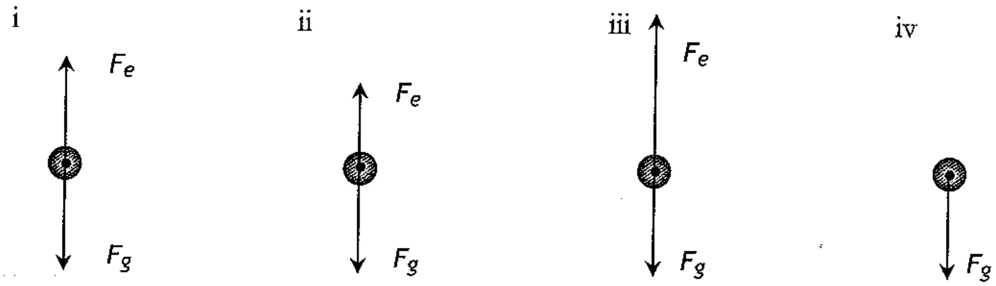
10. Thomas Edison became convinced that electrical charge is quantized when he used Millikan and Fletcher's oil drop apparatus. He had previously thought that charge could be any continuous variable. Define quantized [Appendix A]

Quantized means a distinct elemental value.

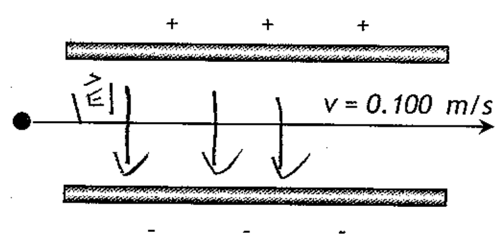
Use the information below to answer question 11.

A free-body diagram is a necessary part of the solution for oil drop problems. Four free-body diagrams for an oil drop are drawn below. [Appendix A]

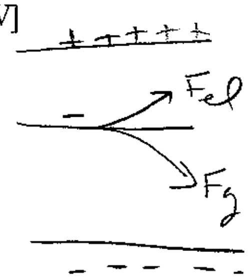


11. Considering only the vertical dimension, identify the free-body diagram(s) that best describes an oil drop that is
   a. moving at a constant velocity. i
   b. accelerating upwards. iii
   c. accelerating downwards. iv and ii

12. A 5.80×10^{-9} kg oil droplet having a charge magnitude of 5.40×10^{-14} C enters the electric field between two horizontally charged plates that are 8.00 cm apart, as shown in the diagram. The oil drop passes through the plates undeflected at a uniform speed of 10.0 cm/s. (Ignore the effects of the nonuniform electric field at the ends of the plates.)



   a. Draw electric field lines between the plates in the diagram. [Appendix A]
   b. Identify the sign of the charge on the oil drop. [Appendix A] negative
   c. Determine the potential difference between the two plates. [84.3 kV]



c) $F_{el} = F_g$

$q|E| = mg$

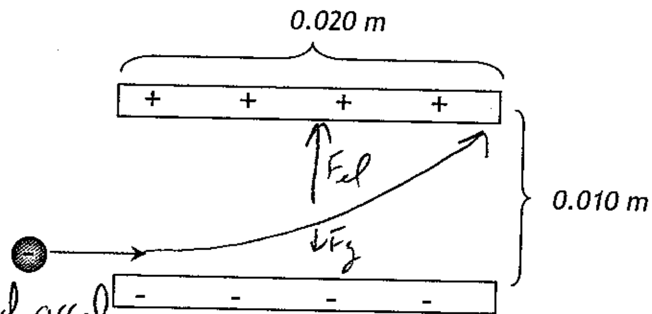
$q\frac{V}{d} = mg$

$5.4\times10^{-14} \cdot \frac{V}{0.08} = (5.80\times10^{-9})(9.81)$

$V = 84293.3\ V$ or $\underline{84.3\ kV}$

13. A charged oil drop is sent in through the uniform electric field between two parallel plates as shown in the diagram below. The potential difference is adjusted so that the charged particle just contacts the upper right side of the positive plate. (Ignore the effects of the non-uniform electric field at the ends of the plates.) Determine the charge on the particle. [1.4 x 10^{-8} C]

