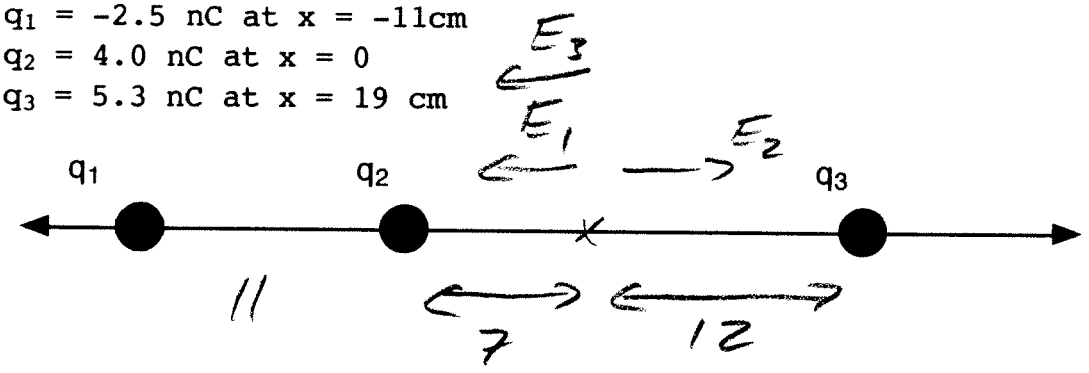
Physics 10164 - Exam 1D

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) Three charges are arranged in a straight line as shown below. What is the magnitude and direction of the electric field at x = 7.0 cm?

q_1 = -2.5 nC at x = -11cm
q_2 = 4.0 nC at x = 0
q_3 = 5.3 nC at x = 19 cm



$$|E_1| = \frac{kq_1}{r_1^2} = \frac{(9\times10^9)(2.5\times10^{-9})}{0.18^2} = 694,\ -x$$

$$|E_2| = \frac{kq_2}{r_2^2} = \frac{(9\times10^9)(4.0\times10^{-9})}{.07^2} = 7347,\ +x$$

$$|E_3| = \frac{kq_3}{r_3^2} = \frac{(9\times10^9)(5.3\times10^{-9})}{0.12^2} = 3313,\ -x$$

$$E_{TOT} = -694 + 7347 - 3313 =$$

$$= 3340 \text{ or } \boxed{3300\ N/C,\ +x\ dir}$$

2. (40 pts) A ~~proton~~ alpha particle is fixed at the origin. A ~~second~~ proton is initially at rest at a coordinate x = 5.0 nm (5.0×10^{-9} m).

a) If the ~~second~~ proton is allowed to move freely, what will its speed be when it reaches an x coordinate x = 25 nm?

b) If the ~~second~~ proton is allowed to move freely to infinity, how much work does the electric force do during this motion?

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

$-q\Delta V = \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2$ ($v_0 = 0$ initially at rest)

$V_i = \frac{k(2e)}{5\times10^{-9}} = 0.576$ Volts

$V_f = \frac{k(2e)}{25\times10^{-9}} = 0.115$ Volts

$-(1.60\times10^{-19})(0.115 - 0.576) = \frac{1}{2}(1.67\times10^{-27})v^2$

$\frac{2(7.38\times10^{-20})}{1.67\times10^{-27}} = v^2$

$v = 9400$ m/s

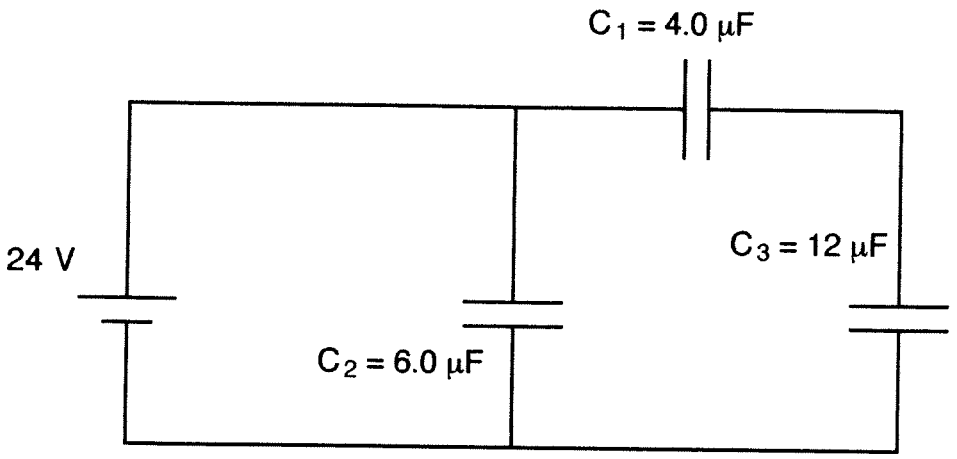
b) $W_E = -q\Delta V = -(1.60\times10^{-19})(-0.576)$

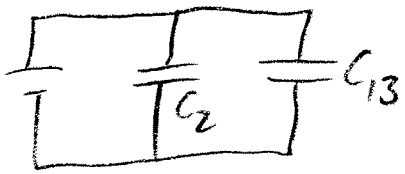
$= 9.2\times10^{-20}$ J

$V_f = 0$

$V_i = 0.576$

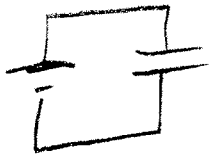
3. (40 pts) For the system below, determine the charge and voltage drop across each capacitor.





$$\frac{1}{C_{13}} = \frac{1}{4} + \frac{1}{12}$$

$$C_{13} = 3\ \mu F$$



$C_{123} = C_2 + C_{13} = 9\ \mu F$

Thus, $Q_{123} = C_{123}\,\Delta V_{123} = (9)(24\ \mu F) = 216\ \mu C$

Since C_2 & C_{123} are parallel,

$\Delta V_2 = 24$ Volts

$Q_2 = C_2 \Delta V_2 = 144\ \mu C$

$\Delta V_{13} = 24$ Volts

$Q_{13} = C_{13}\,\Delta V_{13} = 72\ \mu C$

Since C_1 & C_3 are in series

$Q_1 = 72\ \mu C$

$\Delta V_1 = \frac{Q_1}{C_1} = 18$ Volts

$Q_3 = 72\ \mu C$

$\Delta V_3 = \frac{Q_3}{C_3} = 6$ Volts