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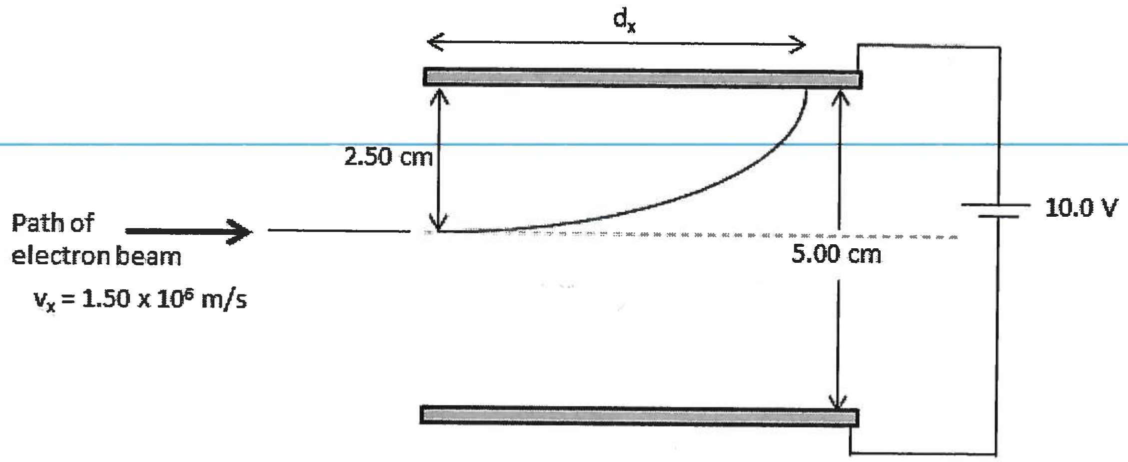
First Name:______________________________ Last Name:______________________________

L07 – Worksheet – Parallel Plates

Introductory Questions

Q1: An electron (beam) is projected horizontally between vertical plates. The electron doesn't make it all of the way through, and instead smashes into one of the plates. What is its horizontal displacement, in meters?



Ⓐ $\lvert\vec{E}\rvert = \frac{\Delta V}{\Delta d}$ $\lvert\vec{E}\rvert = \frac{10.0\,V}{0.05\,m}$ $\lvert\vec{E}\rvert = 200\ N/C$	Ⓑ $\vec{E} = \frac{\vec{F}_e}{q}$ $\vec{F} = q\vec{E}$ $= (1.60\times10^{-19})(200)$ $= 3.2\times10^{-17}\,N$	Ⓒ $\vec{a} = \frac{\vec{F}_{net}}{m}$ $a = \frac{3.2\times10^{-17}}{9.11\times10^{-31}}$ $a = 3.5126\times10^{13}\,m/s^2$	$\vec{d} = \overset{0}{\cancel{\vec{v}_i t}} + \frac{1}{2}\vec{a}t^2$ y-comp $0.025 = \frac{1}{2}(3.5126\times10^{13})t^2$ $t = 3.7728\times10^{-8}\,s$
			$\vec{v}_{ave} = \frac{\Delta\vec{d}}{\Delta t}$ $d_x = v_x t$ $= (1.50\times10^{6})(3.7728\times10^{-8})$ $\boxed{= 0.05659\,m}$ $\approx 5.66\,cm$

