



AP[®] Physics C 1979 Scoring Guidelines

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.

Copyright © 2002 by College Entrance Examination Board. All rights reserved. College Board, Advanced Placement Program, AP, SAT, and the acorn logo are registered trademarks of the College Entrance Examination Board. APIEL is a trademark owned by the College Entrance Examination Board. PSAT/NMSQT is a registered trademark jointly owned by the College Entrance Examination Board and the National Merit Scholarship Corporation. Educational Testing Service and ETS are registered trademarks of Educational Testing Service.

Solution

Distribution
of Points

a) 4 points

Conservation of energy provides the relation

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

1 point

which can be solved for v , the speed.

$$v = \sqrt{2gh}$$

1 point

(This expression is the speed just before collision at P_1 . Since the collision is elastic, it is also the speed after the collision.)

The direction of the ball's motion after the collision at P_1 is,

"horizontal to the right."

2 points

b) & c) 8 points (combined)

Horizontal and vertical motions are considered separately.

During the flight from P_1 to P_2 the ball maintains a horizontal speed of $\sqrt{2gh}$ and travels a horizontal distance $L/\sqrt{2}$, thus $d = vt$ yields

$$\frac{L}{\sqrt{2}} = \sqrt{2gh} t$$

2 points

During the same time t the ball travels the same distance vertically, given by

$$\frac{L}{\sqrt{2}} = \frac{1}{2}gt^2$$

2 points

Equating the two expressions for $L/\sqrt{2}$ gives

$$\sqrt{2gh} t = \frac{1}{2}gt^2$$

1 point

and cancelling times (which means recognizing they are equal), we obtain

$$\sqrt{2gh} = \frac{1}{2}gt$$

1 point

leading to the answer to part (b) of

$$t = 2\sqrt{2gh}/g = \sqrt{8h/g}$$

1 point

Substitution of this value back into either the horizontal or vertical expression for $L/\sqrt{2}$ gives

$$L/\sqrt{2} = \sqrt{2gh} \quad 2\sqrt{2gh}/g$$

or

$$L = 4\sqrt{2}h$$

1 point

d) 3 points

The speed just before striking P_2 may be found from conservation of energy

$$mgh + mgL/\sqrt{2} = \frac{1}{2}mv_2^2$$

1 point

Substituting $L = 4\sqrt{2}h$ gives

$$mgh + 4mgh = \frac{1}{2}mv_2^2$$

1 point

from which $v_2 = \sqrt{10gh}$

1 point

Total

15 points

1979 C EXAM: MECHANICS-2

a) 5 points

Linear momentum is conserved during collision, therefore

$$M_1 V_{\text{initial}} = (M_1 + M_2) V_{\text{final}}$$

3 points

Substituting appropriate values one obtains

$$M_2 = 10^5 \text{ kg}$$

2 points

b) 5 points

$$x = \int v dt$$

1 point

$$x = \int_a e^{-4t} dt = -\frac{1}{4}e^{-4t} + C$$

2 points

$$\text{At } t = 0, x = 0, \text{ thus } C = \frac{1}{4}$$

1 point

$$\text{Thus as } t \rightarrow \infty, x_{\text{final}} \rightarrow \frac{1}{4} \text{ meter}$$

1 point

(or full credit for correct limits of integration.)

c) 5 points

The retarding force F_R can be calculated directly from Newton's second law and the expression for the velocity:

$$F_R = m \frac{dv}{dt}$$

1 point

$$F_R = m \frac{d}{dt} \left(\frac{1}{3} + \beta t \right)^{-1}$$

3 points

$$F_R = -m\beta \left(\frac{1}{3} + \beta t \right)^{-2} = -m\beta v^2$$

1 point

Total

15 points

1979 C EXAM: MECHANICS-3

a) 5 points

The answer is obtained from Newton's second law and knowledge of the spring force and centripetal acceleration.

$$F = ma$$

1 point

$$kx = m\omega^2 r$$

2 points

$$k(\ell_2 - \ell_1) = m\omega_o^2 \ell_2$$

1 point

$$\ell_2 = \frac{k\ell_1}{k - m\omega_o^2}$$

1 point

b) 5 points

$$PE = \frac{1}{2}kx^2 = \frac{1}{2}k(\ell_2 - \ell_1)^2$$

2 points

$$KE = \frac{1}{2}mv^2 = \frac{1}{2}m(\ell_2 \omega_o)^2$$

2 points

$$E_T = PE + KE = \frac{1}{2}k\ell_1^2 \frac{1}{(k/m - \omega_o^2)} \frac{1}{2} m k \ell_1^2 \omega_o^2 \frac{(k + m\omega_o^2)}{(k - m\omega_o^2)^2}$$

