Physics 10164 - Exam 1B

Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work even if you get the right answer. Clearly indicate your answer with a circle or a box and remember to include correct units and significant figures.

1. (30 pts) An iron nucleus with a charge of +26e is fixed at the origin. In order for fusion to occur, assume a proton approaching the iron nucleus must reach a minimum distance of 2.5 x 10^{-16} meters before stopping. If the proton starts off at a great distance from the iron nucleus and the electric force is the only relevant force, how fast must the proton be moving initially?

$$\Sigma W_F = W_E = \Delta K$$

$$W_E = -q_2 \Delta V_1 = \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2$$

$$= -q_2\left(\frac{kq_1}{r_{min}} - \cancel{\frac{kq_1}{\infty}}^{\,0}\right) = \cancel{\frac{1}{2}mv^2}^{\,0} - \frac{1}{2}mv_0^2$$

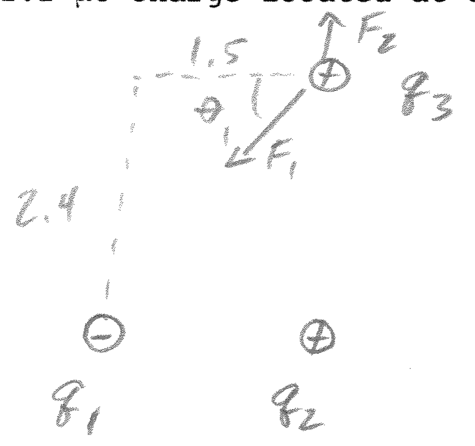
$$-\frac{(1.6\times10^{-19})(9\times10^{9})(26\times1.6\times10^{-19})}{2.5\times10^{-16}} = -\frac{1}{2}(1.67\times10^{-27})v^2$$

$$2.40\times10^{-11} = \frac{1}{2}(1.67\times10^{-27})v^2$$

$$2.87\times10^{16} = v^2$$

$$v = 1.7\times10^{8}\ \text{m/s}$$

2. (40 pts) A -4.0 μC particle is fixed at the origin, and a 5.5 μC charge is fixed at the coordinates (x,y) = (1.50,0.00) meters. What is the magnitude and direction of the net electric force on a 2.2 μC charge located at coordinates (x,y) = (1.50,2.40) meters?



$$\theta_1 = \tan^{-1}\left(\frac{2.4}{1.5}\right) = 58°$$

$$|F_1| = \frac{k q_1 q_3}{r_{13}^2}$$

$$r_{13} = \sqrt{1.5^2 + 2.4^2} = 2.83$$

$$|F_1| = \frac{(9\times10^9)(4.0\times10^{-6})(2.2\times10^{-6})}{(2.83)^2} = 9.89\times10^{-3}N$$

$$|F_2| = \frac{(9\times10^9)(5.5\times10^{-6})(2.2\times10^{-6})}{2.4^2} = 1.89\times10^{-2}N$$

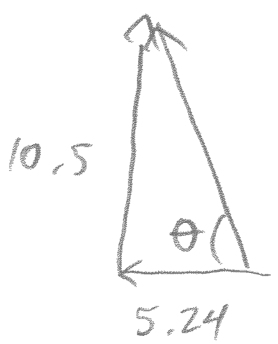
$$\Sigma F_x = F_{1,x} + F_{2,x}$$

$$= -(9.89\times10^{-3})\cos 58° + 0 = \underline{-5.24\times10^{-3}N}$$

$$\Sigma F_y = F_{1,y} + F_{2,y}$$

$$= -(9.89\times10^{-3})\sin 58° + 1.89\times10^{-2} = 1.05\times10^{-2}N$$

or $\underline{10.5\times10^{-3}N}$



$$|\vec{F}| = \sqrt{F_x^2 + F_y^2} = \boxed{1.2\times10^{-2} \text{ or } .012\,N}$$

$$\theta = \tan^{-1}\left(\frac{10.5}{5.24}\right) = \boxed{63° \text{ above } -x}$$

3. (30 pts) A wire made of Nichrome has a resistivity of 150 x 10^{-8} Ohm-meters and a temperature coefficient of resistivity of 4.0 x 10^{-4}. The wire has a length of 55 meters and a diameter of 2.3 mm, and it is attached to the terminals of a 120 Volt power source.

a) When the circuit is initially connected, the wire has a temperature of 20°C. What is the wire's resistance?

b) After a while, the wire heats up to a temperature of 850°C. What is the new resistance of the wire?

c) How much power is being supplied to the wire at a temperature of 850°C?

d) If power costs 15 cents per kilowatt-hr, and the wire stays connected to the power source for 3.5 hours, how much does it cost?

a) $R = \frac{\rho l}{A} = \frac{(150 \times 10^{-8})(55)}{\pi (.0023)^2 / 4} = 19.86\ \Omega$

or $20\ \Omega$

b) $R = R_0(1 + \alpha \Delta T) = 19.86(1 + (.4 \times 10^{-3})(830))$

$= 26.45$ or $26\ \Omega$

c) $P = \frac{\Delta V^2}{R} = \frac{120^2}{26} = 540\ W$

d) $E = Pt = (540)(3.5\ hr)\left(\frac{3600\ s}{hr}\right) = 6.86 \times 10^6\ J$

$6.86 \times 10^6\ J \cdot \frac{15¢}{3.6 \times 10^6\ J} = 29¢$