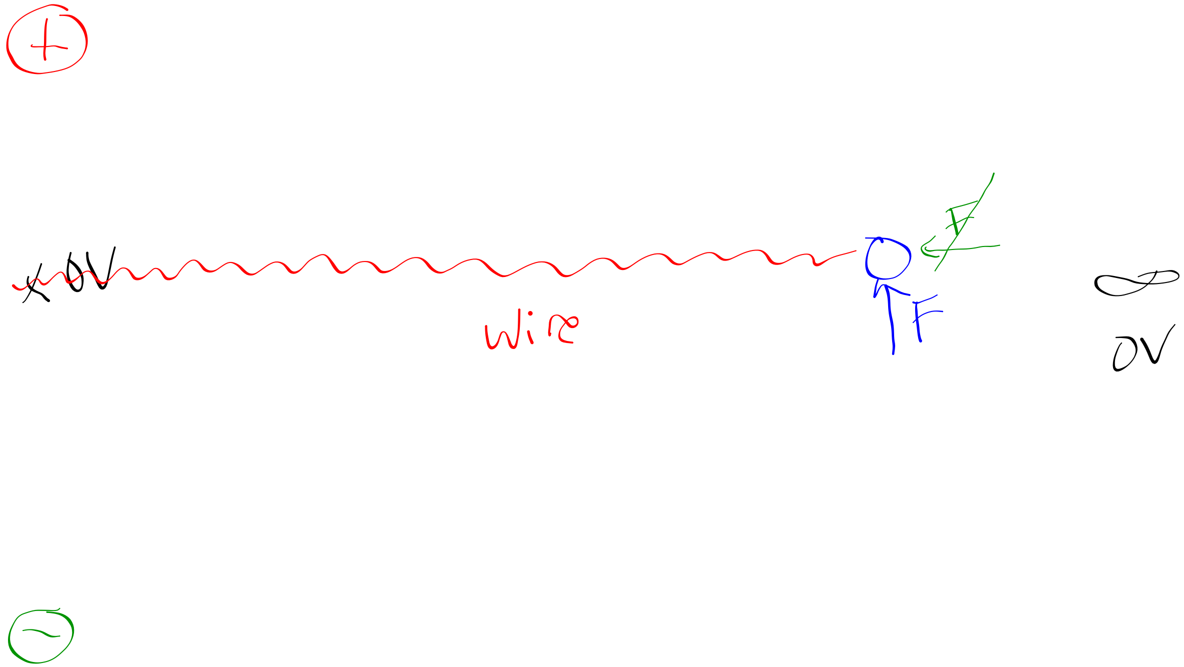
Concepts & problems

⊕ & ⊖ behave opposite
in same e-field!

