AP® Physics B
1999 Sample Student Responses

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2. (15 points)
In a television set, electrons are first accelerated from rest through a potential difference in an electron gun. They then pass through deflecting plates before striking the screen.

(a) Determine the potential difference through which the electrons must be accelerated in the electron gun in order to have a speed of 6.0 $\times 10^7$ m/s when they enter the deflecting plates.

$E_0 = E_f$

$PE_0 + KE_0 = KE_f + PE_f$ (PE$_0$ = 0, PE$_f$ = 0)

$PE_0 = KE_f$

$qV = \frac{1}{2} m v_e^2$

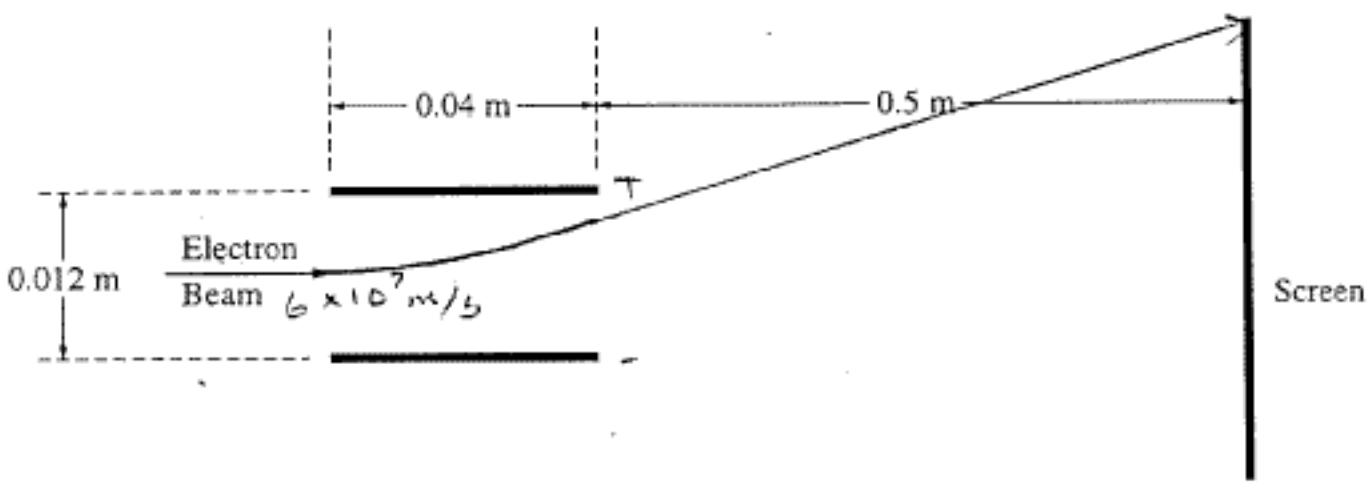
$V = \frac{m v_e^2}{2q}$

$V = \frac{(9.11 \times 10^{-31}\,kg)(6.0 \times 10^7\,m/s)^2}{2(1.6 \times 10^{-19}\,C)}$

$V = 10249.75$ Volts

$V = 1.0 \times 10^4$ Volts

The pair of horizontal plates shown below is used to deflect electrons up or down in the television set by placing a potential difference across them. The plates have length 0.04 m and separation 0.012 m, and the right edge of the plates is 0.50 m from the screen. A potential difference of 200 V is applied across the plates, and the electrons are deflected toward the top of the screen. Assume that the electrons enter horizontally midway between the plates with a speed of 6.0 $\times 10^7$ m/s and that fringing effects at the edges of the plates and gravity are negligible.



Note: Figure not drawn to scale.

(b) Which plate in the pair must be at the higher potential for the electrons to be deflected upward? Check the appropriate box below.

☑ Upper plate ☐ Lower plate

Justify your answer.

Since electrons are attracted to positive charges and since by convention current flows from "+" to "-", which places positive charges at a higher potential, the upper plate must be positive and therefore at a higher potential.

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(c) Considering only an electron's motion as it moves through the space between the plates, compute the following.