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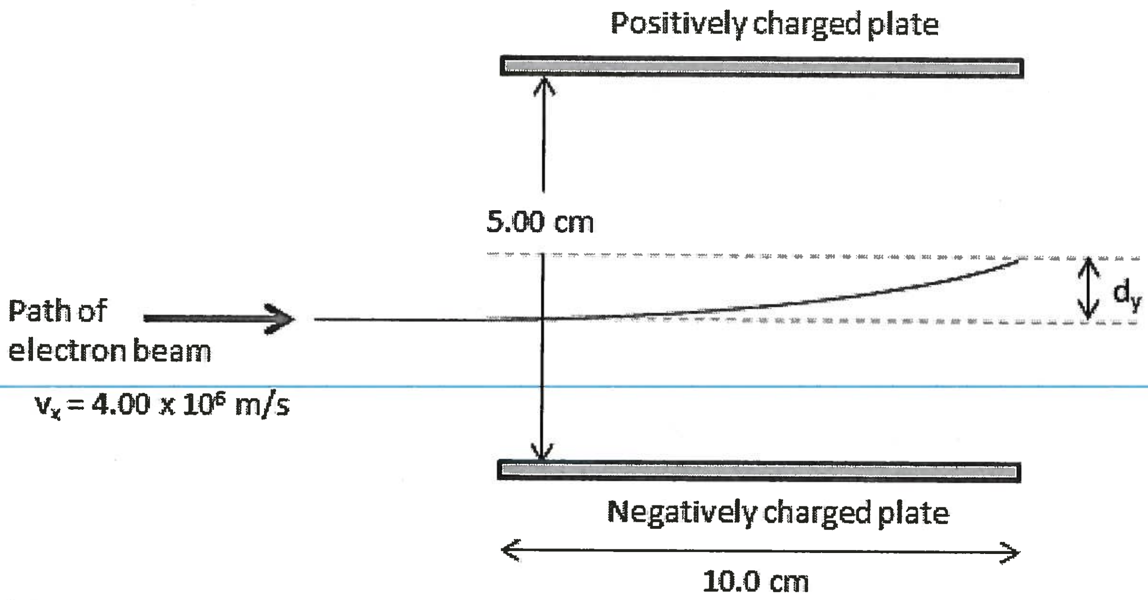
Q2: An electron (beam) is projected horizontally between vertical plates with a uniform electric field of 350 N/C. The electron successfully makes it through the plates. What is its vertical deflection, in meters?



Ⓐ $\lvert\vec{E}\rvert = \frac{\Delta V}{\Delta d}$ Given $\lvert\vec{E}\rvert = 350$ N/C	Ⓑ $\vec{E} = \frac{\vec{F}_e}{q}$ $\vec{F} = q\vec{E}$ $= (1.60\times10^{-19})(350)$ $= 5.60\times10^{-17}$ N	Ⓒ $\vec{a} = \frac{\vec{F}_{net}}{m}$ $a = \frac{5.60\times10^{-17}}{9.11\times10^{-31}}$ $a = 6.147\times10^{13}$ m/s²	$\vec{v}_{ave} = \frac{\Delta\vec{d}}{\Delta t}$ x-comp $t = \frac{d}{v} = \frac{0.10}{4.0\times10^6}$ $t = 2.50\times10^{-8}$ s
			$\vec{d} = \cancel{\vec{v}_i t}^{\,0} + \frac{1}{2}\vec{a}t^2$ y-comp $d = \frac{1}{2}(6.147\times10^{13})(2.5\times10^{-8})^2$ $\boxed{d = 1.92\times10^{-2}\text{ m}}$ ≈ 1.92 cm

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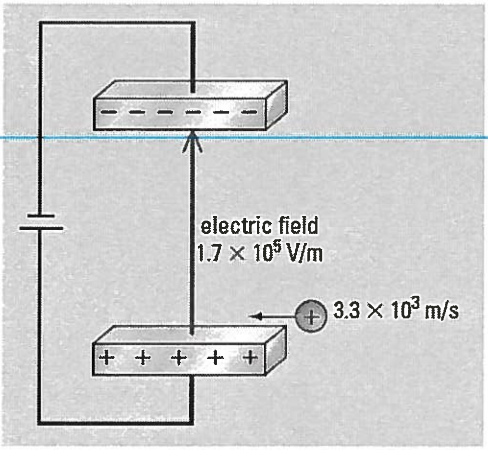
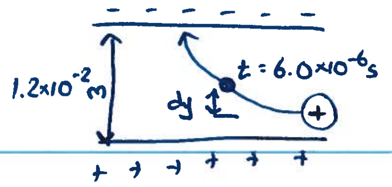
Textbook Questions

Pg 574 #1: Two horizontal parallel plates, 1.2×10^{-2} m apart, are connected to a DC power supply, as shown in the figure below. The electric field between the plates is 1.7×10^{5} V/m. A sphere of mass 3.0×10^{-15} kg with a positive charge of 2.6×10^{-12} C is injected into the region between the plates, with an initial speed of 3.3×10^{3} m/s, as shown. It accelerates toward the negative plate. Sketch the motion of the positive charge through the region between the plates, and determine the distance the positive charge moves towards the negative plate after 6.0×10^{-6}s have elapsed. Gravitational effects may be ignored in this case.