Uniform e-field vs. Non-uniform e-field

$W = F \cdot d$ ← must be <u>colinear</u>



+4 V

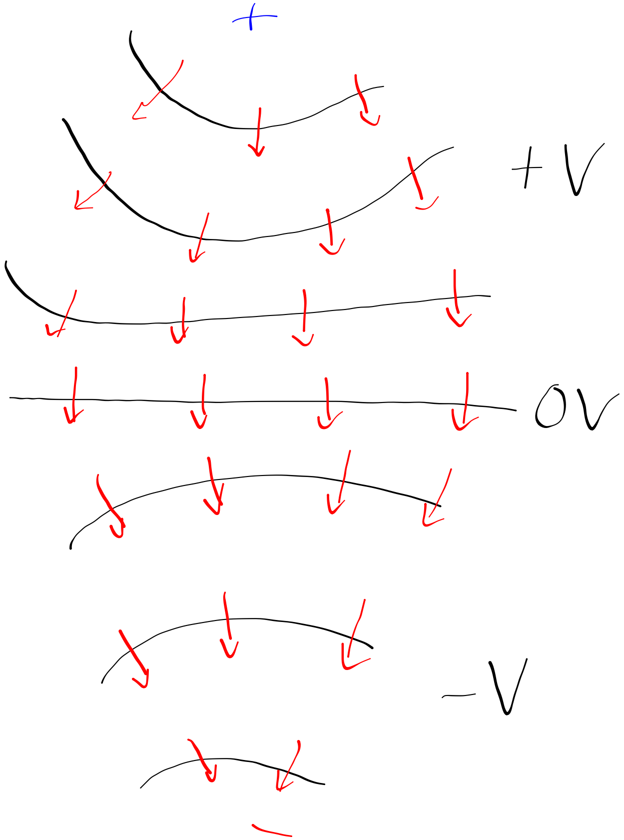
A

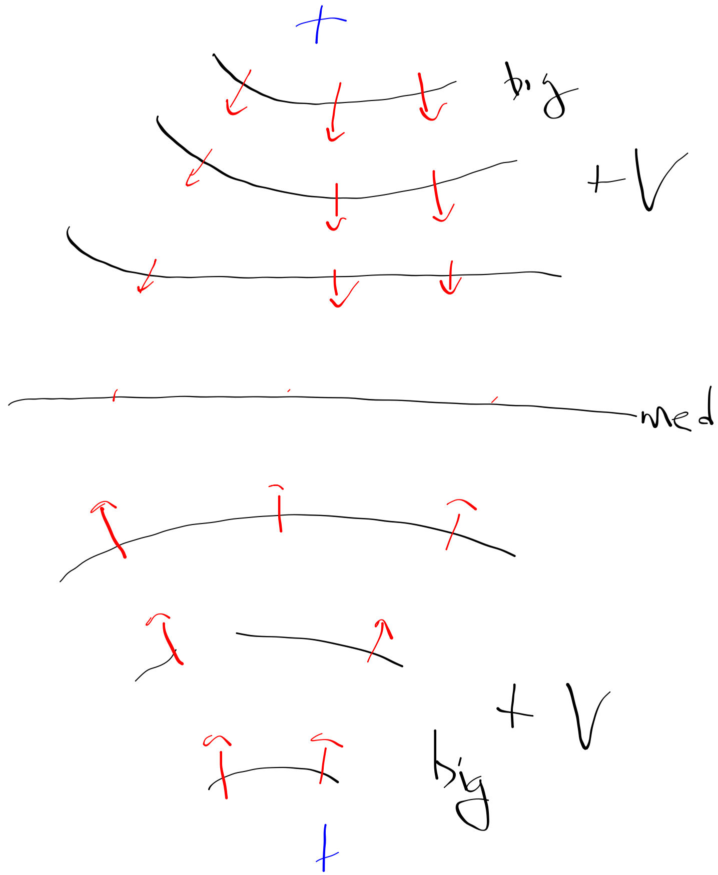
$a = \emptyset$

$E = \emptyset$

-3V

B


+
+V
0V
−V
−


+
big
+V
med
+V
big
+

2. What is the charge on Particle 1 if it levitates over Particle 2 ($3.2\times10^{-8}$ C) at a height of 2 cm? The mass of Particle 1 is .82-grams. Assume the particles are on the surface of the Earth ($g = 9.8\ m/sec^2$).
[$1.12\times10^{-8}$ C]

