# AP® PHYSICS B (Form B)
# 2007 SCORING GUIDELINES

## General Notes About 2007 AP Physics Scoring Guidelines

1. The solutions contain the most common method of solving the free-response questions and the allocation of points for this solution. Some also contain a common alternate solution. Other methods of solution also receive appropriate credit for correct work.

2. Generally, double penalty for errors is avoided. For example, if an incorrect answer to part (a) is correctly substituted into an otherwise correct solution to part (b), full credit will usually be awarded. One exception to this may be cases when the numerical answer to a later part should be easily recognized as wrong, e.g., a speed faster than the speed of light in vacuum.

3. Implicit statements of concepts normally receive credit. For example, if use of the equation expressing a particular concept is worth one point, and a student's solution contains the application of that equation to the problem but the student does not write the basic equation, the point is still awarded. However, when students are asked to derive and expression it is normally expected that they will begin by writing one or more fundamental equations, such as those given on the AP Physics exam equation sheet. For a description of the use of such terms as "derive" and "calculate" on the exams, and what is expected for each, see "The Free-Response Sections—Student Presentation" in the *AP Physics Course Description* .

4. The scoring guidelines typically show numerical results using the value $g = 9.8 \text{ m/s}^2$ , but use of $10 \text{ m/s}^2$ is of course also acceptable. Solutions usually show numerical answers using both values when they are significantly different.

5. Strict rules regarding significant digits are usually not applied to numerical answers. However, in some cases answers containing too many digits may be penalized. In general, two to four significant digits are acceptable. Numerical answers that differ from the published answer due to differences in rounding throughout the question typically receive full credit. Exceptions to these guidelines usually occur when rounding makes a difference in obtaining a reasonable answer. For example, suppose a solution requires subtracting two numbers that should have five significant figures and that differ starting with the fourth digit (e.g., 20.295 and 20.278). Rounding to three digits will lose the accuracy required to determine the difference in the numbers, and some credit may be lost.

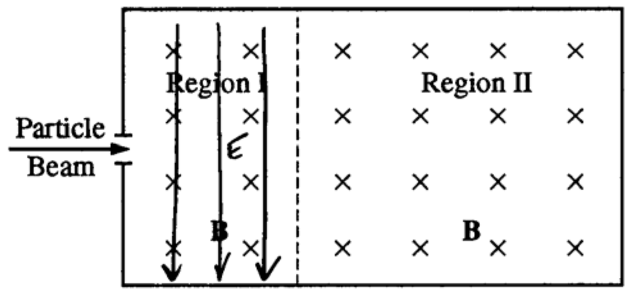
# AP® PHYSICS B
# 2007 SCORING GUIDELINES (Form B)

## Question 2

**10 points total** | **Distribution of points**

(a)

(i) 2 points




For at least two correct electric field lines in the right directions — 1 point

For the lines going through the entire Region I from top to bottom — 1 point

<u>Note:</u> *A single line going from top to bottom could earn a maximum of 1 point.*

(ii) 2 points

For either of the first two equations below — 1 point

$qvB = qE$

$v = E/B$

$v = (4800\ \text{N/C})/(0.12\ \text{T})$

$v = 4.0 \times 10^4\ \text{m/s}$

For the correct answer with units — 1 point

(b) 2 points

$qvB = \dfrac{mv^2}{r}$

For the correct equation for the radius — 1 point

$r = \dfrac{mv}{qB}$

For correct substitutions consistent with the answer to (a)(ii) — 1 point

$$r = \frac{\left(6.68 \times 10^{-26}\ \text{kg}\right)\left(4.0 \times 10^4\ \text{m/s}\right)}{\left(3.2 \times 10^{-19}\ \text{C}\right)(0.12\ \text{T})}$$

$r = 0.070\ \text{m}$

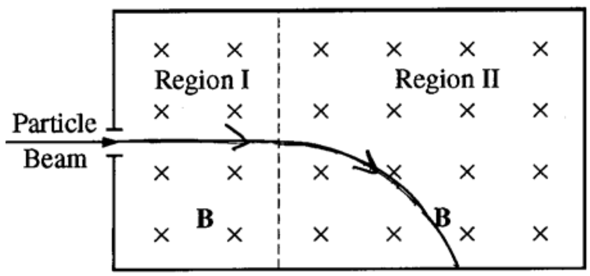
**Question 2 (continued)**

**Distribution of points**

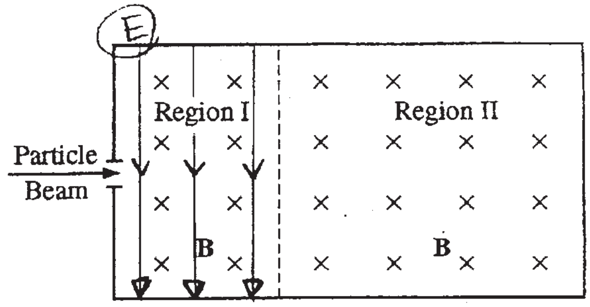
(c) 2 points

| | |
|---|---|
| For indicating that the initial force is "Toward the bottom of the page" | 1 point |
| For a correct justification indicating that the magnetic force ( $F_B = qvB$ ) decreases as velocity decreases, while the electric force ( $F_E = qE$ ) remains the same, so $F_E > F_B$. | 1 point |

