \boxed{4.0352\times10^{-19}\ J\ or\ 2.52\ eV}$

4. A proton is released from rest in a uniform electric field, ***E*** = 7.25 x 10^5 V/m. It's displacement is 0.420 m in the direction of the field. (a) What is the change in electrical potential? (b) What is the change in electrical potential energy? (c) What is its velocity after it traveled the 0.420 m?

a. $V = E \cdot d = 7.25\times10^5\ V/m \cdot 0.420\ m = 3.045\times10^5\ V = \boxed{3.05\times10^5\ V}$
b. $U = qV = 1.6\times10^{-19}\ C \cdot 3.045\times10^5\ V = 4.872\times10^{-14}\ J = \boxed{4.87\times10^{-14}\ J}$
c. $v = (2U/m)^{1/2} = (2 \cdot 4.872\times10^{-14}\ J/1.67\times10^{-27}\ kg)^{\frac{1}{2}} = 7638540.789\ m/s = \boxed{7.64\times10^6\ m/s}$

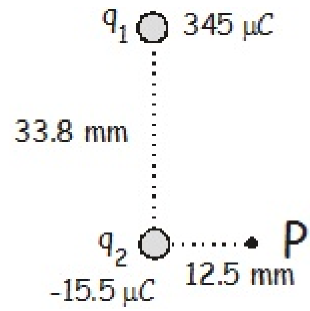
5. 7.45×10^{18} electrons take 0.52 seconds to flow through a 75 Ω resistor in a circuit. (a) What is the current? (b) What is the voltage drop across the resistor? (c) What is the power consumed by the resistor?

a. $I = Q/t = (7.45\times10^{18}\ e^- \cdot 1.6\times10^{-19}\ C/e^-) / 0.52\ s = 2.29230769\ A =$ $\boxed{2.29\ A}$

b. $V = RI = 75\ \Omega \cdot 2.29230769\ A = 171.9230769\ V =$ $\boxed{172\ V}$

c. $P = VI = 394.1005917\ W =$ $\boxed{394\ W}$

6. Two charges are arranged as shown. (a) find the electric potential at P. (b) how much work would it take to bring in a charge of 48.0 μC from infinity to point P?



a. $d_1 = (33.8^2 + 12.5^2)^{\frac{1}{2}} = 36.03734174$ mm

$V = k(q_1/r_1 + q_2/r_2)$

$= 9.0\times10^9\ N{\cdot}m^2/C^2\ (345\ \mu C/0.0360\ m + -15.5\ \mu C/0.0125\ m)$

$=$ $\boxed{75\ 090\ 000\ V \text{ or } 75.09\ MV}$

b. $W = \Delta U = U_P - U_\infty = qV_P - qV_\infty = 48.0\ \mu C \cdot 75\ 090\ 000\ V$

$= 3604.32\ J =$ $\boxed{3600\ J \text{ or } 3.6\ kJ}$

7. Two wires run parallel to each other. They are both 12.0 cm in length. They are separated by 3.65 cm. The wire on the left is carrying a current of 2.50 A and the wire on the right is carrying a current of 1.85 A. The currents have opposite directions. What is the force that is acting between them?

$F_1 = I_1\ell_1B_2 = I_1\ell_1(\mu_0 I_2/2\pi r) = 2.50\ A \cdot 0.120\ m\ (4\pi\times10^{-7}\ T{\cdot}m/A \cdot 1.85\ A\ /\ 2\pi \cdot 0.0365\ m)$

$= 3.04109589\times10^{-8}\ N =$ $\boxed{3.04\times10^{-8} \text{ or } 30.4\ nN}$

The wires will be pushing apart or repelling each other with the above force.

8. A hot plate is in a parallel circuit with a voltage drop of 120 V (household AC electricity). The current in the circuit is 5.8 A (a) What is the resistance of the hot plate? (b) How much power did it develop? (c) If it operated for 18 minutes, how much heat did it develop? (d) If a kWh costs 5.6 cents, how much did it cost to run the thing for the 18 minutes?

a. $R = V/I = 120\ V/5.8\ A = 20.68965517\ \Omega =$ $\boxed{20.7\ \Omega}$

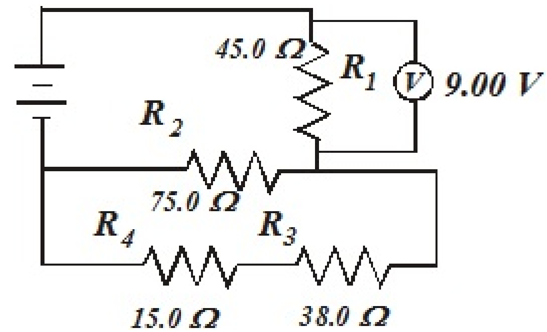
b. $P = VI = 120\ V \cdot 5.8\ A =$ $\boxed{696\ W}$

c. $E = P \cdot t = 696\ W \cdot 1080\ s = 751\ 680\ J =$ $\boxed{752\ 000\ J \text{ or } 752\ kJ}$

d. $E = 0.696\ kW \cdot 0.3\ h = 0.2088\ kWh$

cost = 5.6 cents/kWh · 0.2088 kWh = 1.16928 cents = $\boxed{1.17 \text{ cents}}$

9. Examine this useless circuit. What is: (a) the total resistance, (b) the total current, (c) the terminal voltage of the battery? The voltage drop across $\boldsymbol{R_1}$ is 9.00 V.