Mass of oil drop:	5.0×10^{-5} kg
Initial velocity of particle:	0.70 m/s, directly to the right
Electric field between plates:	120 kV/m



i) find upward accel

x	y
$v_x = \frac{d_x}{t}$	$d = \cancel{v_i t} + \frac{1}{2}at^2$
$t = \frac{0.020\,m}{0.70\,m/s}$	$0.010\,m = \frac{1}{2}a(0.028...)^2$
$t = 0.02857\,s$	$a = 24.5\,m/s^2$

ii) find q)

$$F_{net} = F_{el} - F_g$$

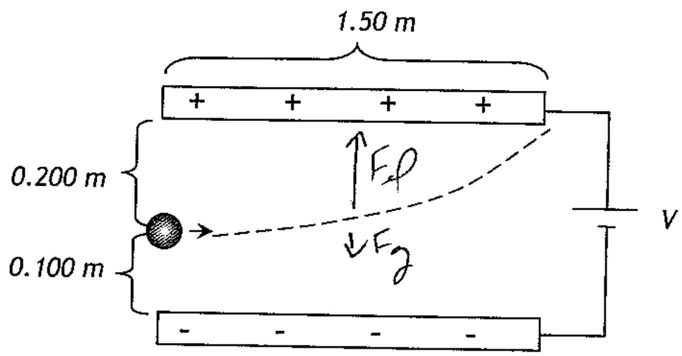
$$ma = q|\vec{E}| - mg$$

$$\frac{m(a+g)}{|\vec{E}|} = q$$

$$\frac{(5.0\times10^{-5})(24.5+9.81)}{120\,000} = q$$

$$1.4\times10^{-8}\,C = q$$

14. A 1.20 x 10^{-6} kg particle having a charge of -0.500 μC is travelling horizontally at 5.00 m/s when it enters the region between two charged plates as shown in the diagram. The particle strikes the top plate at its extreme right end. Determine the potential difference between the plates. (Ignore the effects of the nonuniform electric field at the ends of the plates.) [10.3 V]



$F_{el} > F_g$

i)

x	y
$v_x = \frac{d_x}{t}$	$d = \cancel{v_i t} + \frac{1}{2}at^2$
$5.00\,m/s = \frac{1.50\,m}{t}$	$0.200 = \frac{1}{2}a(0.30)^2$
$t = 0.30\,s$	$a = 4.44\,m/s^2$

ii) $\vec{F}_{net} = \vec{F}_{el} - F_g$

$ma = q|\vec{E}| - mg$

$(1.20\times10^{-6} \cdot 4.44\,m/s^2) = .5\times10^{-6} \cdot |\vec{E}| - (1.20\times10^{-6} \cdot 9.81)$

$5.333\times10^{-6} = .5\times10^{-6} \cdot |\vec{E}| - 1.1772\times10^{-5}$

$1.710\times10^{-5} = .5\times10^{-6}|\vec{E}|$

$34.21\ldots \frac{V}{m} = |\vec{E}|$

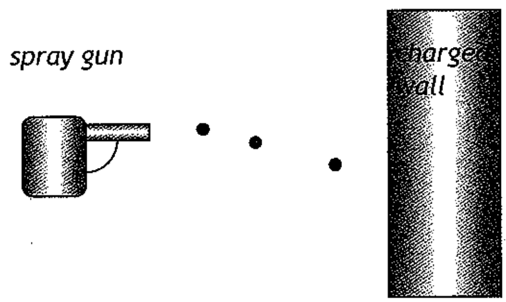
iii) $|\vec{E}| = \frac{V}{d}$

$34.21\ldots = \frac{V}{0.30\,m}$

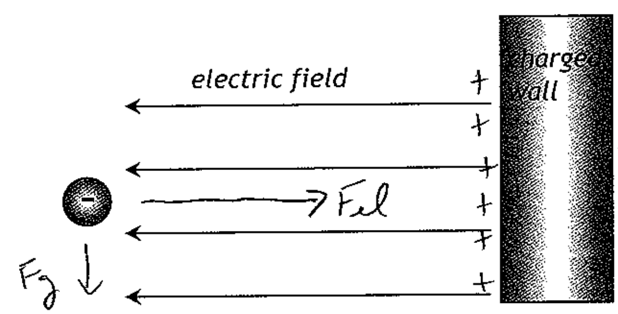
$V = 10.3\,V$

Use the information below to answer question 15.