(d) 2 points




| | |
|---|---|
| For the path in Region I being straight and horizontal | 1 point |
| For the path in Region II being a circular arc, curving downward | 1 point |




2. (10 points)

A beam of particles of charge $q = +3.2 \times 10^{-19}$ C and mass $m = 6.68 \times 10^{-26}$ kg enters region I with a range of velocities all in the direction shown in the diagram above. There is a magnetic field in region I directed into the page with magnitude $B = 0.12$ T. Charged metal plates are placed in appropriate locations to create a uniform electric field of magnitude $E = 4800$ N/C in region I. As a result, some of the charged particles pass straight through region I undeflected. Gravitational effects are negligible.

(a)

i. On the diagram above, sketch electric field lines in region I.

ii. Calculate the speed of the particles that pass straight through region I.

for the particles to go in a straight line, magnetic force and electric force must be given to the particle in the same magnitude, but opposite directions.

$$\therefore \cancel{q}vB = \cancel{q}E \rightarrow v = \frac{E}{B} = \frac{4800\ N/C}{0.12T} = 40000\ m/s$$

The particles that pass straight through enter region II in which there is no electric field and the magnetic field has the same magnitude and direction as in region I. The path of the particles in region II is a circular arc of radius $R$.

(b) Calculate the radius $R$.

Without electric field, the particles receive only magnetic fields. These will ~~mo~~ do uniform circular motion.

$$\frac{mv^{\cancel{2}}}{R} = q\cancel{v}B \rightarrow R = \frac{mv}{qB} = \frac{6.68\times10^{-26}kg \times 40000\ m/s}{3.2\times10^{-19}C \times 0.12T}$$

$$\doteqdot 0.07\ m$$

GO ON TO THE NEXT PAGE.

(c) Within the beam there are particles moving slower than the speed you calculated in (a)ii. In what direction is the net initial force on these particles as they enter region I?

____ To the left ____ Toward the top of the page ____ Out of the plane of the page

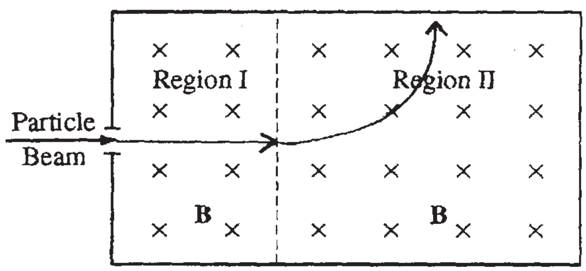
____ To the right ✓ Toward the bottom of the page ____ Into the plane of the page

Justify your answer.

Since these particles are positively charged, they receive upward magnetic force and downward electric force. If v is smaller than 40000 m/s,

$F_B = qvB < F_E = qE$. Therefore they will move toward the direction which electric force does work, which is downward.

(d) A particle of the same mass and the same speed as in (a)ii but with charge $q = -3.2 \times 10^{-19}$ C enters region I. On the following diagram, sketch the complete resulting path of the particle.

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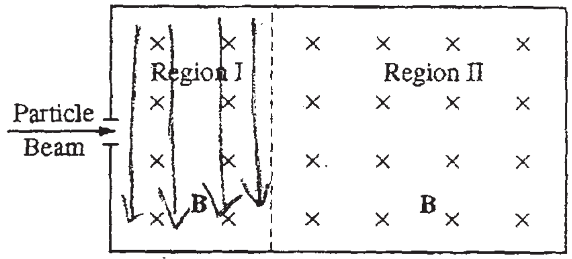



2. (10 points)

A beam of particles of charge $q = +3.2 \times 10^{-19}$ C and mass $m = 6.68 \times 10^{-26}$ kg enters region I with a range of velocities all in the direction shown in the diagram above. There is a magnetic field in region I directed into the page with magnitude $B = 0.12$ T. Charged metal plates are placed in appropriate locations to create a uniform electric field of magnitude $E = 4800$ N/C in region I. As a result, some of the charged particles pass straight through region I undeflected. Gravitational effects are negligible.

(a)

i. On the diagram above, sketch electric field lines in region I.

ii. Calculate the speed of the particles that pass straight through region I.

$F = qvB \sin\theta$

$1.536\times10^{-15} = 3.2\times10^{-19} \times v \times 0.12$

$v = \frac{1.536\times10^{-15}}{3.2\times10^{-19}\times0.12} = 4\times10^{4}$ m/s

$F = qE$

$= 3.2\times10^{-19} \times 4800$

$= 1.536\times10^{-15}$ N

The particles that pass straight through enter region II in which there is no electric field and the magnetic field has the same magnitude and direction as in region I. The path of the particles in region II is a circular arc of radius $R$.

(b) Calculate the radius $R$.

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

$1.536\times10^{-15} = \frac{6.68\times10^{-26}\times(4\times10^{4})^2}{r}$

$R = 0.696$ m

GO ON TO THE NEXT PAGE.