a. $R_T = R_1 + (R_2^{-1} + (R_3 + R_4)^{-1})^{-1}$
$= 45.0\ \Omega + (75.0^{-1} + 53.0^{-1})^{-1}\ \Omega$
$= 76.0546875\ \Omega = \boxed{76.1\ \Omega}$

b. $I_T = I_1 = V_1/R_1 = 9.00\text{ V}/45.0\ \Omega = \boxed{0.200\text{ A}}$

c. $V_{BAT} = R_T \cdot I_T = 76.0546875\ \Omega \cdot 0.200\text{ A}$
$= 15.2109375\text{ V} = \boxed{15.2\text{ V}}$

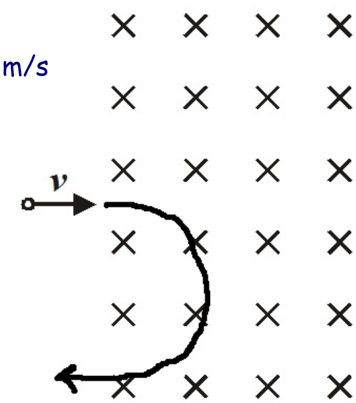
10. What is the magnetic field 2.50 cm from a straight wire carrying a current of 0.858 A? If the current is from left to right, what is the direction of the magnetic field?

$B = \mu_0 I/2\pi r = (4\pi\times10^{-7}\text{ T}\cdot\text{m/A} \cdot 0.858\text{ A}) / (2\pi \cdot 0.0250\text{ m})$
$= 6.864\times10^{-6}\text{ T} = \boxed{6.86\times10^{-6}\text{ T or } 6.86\ \mu\text{T}}$

directionality:

By right-hand rule, the magnetic field would be coming out of the paper above the wire and going into the paper below the line

11. An electron enters a magnetic field (2.35×10^3 T) as shown. The electron's kinetic energy is 2.56×10^{-15} J. (a) draw in a likely path for the electron to follow when it enters the magnetic field. (b) What is the magnetic force acting on the electron in the field? (c) What is the radius of the electron's path in the magnetic field?



a. see picture

b. $v = (2KE/m)^{\frac{1}{2}} = (2 \cdot 2.56\times10^{-15}\text{ J}/9.11\times10^{-31}\text{ kg})^{\frac{1}{2}} = 74967977.06\text{ m/s}$
$F_B = qvB\sin\theta = 1.6\times10^{-19}\text{ C} \cdot 74967977.06\text{ m/s} \cdot 2.35\times10^3\text{ T}$
$= 2.818796\times10^{-8}\text{ N} = \boxed{2.82\times10^{-8}\text{ N or } 28.2\text{ nN}}$

c. $F_c = F_B$
$mv^2/r = F_B$
$r = mv^2/F_B = 2KE/F_B = 5.12\times10^{-15}\text{ J}/2.82\times10^{-8}\text{ N}$
$= 1.816378\times10^{-7}\text{ m} = \boxed{1.82\times10^{-7}\text{ m}}$

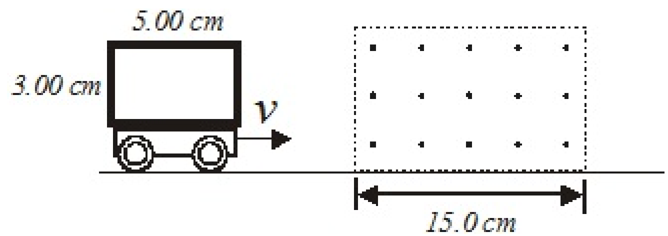
12. A rectangular loop enters a magnetic field of 1.25×10^2 T. It is moving at a constant speed. The induced ***emf*** when it enters the field is 24.5 V. What is the velocity of the cart?

$\mathcal{E} = B\ell v$

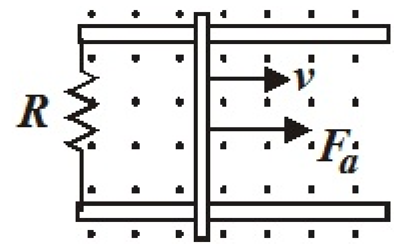
$v = \mathcal{E}/B\ell$

$= 24.5\ \text{V}/(1.25\times10^2\ \text{T} \cdot 0.03\ \text{m})$

$= 6.5333333\ \text{m/s} =$ 6.53 m/s



13. A metal rod is pulled into a magnetic field, B = 60.6 T, at a constant velocity of 12.5 m/s while it is in contact with two conducting rails. The rails are separated by a distance of 7.50 cm. A resistor has been placed between the rails at the edge of the field as shown. The current through the resistor is 1.25 A. Find (a) the ***emf*** induced into the rod by its motion through the field. (b) The resistance of *R*, the resistor between the rails. (c) The direction of the current through *R*. (d) The Force, F_a, applied to the rod to make it move through the magnetic field.



a. $\mathcal{E} = B\ell v = 60.6\ \text{T} \cdot 0.0750\ \text{m} \cdot 12.5\ \text{m/s} = 56.8125\ \text{V} =$ 56.8 V

b. $R = V/I = 56.8125\ \text{V}/1.25\ \text{A} = 45.45\ \Omega =$ 45.5 Ω

c. Current will flow upward through R. Right-hand rule for the electrons in the conducting rod: they're moving to the right, the magnetic field is out of the page, therefor a positive charge would move down through the conducting rod (and an electron would move up).

d. If the metal rod is moving at a constant speed, then the force pushing/pulling the rod is equal to the force from the magnetic field on the rod, so there's no net force and therefore no acceleration.

$F = I\ell B\sin\theta = 1.25\ \text{A} \cdot 0.0750\ \text{m} \cdot 60.6\ \text{T} = 5.68125\ \text{N} =$ 5.68 N