Paint may be applied to a surface using electrostatic principles. This process was invented by Ransburg in 1938. Negatively charged paint particles are sprayed at low speed to a charged surface which attracts the charged particles. This method of painting has the advantage of wasting much less paint than conventional painting methods. [Appendix A]



15. A 2.30×10^{-10} kg negatively charged paint droplet of 9.25×10^{-14} C is travelling towards the wall where it enters the wall's uniform electric field of 4.50×10^{4} N/C shown below.
   a. Draw the forces (i.e., free-body diagram) acting on the charged particle below.
   b. Identify the charge (positive, negative or neutral) on the wall's surface. +
   c. Determine the net force acting on the particle. [4.74 nN, 28.5° down from the horizontal]



$F_g = mg$
$= (2.30 \times 10^{-10})(9.81)$
$= 2.256 \times 10^{-9}$ N

$|\vec{E}| = \frac{F_{el}}{q}$

$4.50 \times 10^{4} = \frac{F_{el}}{9.25 \times 10^{-14}\ C}$

$F_{el} = 4.163 \times 10^{-9}$ N

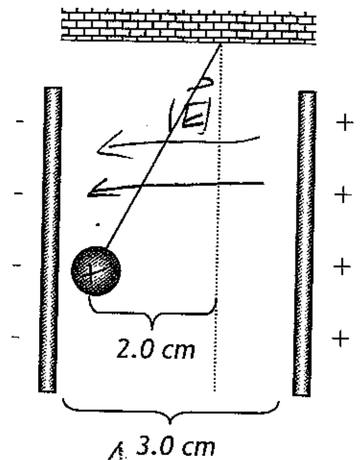
4.163×10^{-9}
2.256×10^{-9}
θ
F_{net}

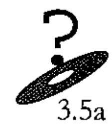
$F_{net} = \sqrt{(4.163 \times 10^{-9})^2 + (2.256 \times 10^{-9})^2}$
$= 4.7349.. \times 10^{-9}$ N

or 4.74 nN

$\tan \theta = \frac{opp}{adj}$
$= 28.5°$

16. A 4.20×10^{-3} kg pith ball, having a charge magnitude of 2.40 μC, is suspended on a 90.0 cm long string between two oppositely charged parallel plates as shown in the diagram. The pith ball is 2.00 cm from its original vertical position before the plates were charged. [Appendix A]

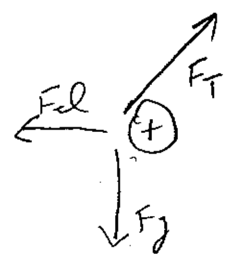




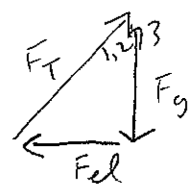
3.5a

a. Identify the sign of the charge on the pith ball. +
b. Use arrows to draw the electric field direction between the two charged plates on the diagram.
c. Draw a free-body diagram for the pith ball.
d. Determine the magnitude of the electric field between the plates. [381 N/C]
e. Determine the potential difference between the two charged plates. [11.4 V] $|E| = \frac{V}{d}$

c)



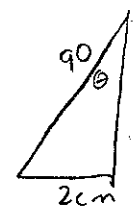
suspended ... so F_T and $F_{el} + F_g$ balance



d) $|\vec{E}| = \frac{F_{el}}{q} = \frac{9.15 \times 10^{-4}}{2.40 \times 10^{-6}\,C}$

$= 381.49$
$= 381\ N/C$

$\tan 1.273 = \frac{F_{el}}{F_g}$



$\sin\theta = \frac{2}{90}$

$\theta = 1.273^{\circ}$

$\tan 1.273 = \frac{F_{el}}{4.2 \times 10^{-3} \times 9.81}$

$F_{el} = 9.15578 \times 10^{-4}\,N$

e) $|E| = \frac{V}{d}$

$381.49 = \frac{V}{0.03}$

$V = 11.44\,V$

$11.4\,V$