$F_E$

$P_1 = +$

$mg$

$\underbrace{\quad}_{0.02m}$

$P_2 = +3.2E-8\ C$

$\Sigma F = ma = \emptyset$

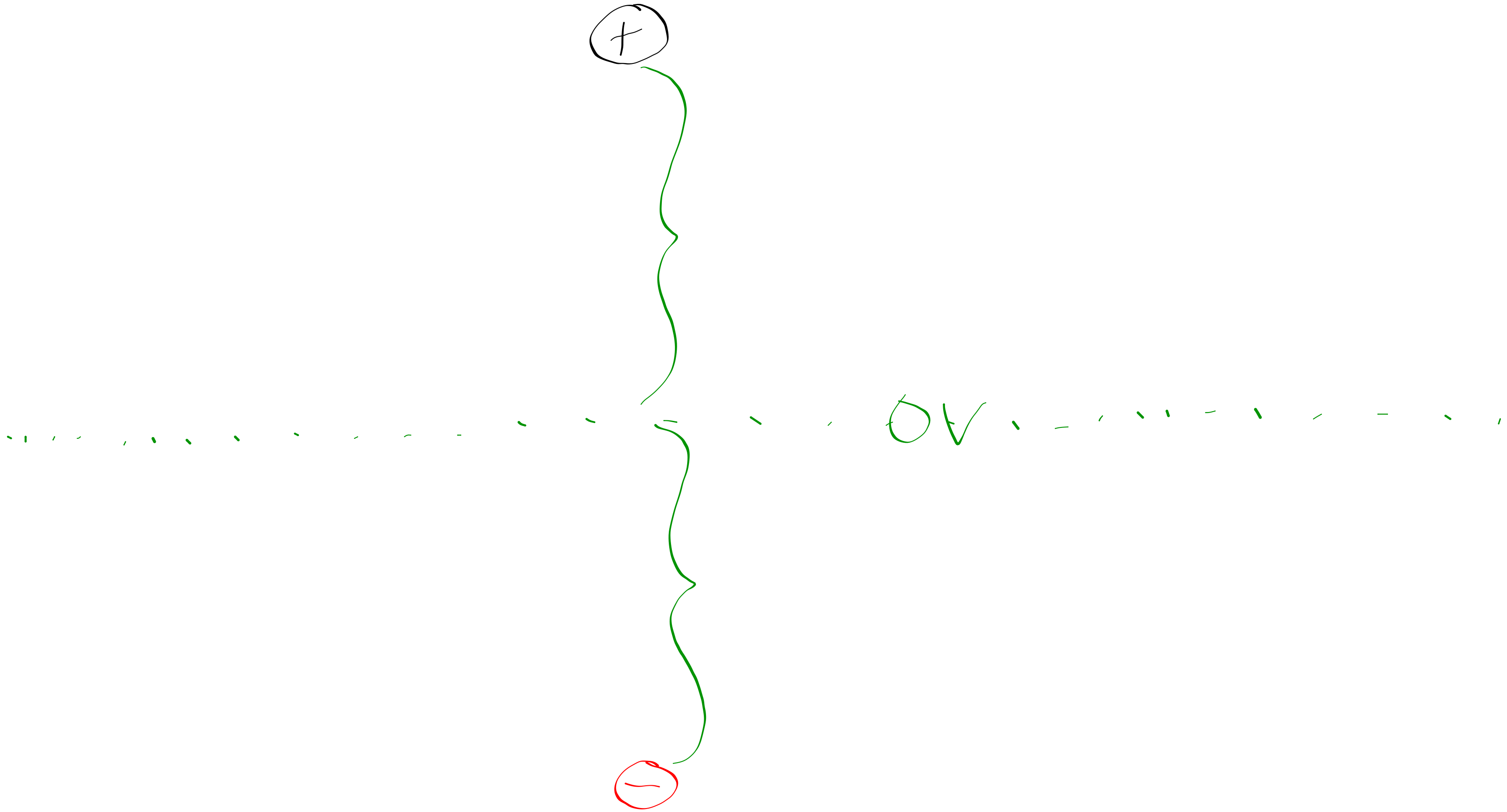
$F_E - mg = \emptyset$

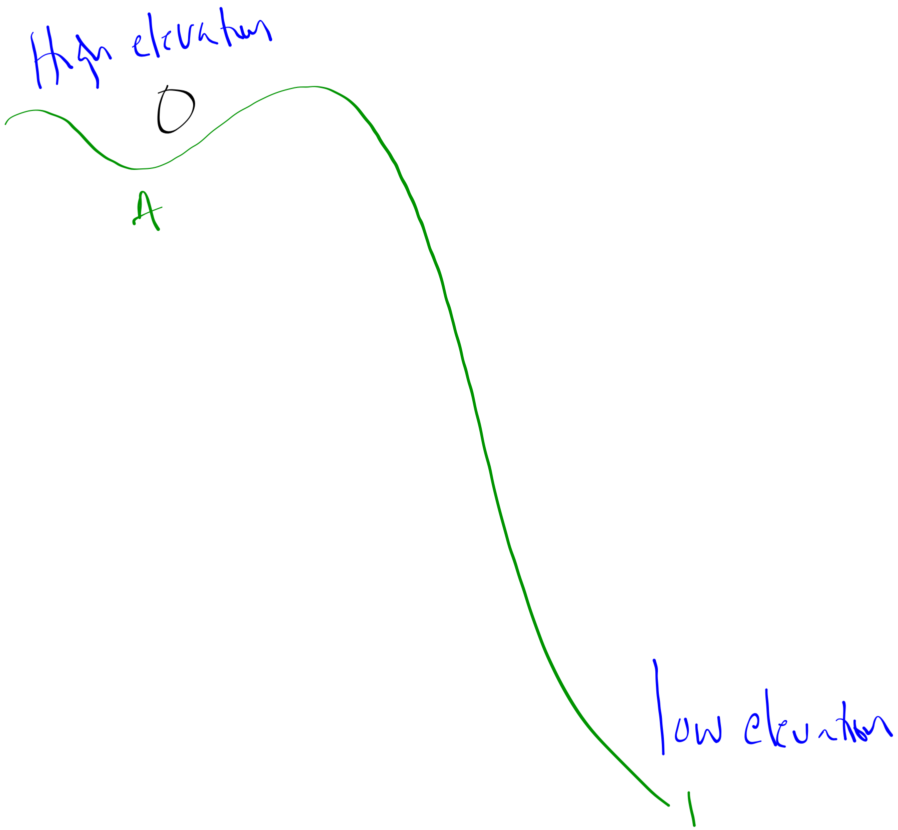
$\boxed{F_E = mg}$

$F_E = mg$

$$\frac{k q_1 q_2}{r^2} = mg$$

$$q_1 = \frac{mg \cdot r^2}{k q_2} = \frac{(0.00082\ kg)(9.8)(0.02^2)}{(9E+9)(3.2E-8)} =$$


+
0V
−


High elevation
low elevation

5. A 0.6-gram object with a charge of $8 \times 10^{-7}$ C orbits a second object