1 point

c) 3 points

$$L = I\omega$$

1 point

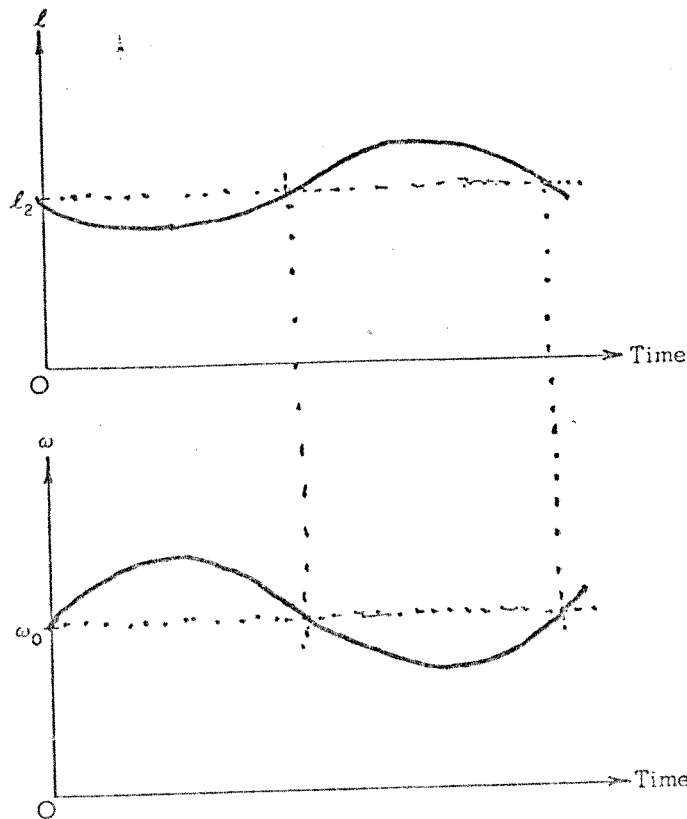
$$L = m\ell_2^2 \omega_o$$

1 point

$$L = m \left(\frac{k\ell_1}{k - m\omega_o^2} \right)^2 \omega_o$$

1 point

d) 2 points



2 points

Total

15 points

1979 C EXAM: E & M-1

a) 3 points

$$\oint \vec{E} \cdot d\vec{A} = Q/\epsilon_0$$

1 point

$$E (4\pi r^2) = Q/\epsilon_0$$

1 point

$$E = Q/4\pi\epsilon_0 r^2 \text{ or } KQ/r^2$$

1 point

b) 3 points

$$r > c, E = Q/2\pi\epsilon_0 r^2 \text{ or } 2KQ/r^2$$

1 point

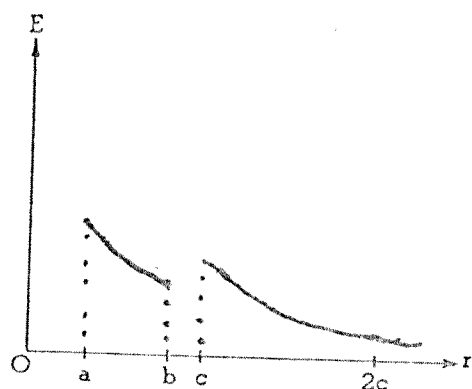
$$b < r < c, E = 0$$

1 point

$$r < a, E = 0$$

1 point

c) 3 points



$$E = 0 \text{ for } 0 < r < a$$

1 point

$$\text{and } b < r < 2c$$

Curve concave for

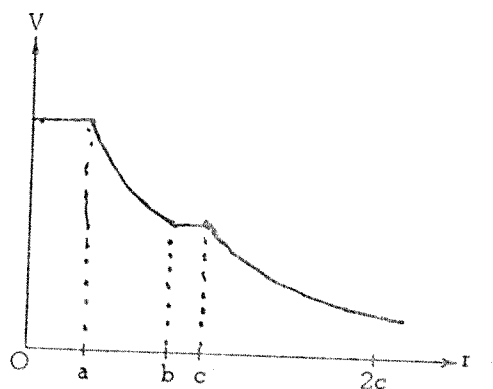
1 point

$$a < r < b \text{ and } c < r$$

$$E(c) > E(b)$$

1 point

d) 3 points



$$V = \text{constant for}$$

$$0 < r < a \text{ and } b < r < 2c$$

1 point

Curve concave for

$$a < r < b \text{ and } c < r$$

1 point

Continuous curve

1 point

e) 3 points

$$V = \int_b^{\infty} \vec{E} \cdot d\vec{r} \text{ or } V = KQ/r$$

1 point

$$V = \int_c^{\infty} \frac{0}{2\pi\epsilon_0 r^2} dr + \int_6^c \frac{2Q}{4\pi\epsilon_0 r^2} dr = \int_c^c 0 + \int_c^c \frac{2Q}{4\pi\epsilon_0 r^2} dr$$