In x dir:
$v_0 = 6 \times 10^7$ m/s
$v_f = 6 \times 10^7$ m/s
$t = ?$
$a = 0$
$\Delta x = .104$ m

i. The time required for the electron to move through the plates

$\Delta x = v_0 t + \frac{1}{2} a t^2$ (0)

$\frac{\Delta x}{v_0} = t$

$t = \frac{.104\ m}{6 \times 10^7\ m/s}$

$t = 6.7 \times 10^{-10}$ s

y-dir:

$F = E q_0$

$V = Ed$

$\frac{V}{d} = E$

$F = \frac{V q_0}{d}$

ii. The vertical displacement of the electron while it is between the plates

$\Sigma F_y = ma$

$\frac{V q_0}{d} = ma$

$a = \frac{V q_0}{md}$

$a = \frac{(200\ V)(1.6 \times 10^{-19}\ C)}{(9.11 \times 10^{-31}\ kg)(.012\ m)}$

$a = 2.927 \times 10^{15}\ m/s^2$

$v_0 = 0$

$\Delta x = ?$

$t = 6.7 \times 10^{-10}$ s

$\Delta x = v_0 t + \frac{1}{2} a t^2$ ($v_0 t$ = 0)

$\Delta x = \frac{1}{2} (2.93 \times 10^{15}\ m/s^2)(6.7 \times 10^{-10}\ s)^2$

$\Delta x = 6.57 \times 10^{-4}$ m

$\Delta x = 6.6 \times 10^{-4}$ m

(d) Show why it is a reasonable assumption to neglect gravity in part (c).

The force provided by the potential difference is much much greater than the gravitational force exerted on an electron.

$\frac{V q_0}{d} >> mg$

2.4×10^{-15} N $>>$ 8.9278×10^{-30} N

(e) Still neglecting gravity, describe the path of the electrons from the time they leave the plates until they strike the screen. State a reason for your answer.

After the electrons leave the plates, there are no more substantial forces acting on them. This provides for no acceleration as described in #1)d). Since there is no acceleration, the electrons will follow a straight path at the angle formed during the time spent between the plates. (See diagram

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2. (15 points)
In a television set, electrons are first accelerated from rest through a potential difference in an electron gun. They then pass through deflecting plates before striking the screen.

(a) Determine the potential difference through which the electrons must be accelerated in the electron gun in order to have a speed of 6.0×10^7 m/s when they enter the deflecting plates.

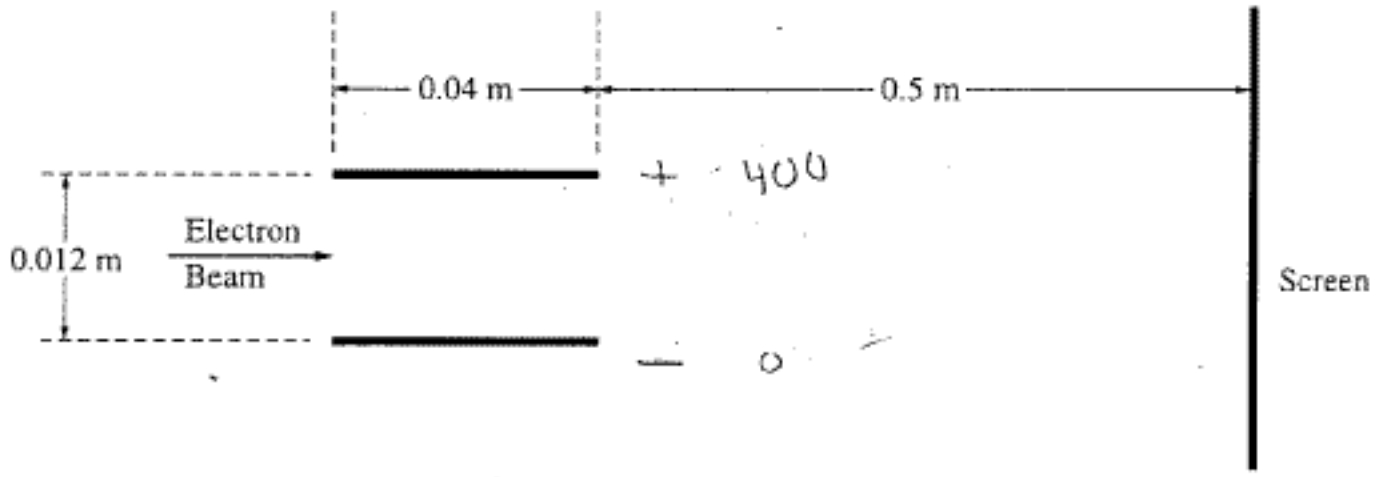
$U_e = KE$

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

$V = \frac{m(6.0\times10^7)^2}{2q}$

$V = \frac{(9.11\times10^{-31})(6\times10^7)^2}{2(1.6\times10^{-19})} = 10,248\text{ V}$

The pair of horizontal plates shown below is used to deflect electrons up or down in the television set by placing a potential difference across them. The plates have length 0.04 m and separation 0.012 m, and the right edge of the plates is 0.50 m from the screen. A potential difference of 200 V is applied across the plates, and the electrons are deflected toward the top of the screen. Assume that the electrons enter horizontally midway between the plates with a speed of 6.0×10^7 m/s and that fringing effects at the edges of the plates and gravity are negligible.