that has a charge of $-5 \times 10^{-8}$ C. The radius of the orbit is 13 mm. What is the orbital velocity of the object in orbit? [6.79 m/sec]

13 mm = 13E-4 m

$Q_1$

8E-7 C

m = 0.6 g = 0.6E-3 kg

$Q_2$

-5E-8 C

$$F_c = \frac{mv^2}{r}$$

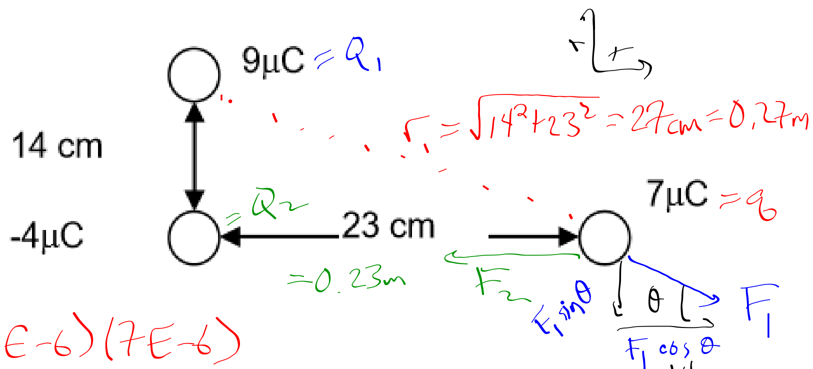
$$F_c = F_E$$

$$F_E = F_c$$

$$\frac{KQ_1Q_2}{r^{\cancel{2}}} = \frac{mv^2}{\cancel{r}}$$

$$6.8\ \text{m/s} = v = \sqrt{\frac{KQ_1Q_2}{r \cdot m}} = \sqrt{\frac{(9E9)(8E-7)(+5E-8)}{(13E-4)(0.6E-3)}}$$