1 point

$$V = Q/2\pi\epsilon_0 c \text{ or } 2KQ/c$$

1 point

Total 15 points

Alternate Solution

$$V = q/4\pi\epsilon_0 r \text{ or } Kq/r$$

1 point

$$q = 2Q \text{ and } r = c$$

1 point

$$V = Q/2\pi\epsilon_0 c \text{ or } 2KQ/c$$

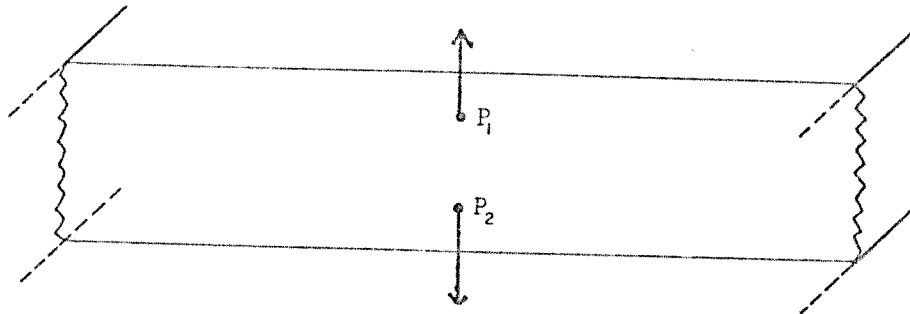
1 point

1979 C: E & M-2

Solution

Distribution
of Points

a) 2 points



For Direction

1 point

For Approximate ^{equal} Magnitude

1 point

b) 5 points

For any statement that there are
no horizontal components

1 point

For statement of Gauss's Law

1 point

$$\oint \mathbf{E} \cdot d\mathbf{s} = q/\epsilon_0$$

Choose a "pill box" with a top and bottom each of area A .
Let the top face passing through P_1 and the bottom through P_2 .
By symmetry, \mathbf{E} is perpendicular to both ends, is directed
outward, and is of equal magnitude (and is parallel to the
sides). Thus

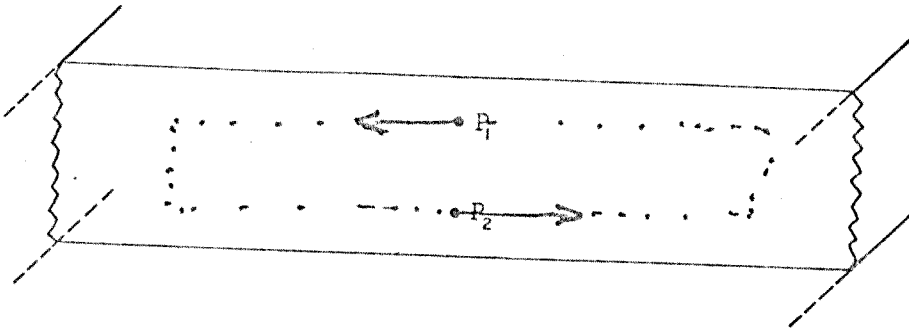
$$2EA = A2\rho a/\epsilon_0$$

2 points

$$E = \rho a/\epsilon_0$$

1 point

c) 3 points



3 points

d) 5 points

For any statement that there are no vertical components

1 point

For statement of Ampere's Law

1 point

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 i$$

Choose a rectangular path of length L and width $2a$ with the top and bottom passing through P_1 and P_2 . By symmetry, B is parallel to both top and bottom, is in the same direction as path increment, and is of equal magnitude (and is normal to the ends w).

$$\begin{aligned} 2BL &= \mu_0 i \\ &= \mu_0 2aLj \\ B &= \mu_0 aj \end{aligned}$$

1 point

1 point

1 point

1979 Physics C: E & M 3

Solution

Distribution
of Points

a) 6 points

Experiment I demonstrates that \vec{B} is in the plane of the paper because F is perpendicular to both \vec{v} & \vec{B} .

3 points

Experiment II demonstrates that \vec{B} makes an angle of -60° in the plane of the paper since it must be perpendicular to \vec{F}_2 and in direction of $\vec{v} \times \vec{B}$.

3 points

b) 5 points

The conditions for a circular orbit are that the force is (1) perpendicular to the velocity and (2) is a constant. These conditions are met if the constant \vec{B} field is perpendicular to the velocity.

2 points

Thus motion in case II is a circle

1 point

$$F = mv^2/r$$

1 point

$$r = mv^2/F$$

1 point

c) 4 points

Since the velocity and the \vec{B} field are not perpendicular in experiment I, the component of velocity parallel to \vec{B} produces no force and hence no change in motion. The perpendicular component of velocity produces circular motion, thus the resulting motion is a helix (spiral) about the \vec{B} vector.

4 points

(Partial credit: Helix (2 points), axis of helix along B (1 point))

Total 15 points