AP® Physics B
2003 Sample Student Responses
Form B

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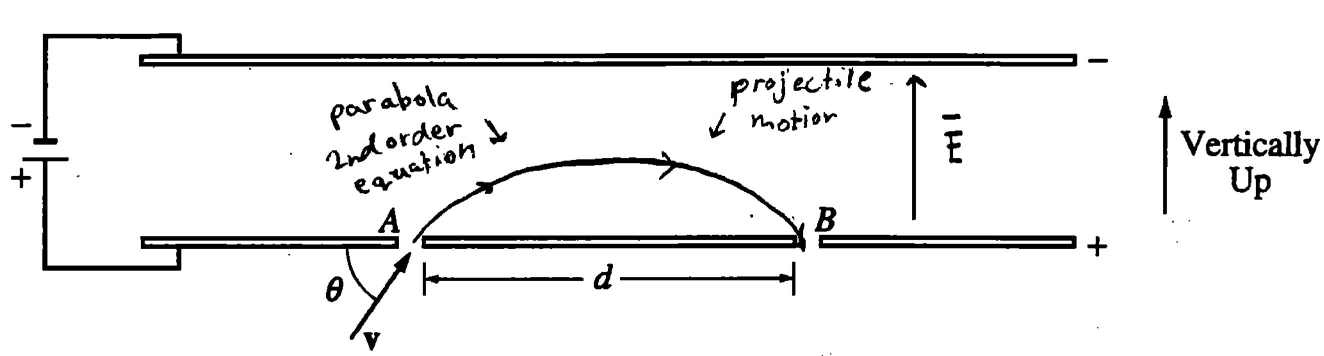
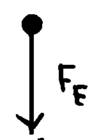


4. (15 points)
An electric field **E** exists in the region between the two electrically charged parallel plates shown above. A beam of electrons of mass *m*, charge *q*, and velocity **v** enters the region through a small hole at position *A*. The electrons exit the region between the plates through a small hole at position *B*. Express your answers to the following questions in terms of the quantities *m*, *q*, **E**, *θ*, and **v**. Ignore the effects of gravity.

(a) i. On the diagram of the parallel plates above, draw and label a vector to show the direction of the electric field **E** between the plates.

ii. On the following diagram, show the direction of the force(s) acting on an electron after it enters the region between the plates.



iii. On the diagram of the parallel plates above, show the trajectory of an electron that will exit through the small hole at position *B*.

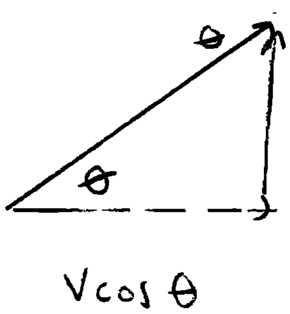
(b) Determine the magnitude of the acceleration of an electron after it has entered the region between the parallel plates.

$F = Eq$ $\quad F = ma$

$ma = Eq$

$$a = \frac{Eq}{m}$$

(c) Determine the total time that it takes the electrons to go from position *A* to position *B*.



$x = \bar{v}t$

$x = v_i t + \frac{1}{2}at^2$

$a = \frac{v_f - v_i}{t}$ (to go up)

$-\frac{Eq}{m} = \frac{0 - v\sin\theta}{t}$

$t = \frac{v\sin\theta\, m}{Eq}$ (to go up)

$$t = \frac{2v\sin\theta\, m}{Eq}$$

GO ON TO THE NEXT PAGE.

(d) Determine the distance d between positions A and B.

$x = \bar{v} t$

$x = v \cos\theta \left(\frac{2 v \sin\theta m}{E q}\right)$

$$d = \frac{2 \cos\theta \sin\theta v^2 m}{E q}$$

(e) Now assume that the effects of gravity cannot be ignored in this problem. How would the distance d change for an electron entering the region at A and leaving at B? Explain your reasoning.

it would be shorter,

because gravity is another force acting down

the electron's acceleration down greater

this would make the time it takes to go up

and come down shorter

$d = v_x t$

because g doesn't change velocity in the

x direction but make t smaller

∴ d would be smaller

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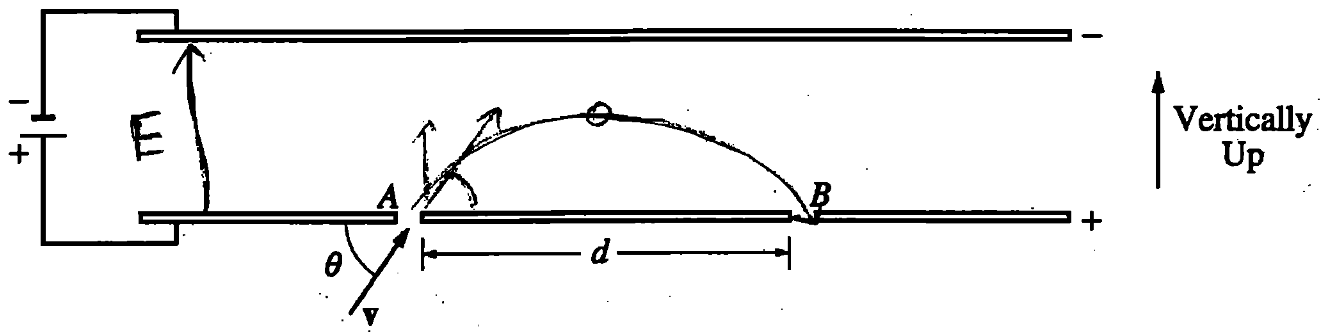
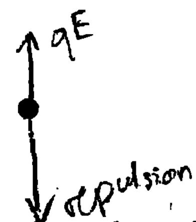


4. (15 points)

An electric field **E** exists in the region between the two electrically charged parallel plates shown above. A beam of electrons of mass m, charge q, and velocity **v** enters the region through a small hole at position A. The electrons exit the region between the plates through a small hole at position B. Express your answers to the following questions in terms of the quantities m, q, **E**, θ, and **v**. Ignore the effects of gravity.

(a) i. On the diagram of the parallel plates above, draw and label a vector to show the direction of the electric field **E** between the plates.

ii. On the following diagram, show the direction of the force(s) acting on an electron after it enters the region between the plates.



iii. On the diagram of the parallel plates above, show the trajectory of an electron that will exit through the small hole at position B.

(b) Determine the magnitude of the acceleration of an electron after it has entered the region between the parallel plates.

$qE = ma$

$a = \frac{qE}{m}$

(c) Determine the total time that it takes the electrons to go from position A to position B.

$v_y = v\sin\theta$

$v_f = v_o + at$

v_f at the top $= 0$ m/s

$v_o = at$

$v\sin\theta = \frac{qE}{m} t$

$t = \frac{mv\sin\theta}{qE}$

$T = 2t = \frac{2mv\sin\theta}{qE}$

GO ON TO THE NEXT PAGE.

(d) Determine the distance d between positions A and B.

$d = v_x t$

$v_x = v\cos\theta$

$d = v\cos\theta \times \frac{2mv\sin\theta}{qE}$

$= \frac{2mv^2\sin\theta\cos\theta}{qE}$

(e) Now assume that the effects of gravity cannot be ignored in this problem. How would the distance d change for an electron entering the region at A and leaving at B? Explain your reasoning.

The acceleration would be less and therefore time would be greater. If time is greater, then d would be greater as well.

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