7. What is the magnitude and direction of the net force acting on the 7μC charge? [4.5 N to the right, 64.7° below the horizontal]




$$\theta = \tan^{-1}\frac{14}{23}$$

$$\theta = 31.3°$$

$$F_1 = \frac{kQ_1 q}{r_1^2} = \frac{(9E9)(9E-6)(7E-6)}{0.27^2}$$

$$= 7.8\text{ N}$$

$$F_{1x} = F_1 \cos\theta = 7.8 \cos 31.3 = 6.67$$

$$F_{1y} = F_1 \sin\theta = -4.05$$

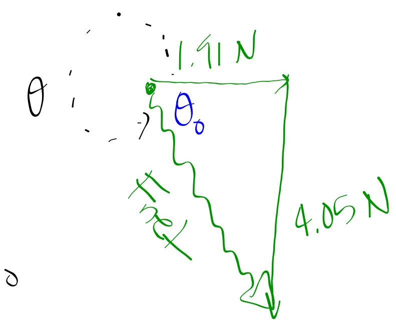
$$F_2 = \frac{kQ_2 q}{r_2^2} = \frac{(9E9)(4E-6)(7E-6)}{0.23^2} = -4.76$$

$$F_x = F_{1x} + F_2 = 6.67 - 4.76 = 1.91\text{ N}$$

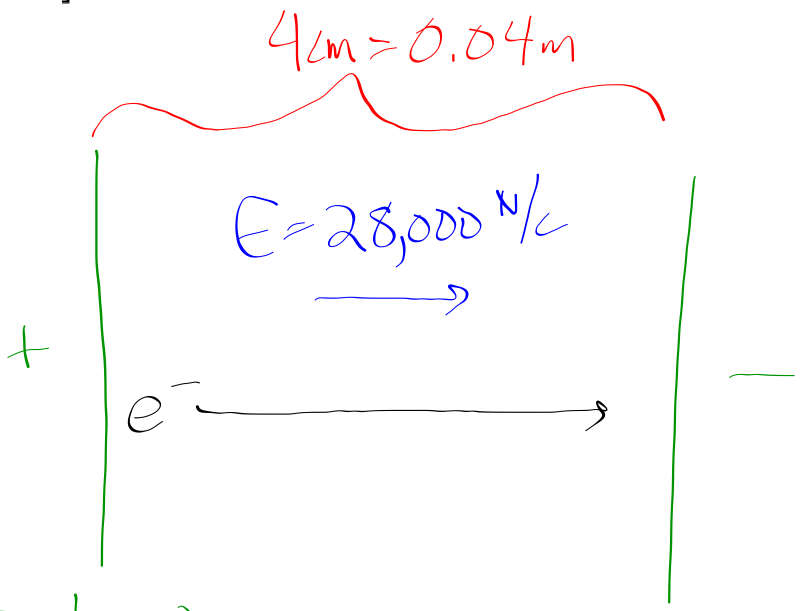
$$F_y = F_{1y} = -4.05\text{ N}$$

$$F_{net} = \sqrt{F_x^2 + F_y^2} = 4.48\text{ N}$$

$$\theta = \left(\tan^{-1}\frac{4.05}{1.91}\right) + 360 = 295°$$



16. An electron is released within a uniform electric field generated by two parallel plates. The plates are separated by 4 cm and the electric field as a strength of 28,000 N/C. After the electron has moved across the entire gap between the plates, what is the speed of the electron? (Hint: think work and energy). [1.98x10$^7$ m/sec]




$V = E \cdot d$ (uniform field)