Note: Figure not drawn to scale.

(b) Which plate in the pair must be at the higher potential for the electrons to be deflected upward? Check the appropriate box below.

☒ Upper plate ☐ Lower plate

Justify your answer.

Because the upper plate must be positive to attract electron. So a positive charge would have higher potential if placed next to the upper plate. So upper plate must be at a higher potential

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(c) Considering only an electron's motion as it moves through the space between the plates, compute the following.

i. The time required for the electron to move through the plates

$S = V_0 \times t$

$\frac{0.04}{6 \times 10^7} = t$

$6.67 \times 10^{-10}\ s = t$

$S = 0.04$
$a = 2.9 \times 10^{15}$
$V_0 = 6 \times 10^7$

$\therefore S = V_0 t + \frac{1}{2} a t^2$

$0.04 = 6 \times 10^7 t + \frac{1}{2} 2.9 \times 10^{15} t^2$

$1.96 \times 10^{15} t^2 + 6 \times 10^7 t - 0.04 = 0$

$t = \frac{-6 \times 10^7 \pm \sqrt{(6 \times 10^7)^2 + 4(1.96 \times 10^{15})(0.04)}}{2(1.96 \times 10^{15})}$

$t = \frac{-6 \times 10^7 \pm \sqrt{3.6 \times 10^{15}}}{2(1.96 \times 10^{15})}$

$t = \frac{0.19}{2(1.96 \times 10^{15})}$

$t = 6.5 \times 10^{-17}\ s$

ii. The vertical displacement of the electron while it is between the plates

$E = \frac{V}{d}$

$E = \frac{200}{0.012}$

$E = 1.67 \times 10^4$

$F = qE = ma$

$\frac{1.6 \times 10^{-19} \times 1.67 \times 10^4}{9.11 \times 10^{-31}} = a$

$2.9 \times 10^{15} = a$

$S_y = \frac{1}{2} a t^2$

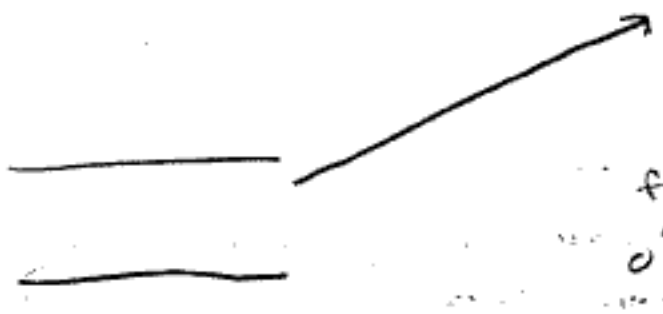
$S_y = \frac{1}{2}(2.9 \times 10^{15})(6.67 \times 10^{-10})^2$

$S_y = 6.52 \times 10^{-4}\ m + \frac{1}{2}(0.012) = 6.65 \times 10^{-3}$

(d) Show why it is a reasonable assumption to neglect gravity in part (c).

because the mass of electron is so small.

(e) Still neglecting gravity, describe the path of the electrons from the time they leave the plates until they strike the screen. State a reason for your answer.



The velocity is constant because there are no acting forces on the electron. 0° speed & direction of electron is constant

2. (15 points)
In a television set, electrons are first accelerated from rest through a potential difference in an electron gun. They then pass through deflecting plates before striking the screen.

