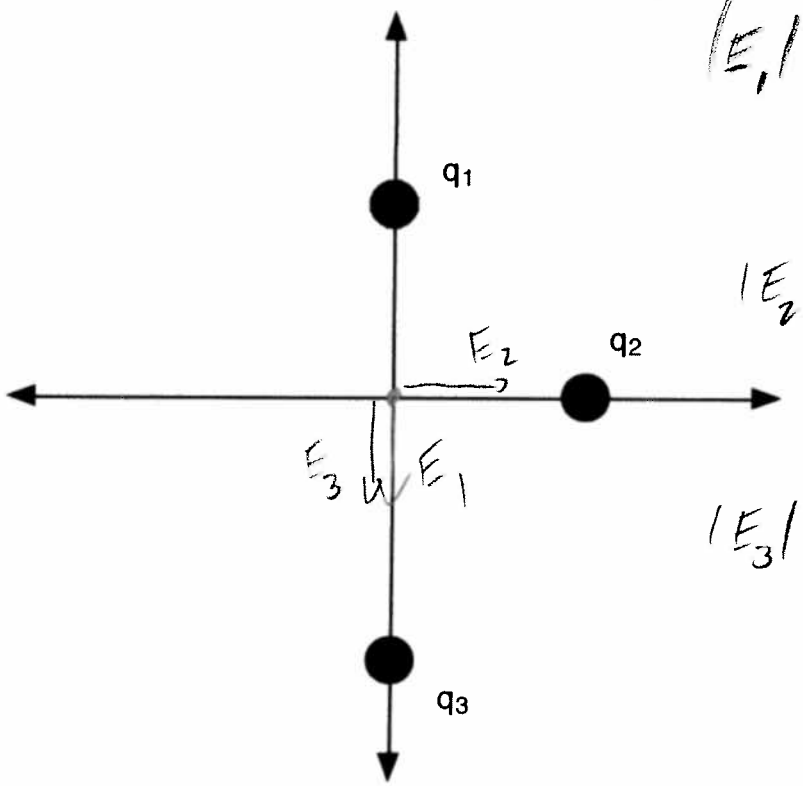
# Physics 10164 - Exam 1C

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. (40 pts) Three charges are arranged as shown below. What is the magnitude and direction of the electric field at the origin?
$q_1$ = +2.5 nC, located at y = 82 cm.
$q_2$ = -4.4 nC, located at ~~y = 110 cm~~ x = 85 cm
$q_3$ = -12 nC, located at ~~x = 85 cm~~. y = -110 cm




$|E_1| = \frac{kq_1}{r_1^2} = \frac{(9\times10^9)(2.5\times10^{-9})}{0.82^2}$

$= 33.5, -y$

$|E_2| = \frac{kq_2}{r_2^2} = \frac{(9\times10^9)(4.4\times10^{-9})}{0.85^2}$

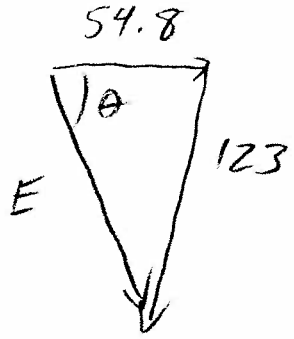
$= 54.8, +x$

$|E_3| = \frac{kq_3}{r_3^2} = \frac{(9\times10^9)(12\times10^{-9})}{1.1^2}$

$= 89.2, -y$

$E_{TOT,x} = 54.8$

$E_{TOT,y} = -123$




$|E_{TOT}| = \sqrt{54.8^2 + 123^2} = 134$ or $130\ N/C$

$\theta = \tan^{-1}\left(\frac{123}{54.8}\right) =$ 66° below +x

2. (30 pts) A ball with mass 35 grams and charge 25 μC is thrown straight up from the Earth's surface with an initial speed of 22 m/s. The maximum height reached by the ball is 16 meters.

a) What is the magnitude of the potential difference between the ground and a height of 16 meters?

b) Where is the voltage higher (more positive), on the ground or at y = 16 m?

$$\Sigma W_F = W_{grav} + W_E = \cancel{\tfrac{1}{2}mv^2} - \tfrac{1}{2}mv_0^2$$

$\cancel{\tfrac{1}{2}mv^2} \to 0$ at max height

$$-mgh - q\Delta V = -\tfrac{1}{2}mv_0^2$$

$$-(.035)(9.8)(16) - (25\times10^{-6})(\Delta V) = -\tfrac{1}{2}(.035)(22)^2$$

$$-5.488 - (25\times10^{-6})(\Delta V) = -8.47$$

$$\Delta V = \frac{-8.47 + 5.488}{-25\times10^{-6}}$$

$$= 120{,}000 \text{ Volts}$$

If $\Delta V$ positive, then $V_F > V_I$, E points ↓

so **voltage higher at y = 16 m**

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Alt: $a = \dfrac{-v_0^2}{2(16)} = -15.125$

$\Sigma F = -mg - qE = ma$

$-.343 - qE = -0.529$

$qE = 0.186$

$E = 7440$ V/m

$\Delta V = (7440)(16) = 120{,}000$ Volts

3. (30 pts) Two parallel plates of cross-section area 3.6 $cm^2$ are separated by 4.0 cm. A 24 Volt battery is connected so that the positive terminal charges the positive plate and the negative terminal charges the negative plate.

a) What is the amount of charge on the positive plate?

b) If a dielectric with constant K = 5.0 is inserted between the plates while the plates are connected to the battery, and the system is allowed to return to an equilibrium state, what is the electric field between the plates?

c) What is the amount of charge on the positive plate after this new equilibrium is attained?

d) What is the capacitance of this parallel-plate capacitor with the dielectric inserted?

a) $E = \frac{24}{.04} = 600 \frac{V}{m} = \frac{4\pi k Q}{A}$

$Q = \frac{600(A)}{4\pi k} = \frac{(600)(3.6\times10^{-4})}{4\pi(9\times10^{9})}$

$= \boxed{1.9\times10^{-12}\,C}$

b) $E$ is still $\frac{\Delta V}{d} = \boxed{600 \frac{V}{m}}$

c) $Q_{new} = K Q_{old} = (5.0)(1.9\times10^{-12})$

$= \boxed{9.5\times10^{-12}\,C}$

d) $C_{new} = K C_{old} = \frac{KA}{4\pi k d} = \frac{(5.0)(3.6\times10^{-4})}{4\pi(9\times10^{9})(.04)}$

$= \boxed{4.0\times10^{-13}\,F}$