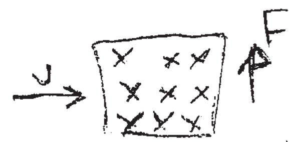
(c) Within the beam there are particles moving slower than the speed you calculated in (a)ii. In what direction is the net initial force on these particles as they enter region I?

____ To the left   _X_ Toward the top of the page   ____ Out of the plane of the page

____ To the right   ____ Toward the bottom of the page   ____ Into the plane of the page

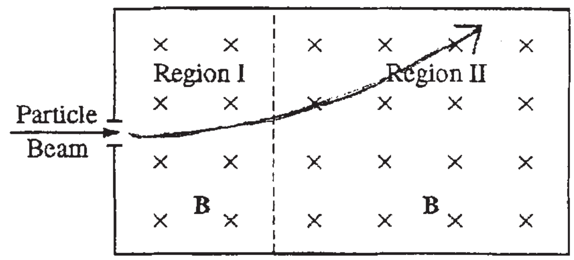
Justify your answer.

By using the right hand theorem




(into the page)

(d) A particle of the same mass and the same speed as in (a)ii but with charge $q = -3.2 \times 10^{-19}$ C enters region I. On the following diagram, sketch the complete resulting path of the particle.

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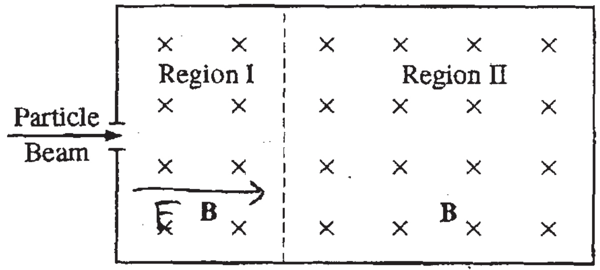



2. (10 points)

A beam of particles of charge $q = +3.2 \times 10^{-19}$ C and mass $m = 6.68 \times 10^{-26}$ kg enters region I with a range of velocities all in the direction shown in the diagram above. There is a magnetic field in region I directed into the page with magnitude $B = 0.12$ T. Charged metal plates are placed in appropriate locations to create a uniform electric field of magnitude $E = 4800$ N/C in region I. As a result, some of the charged particles pass straight through region I undeflected. Gravitational effects are negligible.

(a)

i. On the diagram above, sketch electric field lines in region I.

ii. Calculate the speed of the particles that pass straight through region I.

$F = Eq \qquad F = Bqv$

$E = Bv$

$4800 = (.12)v \qquad v = 4.0 \times 10^4$ m/s

The particles that pass straight through enter region II in which there is no electric field and the magnetic field has the same magnitude and direction as in region I. The path of the particles in region II is a circular arc of radius $R$.

(b) Calculate the radius $R$.

$F = \frac{mv^2}{r} \qquad F = Bqv$

$\frac{mv}{r} = Bq$

$\frac{(6.68 \times 10^{-26})(4 \times 10^4)}{r} = (.12)(3.2 \times 10^{-19})$

$r = .070$ m

GO ON TO THE NEXT PAGE.

(c) Within the beam there are particles moving slower than the speed you calculated in (a)ii. In what direction is the net initial force on these particles as they enter region I?

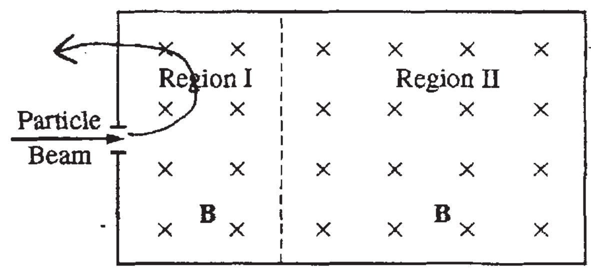
____ To the left   __✓__ Toward the top of the page   ____ Out of the plane of the page

____ To the right   ____ Toward the bottom of the page   ____ Into the plane of the page

Justify your answer.

The Right-Hand Rule

(d) A particle of the same mass and the same speed as in (a)ii but with charge $q = -3.2 \times 10^{-19}$ C enters region I. On the following diagram, sketch the complete resulting path of the particle.

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# AP® PHYSICS B
# 2007 SCORING COMMENTARY (Form B)

## Question 2

**Sample: B2A**
**Score: 9**

The only deduction in this very clearly written response was the loss of 1 point for showing the path of the particle curving in the wrong direction in part (d).

**Sample: B2B**
**Score: 6**

Parts (a) and (b) received full credit. In part (a) the student determines the electric force and then substitutes that value into the equation for magnetic force, thus doing some extra numerical calculation. The final answer to part (b) has a mistake in the placement of the decimal, but credit was awarded for correct substitutions and not the actual numerical answer. Parts (c) and (d) both have incorrect directions and received no credit.

**Sample: B2C**
**Score: 4**

Parts (a)(ii) and (b) each received 2 points full credit for correct work and answers. The rest of the work received no credit.