$|\vec{E}| = 1.7\times10^{5}$ V/m
$m = 3.0\times10^{-15}$ kg
$q = 2.6\times10^{-12}$ C





Ⓐ $|\vec{E}| = 1.7\times10^{5}$ V/m

Ⓑ $\vec{E} = \frac{\vec{F}}{q}$

$\vec{F} = q\vec{E}$
$= (2.6\times10^{-12})(1.7\times10^{5})$
$= 4.42\times10^{-7}$ N

Ⓒ $a = \frac{F_{net}}{m} = \frac{4.42\times10^{-7}}{3.0\times10^{-15}} = 1.473\times10^{8}$ m/s²

Ⓓ y-comp

$d = v_i t + \frac{1}{2}at^2$
$d = (0)(6.0\times10^{-6}) + \frac{1}{2}(1.473\times10^{8})(6.0\times10^{-6})^2$
$= 2.652\times10^{-3}$ m

Pg 574 #2: An electron, travelling at 2.3×10^{3} m/s, enters perpendicular to the electric field between two horizontal charged parallel plates. If the electric field strength is 1.5×10^{2} V/m, calculate the time taken for the electron to deflect a distance of 1.0×10^{-2} m towards the positive plate. Ignore gravitational effects.

$|\vec{E}| = 1.5\times10^{2}$ V/m or N/C
$m_e = 9.11\times10^{-31}$ kg
$q_e = 1.60\times10^{-19}$ C

Ⓐ $|\vec{E}| = 1.5\times10^{2}$ V/m

Ⓑ $\vec{E} = \frac{\vec{F}}{q}$

$\vec{F} = q\vec{E}$
$= (1.60\times10^{-19})(1.5\times10^{2})$
$= 2.40\times10^{-17}$ N

Ⓒ $a = \frac{F_{net}}{m} = \frac{2.40\times10^{-17}}{9.11\times10^{-31}} = 2.634\times10^{13}$ m/s²

Ⓓ y-comp

$d = v_i t + \frac{1}{2}at^2$
$1.0\times10^{-2} = (0)t + \frac{1}{2}(2.634\times10^{13})t^2$
$t = 2.756\times10^{-8}$ s

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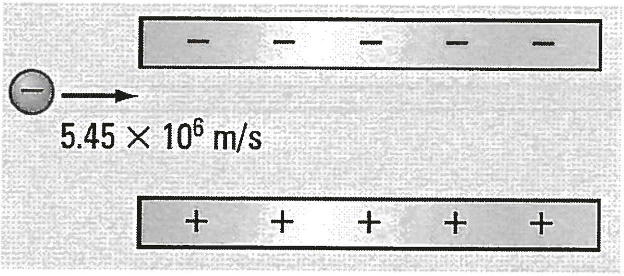
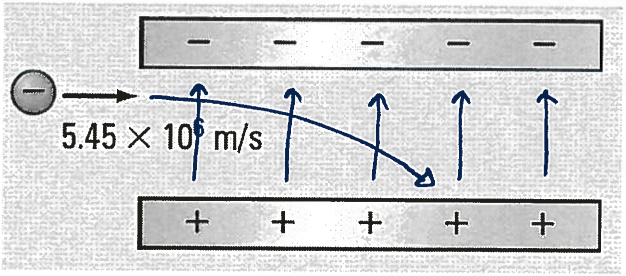
Pg 576 #10: An electron, travelling horizontally at a speed of 5.45×10^6 m/s, enters a parallel plate capacitor with an electric field of 125 N/C between the plates, as shown in the figure below.



$|\vec{E}| = 125 \, N/C$

$q = 1.60 \times 10^{-19} C$

a. Sketch the electric field lines between the plates, and the motion of the electron through the capacitor.



Field lines go out of a positive, into the negative.

Electron moves against field lines. Is attracted to positive plate.

b. Determine the force due to the electric field on the electron.

$|\vec{E}| = \frac{|\vec{F_e}|}{q}$

$\vec{F_e} = q\vec{E}$

$= (1.60 \times 10^{-19})(125)$

$= 2.00 \times 10^{-17} N$

c. Ignoring gravitational effects, calculate the acceleration of the electron.

