Circuits/Electromagnetics

W O R K S H E E T # 1

Name: ________________________

1. A charge of 12.7 μC is placed 18.5 cm from a second charge. If the force between the charges is 25.5 N, what is the magnitude of the second charge?

$F = k\, q_1 q_2 / r^2$

$q_2 = F \cdot r^2 / (k \cdot q_1)$

$= 25.5\ \text{N} \cdot (0.185\ \text{m})^2 / ((9.0\times10^{9}\ \text{N}\cdot\text{m}^2/\text{C}^2) \cdot 12.7\times10^{-6}\ \text{C}) = 7.6354987\times10^{-6}\ \text{C} = \boxed{7.64\ \mu\text{C}}$

2. 7.45×10^{17} electrons take 0.810 seconds to flow past a point in the circuit. What is the current?

$I = Q/t = (7.45\times10^{17}\ e^- \cdot 1.60\times10^{-19}\ \text{C}/e^-) / 0.810\ \text{s} = 0.1471604938\ \text{A} = \boxed{0.147\ \text{A} \text{ or } 147\ \text{mA}}$

3. If the current in a circuit is 0.250 A, how many electrons are flowing past a set point in 0.155 second?

$Q = I \cdot t = 0.250\ \text{A} \cdot 0.155\ \text{s} = 0.03875\ \text{C}$

$\#e^- = 0.03875\ \text{C} / (1.60\times10^{-19}\ \text{C}/e^-) = 2.421875\times10^{17}\ e^- = \boxed{2.42\times10^{17}\ e^-}$

4. What is the direction of current flow in a circuit? Why can this question be confusing?

Current flows from positive to negative in a circuit. This is a convention established by Ben Franklin a long time ago. This can be confusing as current is often carried by negative charges which are flowing the opposite direction of the "conventional" current.

5. A hair dryer draws 1.12 A when plugged into a 120.0 V circuit. What is its resistance?

$R = V/I = 120.0\ \text{V} / 1.12\ \text{A} = 107.1428571\ \Omega = \boxed{107\ \Omega}$

6. A light bulb has stamped upon it the following information, "60 W 120 V". How much current will flow through the bulb?

$I = P/V = 60\ \text{W} / 120\ \text{V} = \boxed{0.5\ \text{A}}$

7. What is the resistance of a copper wire, diameter of 1.50 mm and length 25.0 m?

$R = \rho \cdot \ell / A = 1.68\times10^{-8}\ \Omega\cdot m \cdot 25.0\ m / \pi\ (0.000750\ m)^2 = 0.2376713817\ \Omega =$ $\boxed{0.238\ \Omega}$

8. If a kilowatt-hour costs 0.055 dollars (i.e., $ 0.055 or five and a half cents), how long could $10.00 worth of electricity operate an 1850 W toaster?

$cost = P \cdot t \cdot rate$

$t = cost/(P \cdot rate) = 10\ dollars/(1.85\ kW \cdot (0.055\ dollars/kW\cdot hr)) = 98.28009828\ hr =$ $\boxed{98.3\ hr}$

9. A roller coaster starts from rest at the top of a hill. It goes down the hill and up a second hill that is 21.5 m above the first drop. Its speed at the top of the second hill is 19.7 m/s. How high is the initial hill?

$KE = PE$

$\frac{1}{2}\ m(\Delta v)^2 = mg\Delta h$

$\Delta h = 1/2(\Delta v)^2\ /\ g = 0.5 \cdot (19.7\ m/s)^2\ /\ 9.8\ m/s^2 = 19.8005102\ m =$ $\boxed{19.8\ m}$

19.8 m higher than 2nd hill or 41.3 m higher than first drop

10. An 85 g wooden block is set up against a spring. The block rests on a smooth surface. The block is pushed into the spring, compressing it a distance of 2.0 cm and then released. The spring constant is k = 78 N/m. What is the speed of the block when it reaches its initial position (where the spring was not compressed)?

$KE = PE_{spring}$

$\frac{1}{2}\ mv^2 = \frac{1}{2}\ kx^2$

$v = x(k/m)^{\frac{1}{2}} = 0.020\ m\ (78\ N/m\ /\ 0.085\ kg)^{\frac{1}{2}} = 0.6058537972\ m/s =$ $\boxed{0.606\ m/s\ \text{ or }\ 60.6\ cm/s}$

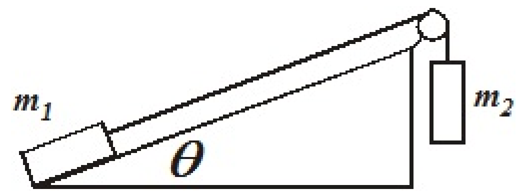
11. A 5.0 kg crate slides down a smooth ramp that is elevated at an angle of 38°. The length of the ramp is 2.0 m. What will be the speed of the crate at the bottom of the ramp?

$\Delta h = 2.0\ m \cdot \sin(38°) = 1.231322951\ m$

$mgh = \frac{1}{2} mv^2$

$v = (2gh)^{\frac{1}{2}} = (2 \cdot 9.8\ m/s^2 \cdot 1.231322951\ m)^{\frac{1}{2}} = 4.912629625\ m/s = \boxed{4.9\ m/s}$

12. A 3.00 kg mass, $\boldsymbol{m_1}$, slides up a ramp. The angle for the ramp is 28.0°. The 3.00 kg mass is connected to a second mass, $\boldsymbol{m_2}$, of 3.25 kg as shown by a light string with a frictionless pulley, &c. Coefficient of kinetic friction is 0.285. Find (a) the acceleration of $\boldsymbol{m_1}$, (b) the kinetic energy of $\boldsymbol{m_1}$ after it has traveled 25.0 cm up the ramp, and (c) the work done on $\boldsymbol{m_1}$ to move it the 25.0 cm.



$w_1 = m_1 \cdot g = 3.00\ kg \cdot 9.8\ m/s^2 = 29.4\ N$

$F_N = w_1 \cdot \cos 28° = 29.4\ N \cdot \cos 28° = 25.95865923\ N$

$F_{fric} = \mu \cdot F_N = 0.285 \cdot 25.95865923\ N = 7.398217881\ N$

$F_{net} = F_2 - F_1 - F_{fric} = 3.25\ kg \cdot 9.8\ m/s^2 - 3.00\ kg \cdot 9.8\ m/s^2 \cdot \sin 28° - 7.398217881\ N$
$= 10.64931817\ N$

a. $a = F_{net} / m_{sys} = 10.64931817\ N / 6.25\ kg = 1.703890908\ m/s^2 = \boxed{1.70\ m/s^2}$

b. $v^2 = v_o^2 + 2ad = 0 + 2 \cdot 1.703890908\ m/s^2 \cdot 0.25\ m = 0.8519454539\ m^2/s^2$
$KE = \frac{1}{2} m_1 v^2 = 0.5 \cdot 3.00\ kg \cdot 0.8519454539\ m^2/s^2 = 1.277918181\ J = \boxed{1.28\ J}$

c. $W = \Delta KE + \Delta PE + W_{fric} = \frac{1}{2} mv^2 + mg\Delta h + F_{fric} \cdot d$
$= 1.277918181\ J + 3.00\ kg \cdot 9.8\ m/s^2 \cdot 0.25\ m \cdot \sin 28° + 7.398217881\ N \cdot 0.25\ m$
$= 1.277918181\ J + 3.450615986\ J + 1.84955447\ J = 6.578088637\ J = \boxed{6.58\ J}$