$= (28{,}000\ N/C)(0.04m)$

$= 1120\ V$

$V_{ba} = \frac{W_{ba}}{q}$

$W_{ba} = V_{ba} \cdot q$

$= (1120)(1.6E{-}19)$

$= 1.8E{-}16\ J$

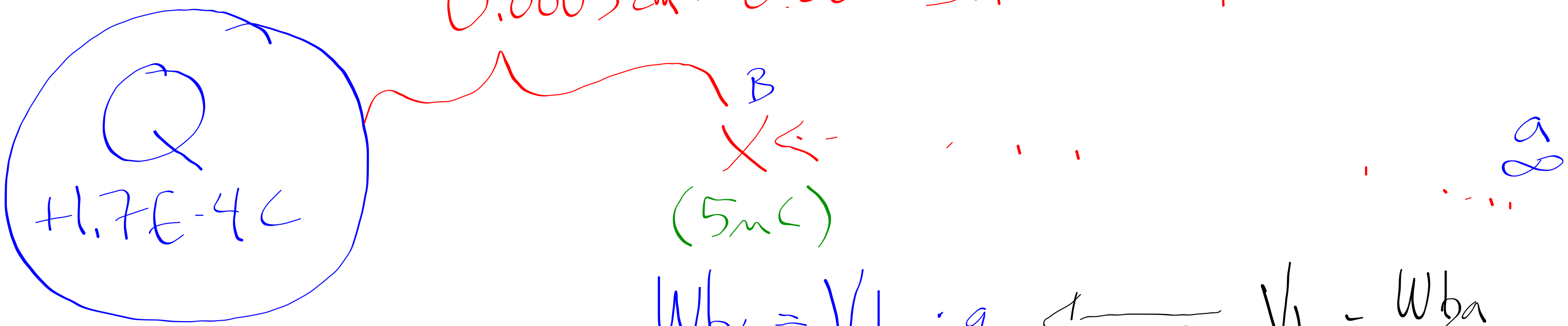
$KE = \frac{1}{2}mv^2$

$v = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{2(1.8E{-}16)}{9.11E{-}31\ kg}}$

$\boxed{v = 1.98\ E7\ m/s}$

22. A 5μC charge is brought from infinity to a distance of .0003 cm from a $1.7 \times 10^{-4}$ C charge. How much work was required in moving the 5μC charge? What is the final potential energy of the 5μC charge? What is the electric potential at the final position of the 5μC charge? [$2.55 \times 10^{6}$ J, $2.55 \times 10^{6}$ J, $5.10 \times 10^{12}$ V]

0.0003 cm = 0.000003 m = 3E-6 m




$W_{ba} = V_{ba} \cdot q \Longleftarrow V_{ba} = \frac{W_{ba}}{q}$

"point voltage"

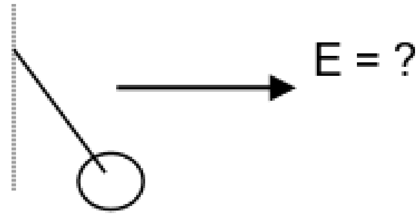
$V_{x\infty} = \frac{kQ}{r} = \frac{(9E9)(1.7E-4)}{3E-6}$

$= 5.1E11$ V

$W_{ba} = (5.1E11)(5\mu C)$

$= \boxed{2.6E6 \text{ J}}$

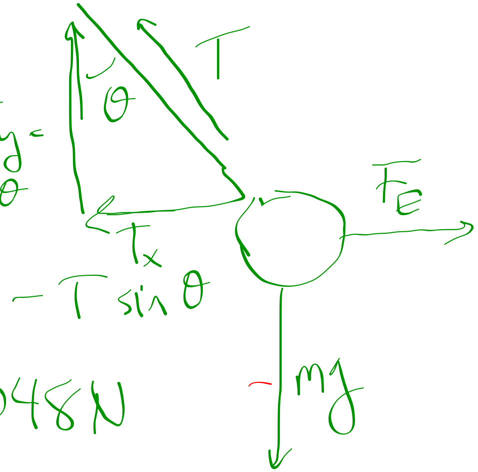
8. What electric field must be present to suspend the 7-gram, $4 \times 10^{-9}$ C charged ball at an angle of 35 degrees from the vertical? [$1.2 \times 10^{7}$ N/C]

