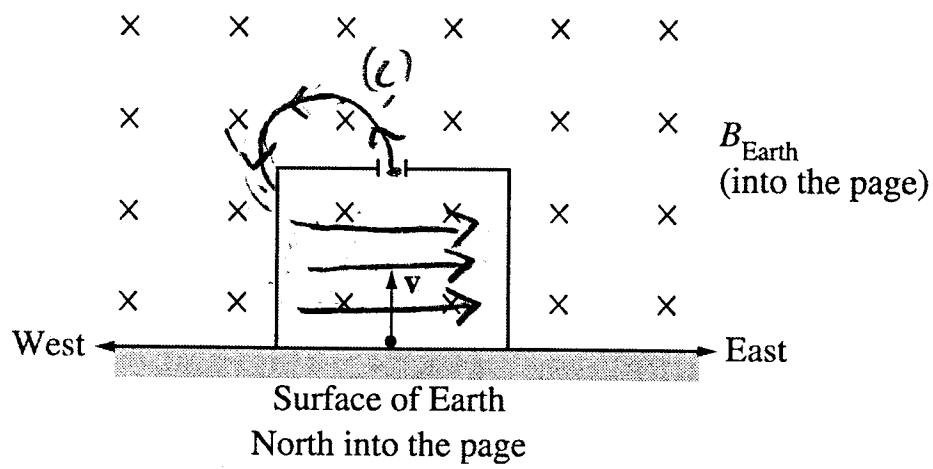
AP® Physics B
2002 Sample Student Responses

The materials included in these files are intended for use by AP teachers for course and exam preparation in the classroom; permission for any other use must be sought from the Advanced Placement Program®. Teachers may reproduce them, in whole or in part, in limited quantities, for face-to-face teaching purposes but may not mass distribute the materials, electronically or otherwise. These materials and any copies made of them may not be resold, and the copyright notices must be retained as they appear here. This permission does not apply to any third-party copyrights contained herein.

These materials were produced by Educational Testing Service® (ETS®), which develops and administers the examinations of the Advanced Placement Program for the College Board. The College Board and Educational Testing Service (ETS) are dedicated to the principle of equal opportunity, and their programs, services, and employment policies are guided by that principle.

The College Board is a national nonprofit membership association dedicated to preparing, inspiring, and connecting students to college and opportunity. Founded in 1900, the association is composed of more than 4,200 schools, colleges, universities, and other educational organizations. Each year, the College Board serves over three million students and their parents, 22,000 high schools, and 3,500 colleges, through major programs and services in college admission, guidance, assessment, financial aid, enrollment, and teaching and learning. Among its best-known programs are the SAT®, the PSAT/NMSQT®, and the Advanced Placement Program® (AP®). The College Board is committed to the principles of equity and excellence, and that commitment is embodied in all of its programs, services, activities, and concerns.



5. (10 points)

A proton of mass m_p and charge e is in a box that contains an electric field E, and the box is located in Earth's magnetic field B_{Earth}. The proton moves with an initial velocity **v** vertically upward from the surface of Earth. Assume gravity is negligible.

(a) On the diagram above, indicate the direction of the electric field inside the box so that there is no change in the trajectory of the proton while it moves upward in the box. Explain your reasoning.

The electric field must be to the right. By the right hand rule, the proton will be pushed toward the left. Therefore, to counteract this force and keep the proton going straight the electric field must be to the right.

(b) Determine the speed of the proton while in the box if it continues to move vertically upward. Express your answer in terms of the fields and the given quantities.

$F_B = Bqv \qquad F_E = Eq$

$F_B = F_E$

$B_{Earth} \cdot e \cdot v = Ee$

$$v = \frac{E}{B_{Earth}}$$

GO ON TO THE NEXT PAGE.

The proton now exits the box through the opening at the top.

(c) On the figure on the previous page, sketch the path of the proton after it leaves the box.

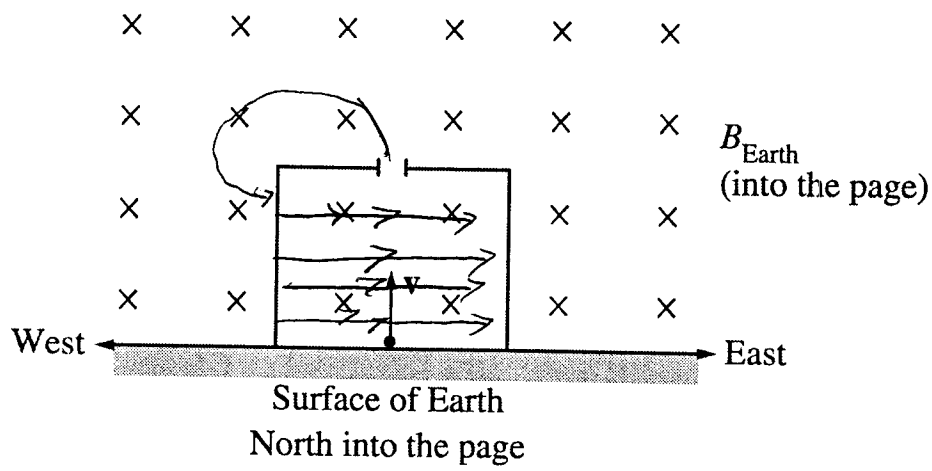
(d) Determine the magnitude of the acceleration a of the proton just after it leaves the box, in terms of the given quantities and fundamental constants.

$$F = Bqv$$

$$m_p a = B_{Earth} \cdot e \cdot v$$

$$a = \frac{B_{Earth} \times e \times v}{m_p}$$

GO ON TO THE NEXT PAGE.



5. (10 points)

A proton of mass m_p and charge e is in a box that contains an electric field E, and the box is located in Earth's magnetic field B_{Earth}. The proton moves with an initial velocity **v** vertically upward from the surface of Earth. Assume gravity is negligible.

(a) On the diagram above, indicate the direction of the electric field inside the box so that there is no change in the trajectory of the proton while it moves upward in the box. Explain your reasoning.

Using the right hand rule, a positive charge moving upward through earths magnetic field would feel a force to the west. The electric field must be directed west to east to exert a force that counterbalances the westward magnetic force.

(b) Determine the speed of the proton while in the box if it continues to move vertically upward. Express your answer in terms of the fields and the given quantities.

$F_B = qvB$ $\quad F_E = qE$

$qvB_e = qE$

$vB_e = E$

$v = E/B_e$

GO ON TO THE NEXT PAGE.

The proton now exits the box through the opening at the top.

(c) On the figure on the previous page, sketch the path of the proton after it leaves the box.

(d) Determine the magnitude of the acceleration a of the proton just after it leaves the box, in terms of the given quantities and fundamental constants.

$$F_c = \frac{mv^2}{R} \qquad F_c = qv \times B$$

$$ma = \frac{mv^2}{r} \qquad qv \times B = \frac{mv^2}{r}$$

$$a = \frac{v^2}{r} \qquad qB = \frac{m_p}{r}$$

$$r = \frac{m_p}{qB_e}$$

$$a = \left(E/B_e\right)^2 \Big/ \left(\frac{m_p}{eB_e}\right)$$

$$a = \frac{E^2}{B_e^{\,2}} \cdot \frac{eB_e}{m_p}$$

$$a = \frac{E^2 e}{B_e m_p}$$

GO ON TO THE NEXT PAGE.