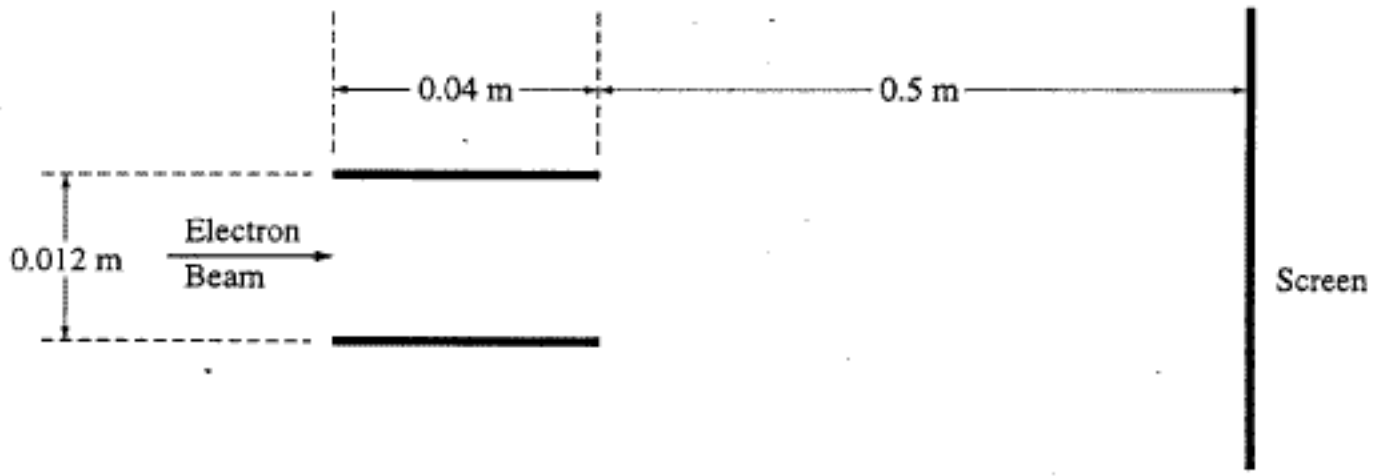
(a) Determine the potential difference through which the electrons must be accelerated in the electron gun in order to have a speed of 6.0×10^7 m/s when they enter the deflecting plates.

$qV = \frac{1}{2}mv^2 \quad (1.6\times10^{-19})(V) = \frac{1}{2}(9.11\times10^{-31})(6.0\times10^{7})^2$

$V = \frac{1.6398\times10^{-15}}{1.6\times10^{-19}} = 10248.75$ Volts

(significant digit) ≈ 10000 Volts

The pair of horizontal plates shown below is used to deflect electrons up or down in the television set by placing a potential difference across them. The plates have length 0.04 m and separation 0.012 m, and the right edge of the plates is 0.50 m from the screen. A potential difference of 200 V is applied across the plates, and the electrons are deflected toward the top of the screen. Assume that the electrons enter horizontally midway between the plates with a speed of 6.0×10^7 m/s and that fringing effects at the edges of the plates and gravity are negligible.



Note: Figure not drawn to scale.

(b) Which plate in the pair must be at the higher potential for the electrons to be deflected upward? Check the appropriate box below.

☐ Upper plate ☑ Lower plate

Justify your answer.

Because the charge of an electron is negative, it would be repelled by a negative plate and attracted to the positive plate. so if the electron hits the top of the screen it must be repelled by the bottom plate (negative) and attracted to the top plate (positive)

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(c) Considering only an electron's motion as it moves through the space between the plates, compute the following.

i. The time required for the electron to move through the plates

$s = vit$

$.04 = 6.0 \times 10^7 t$

$t = 6.667 \times 10^{-10}$

$\approx 6.7 \times 10^{-10}$

ii. The vertical displacement of the electron while it is between the plates

$E = \frac{V}{d}$ $\quad F = qE$

$E = \frac{10000}{.012} = 8.33333 \times 10^5$

$F = Eq = (8.3 \times 10^5)(1.6 \times 10^{-19}) = 1.3 \times 10^{-13}$

So $F = ma$ $\quad \frac{1.3 \times 10^{-13}}{9.11 \times 10^{-31}} = a = 1.4636 \times 10^{17}$

$s = \frac{1}{2} at^2$

$s = .033$ meters

(d) Show why it is a reasonable assumption to neglect gravity in part (c).

because of the extremely large acceleration of the electron, the effect of gravity would be neglected anway because only the first two digits (in this problem) are the significant digits.

(e) Still neglecting gravity, describe the path of the electrons from the time they leave the plates until they strike the screen. State a reason for your answer.

The electron would follow a parabolic path upwards between the plates. Once it leaves the plates the electron would go at a constant velocity and a linear path towards the screen.

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