$a = \frac{F_{net}}{m} = \frac{2.00 \times 10^{-17}}{9.11 \times 10^{-31}} = 2.195 \times 10^{13} m/s^2$

d. If the electron falls a vertical distance of 6.20×10^{-3} m towards the positive plate, how far will the electron travel horizontally between the plates?

x-comp

$V_x = 5.45 \times 10^6 m/s$

$d_x = ?$

$t = ?$

y-comp

$V_i = 0 m/s$

$a = 2.195 \times 10^{13} m/s^2$

$d = 6.20 \times 10^{-3} m$

$t = ?$

$d = v_i t + \frac{1}{2} a t^2$

$6.20 \times 10^{-3} = (0)t + \frac{1}{2}(2.195 \times 10^{13})t^2$

$t = 2.377 \times 10^{-8} s$

$V_x = \frac{d_x}{t}$

$5.45 \times 10^6 = \frac{d_x}{2.377 \times 10^{-8}}$

$d_x = 0.1295 m$

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Diploma Worksheet Questions – Parallel Plates (Basic Definitions)

Q205: A 9.0 V potential difference exists between two metal plates which are 1.8 x 10^{-3} m apart. The acceleration of an electron that enters the region between these plates will be

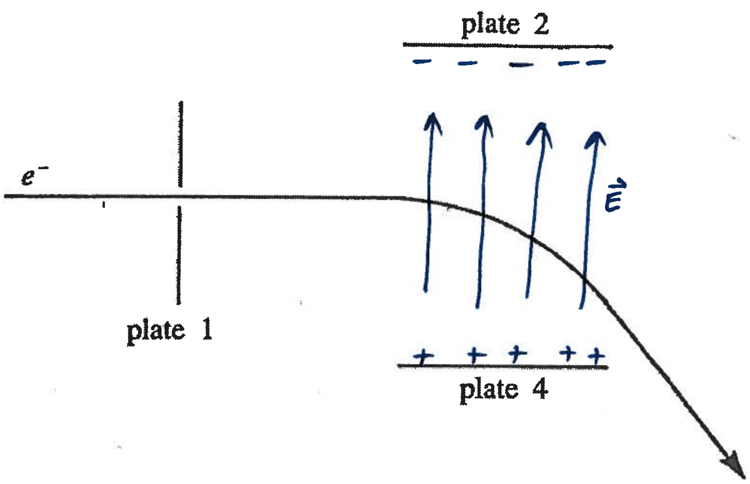
a. 8.0 x 10^{16} m/s^2
[✓ b.] 8.8 x 10^{14} m/s^2
c. 1.6 x 10^{7} m/s^2
d. 5.0 x 10^{3} m/s^2

Ⓐ $|\vec{E}| = \frac{\Delta V}{\Delta d}$ $\quad |\vec{E}| = \frac{9V}{1.8\times10^{-3}} = 5000\,N/C$

Ⓑ $\vec{E} = \frac{\vec{F}}{q}$ $\quad \vec{F} = q\vec{E} = (1.60\times10^{-19})(5000) = 8.0\times10^{-16}\,N$

Ⓒ $a = \frac{F_{net}}{m}$ $\quad a = \frac{F_{net}}{m} = \frac{8.0\times10^{-16}}{9.11\times10^{-31}} = 8.78\times10^{14}\,m/s^2$

Use the following information to answer Q206:



A beam of electrons moves horizontally to the right and enters the region between parallel plates 2 and 4, where the beam is deflected by an electric field as shown.