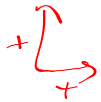



$\Sigma F = \emptyset$

$T\cos\theta - mg = \emptyset$

$T = \frac{mg}{\cos\theta} = \frac{(0.007)(9.8)}{\cos 35} = 0.084\,N$



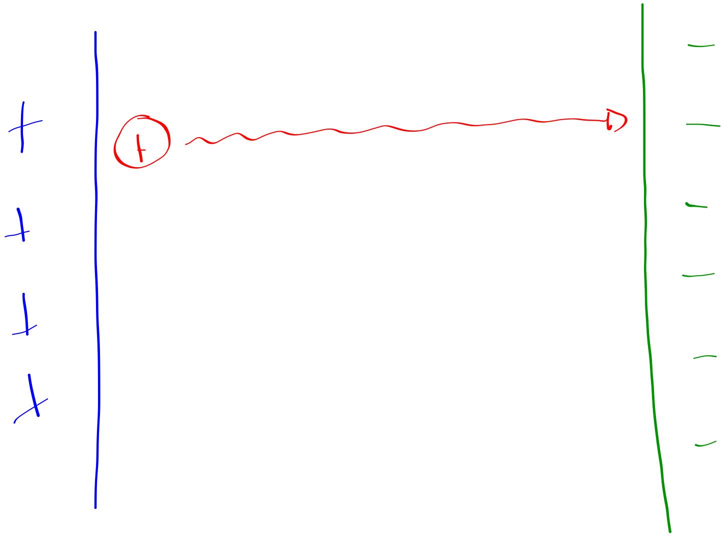

$-T\sin\theta + F_E = \emptyset$

$F_E = T\sin\theta = (0.084)\sin 35 = 0.048\,N$

$E = \frac{F}{q} = \frac{0.048}{4E{-}9} = 1.2\,E7$ N/C to the right

24. A proton falls toward a negative plate at ½ the speed of light (1.5x10⁸ m/sec). What is the potential between the plates? [1.17x10⁸ V]

$v_{final}$



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

$$= \frac{1}{2}(1.67E{-27})(1.5E8)^2$$

$$= 1.88E{-11}\ J$$

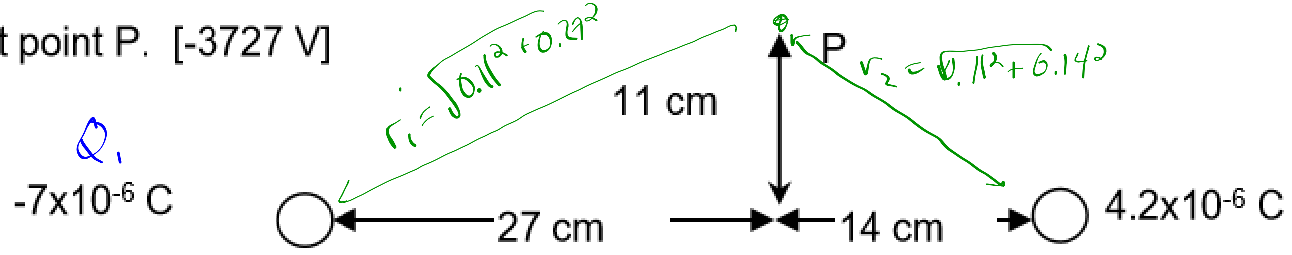
$$V_{ba} = \frac{W_{ba}}{q} = \frac{-1.88E{-11}\ J}{1.6E{-19}\ C}$$

$$\cancel{\frac{1}{2}mv_0^2} + \cancel{mgh_0} + \cancel{\frac{1}{2}kx_0^2} + W_{NC} = \frac{1}{2}mv^2 + \cancel{mgh} + \cancel{\frac{1}{2}kx^2}$$

$$\boxed{V_{ba} = -1.18E8\ V}$$

$$W_{NC} = \frac{1}{2}mv^2$$ (work-KE theorem)

23. Find the potential at point P. [-3727 V]




$$V_{P\infty} = \frac{kQ_1}{r_1} + \frac{kQ_2}{r_2}$$

$\ominus$ $\oplus$