Q206: The direction of the electric field that causes this vertical deflection is from

[✓ a.] Plate 4 to plate 2
b. Plate 2 to plate 4
c. Plate 3 to plate 1
d. Plate 1 to plate 3

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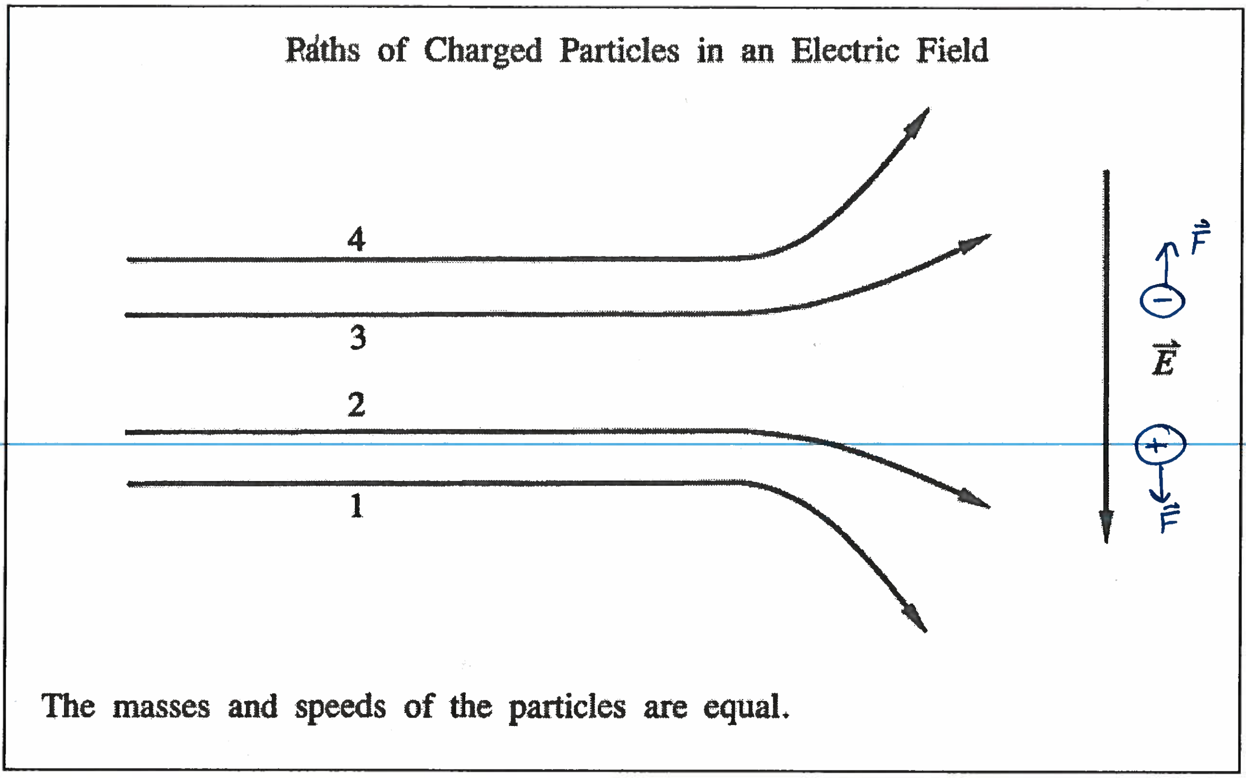
Use the following information to answer Q207:

Paths of Charged Particles in an Electric Field



The masses and speeds of the particles are equal.

Q207: Which statement is true?

- ~~a.~~ The charges on particles 2 and 3 are equal in magnitude and in sign.
- ~~b.~~ The charges on particles 3 and 4 are equal in magnitude and in sign.
- [✓ c.] The charges on particles 2 and 3 are equal in magnitude but not in sign.
- d. The charges on particles 3 and 4 are equal in magnitude but not in sign.

Q208: The acceleration of an electron in a uniform electric field of magnitude 5.0 x 10^{-4} N/C is

- a. 5.5 x 10^{26} m/s^2
- b. 8.0 x 10^{-23} m/s^2
- [✓ c.] 8.8 x 10^{7} m/s^2
- d. 9.0 x 10^{6} m/s^2

Ⓐ $|\vec{E}| = 5.0\times10^{-4}$ N/C

Ⓑ $\vec{E} = \frac{\vec{F}}{q}$ $\quad |\vec{F}| = q|\vec{E}| = (1.60\times10^{-19})(5.0\times10^{-4})$

$= 8.0\times10^{-23}$ N

Ⓒ $a = \frac{F_{net}}{m} = \frac{8.0\times10^{-23}}{9.11\times10^{-31}} = 8.78\times10^{7}$ m/s^2

Challenge Questions

None

Cumulative Review from Previous Units

None