AP® Physics C
1979 Scoring Guidelines

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Solution | Distribution of Points

a) 4 points

Conservation of energy provides the relation

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

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

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

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

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

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

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

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

$$mgh + mgL/\sqrt{2} = \tfrac{1}{2}mv_2^{\,2}$$ 1 point

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

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

$$M_1 V_{initial} = (M_1 + M_2) V_{final}$$ 3 points

Substituting appropriate values one obtains

$$M_2 = 10^5 kg$$ 2 points

b) 5 points

$$x = \int v dt$$ 1 point

$$x = \int e^{-4t} dt = -\tfrac{1}{2}e^{-4t} + C$$ 2 points

At $t = 0$, $x = 0$, thus $C = \tfrac{1}{2}$ 1 point

Thus as $t \to \infty$, $x_{final} \to \tfrac{1}{2}$ 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

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

$$KE = \tfrac{1}{2}mv^2 = \tfrac{1}{2}m(\ell_2\omega_0)^2$$ 2 points

$$E_T = PE + KE = \cancel{k\omega_o^2\ell_1^2/(k/m - \omega_o^2)}\ \frac{1}{2} m k \ell_1^2 \omega_0^2 \frac{(k + m\omega_0^2)}{(k - m\omega_0^2)^2}$$ 1 point

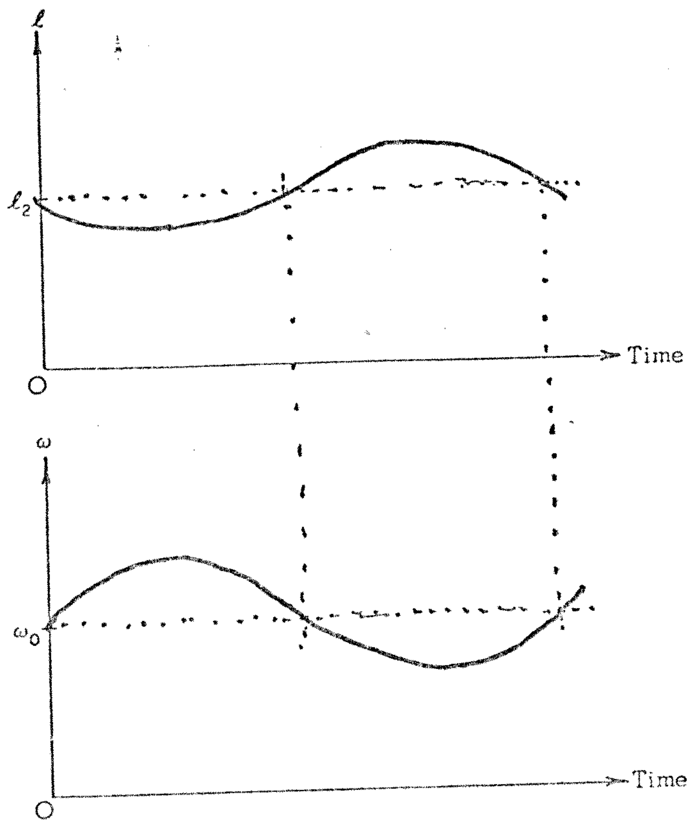
c) 3 points

$$L = I\omega$$ 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

$\oint \vec{E} \cdot d\vec{A} = Q/\varepsilon_o$ 1 point

$E\ (4\pi r^2) = Q/\varepsilon_o$ 1 point

$E = Q/4\pi\varepsilon_o r^2$ or KQ/r^2 1 point

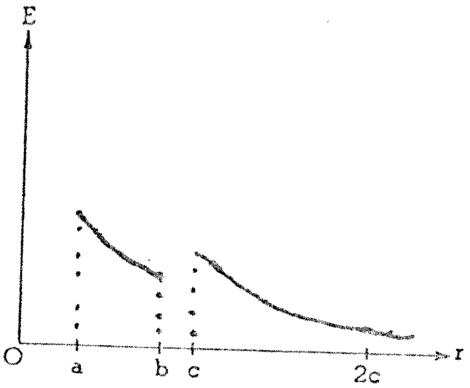
b) 3 points

$r>c,\ E = Q/2\pi\varepsilon_o r^2$ or $2KQ/r^2$ 1 point

$b<r<C,\ E = 0$ 1 point

$r<a,\ E = 0$ 1 point

c) 3 points



E = 0 for 0<r<a 1 point

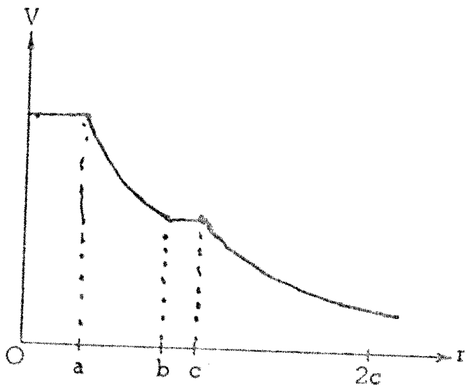
and b<r<2

Curve concave for 1 point

a<r<b and c<r

E(c) > E(b) 1 point

d) 3 points



V = constant for
0< r<a and b< r<2 1 point

Curve concave for
a<r <b and c<r 1 point

Continuous curve 1 point

e) 3 points

$V = \int_b^\infty \vec{E}\cdot d\vec{r}$ or $V = KQ/r$ 1 point

$V = \cancel{\int_c^\infty \frac{Q}{2\pi\epsilon_0}\frac{dr}{r^2} + \int_b^c 0}$ $\int_b^c 0 + \int_c^\infty \frac{2Q}{4\pi\epsilon_0}\frac{dr}{r^2}$ 1 point

$V = Q/2\pi\epsilon_0 c$ or $2KQ/c$ 1 point

Total 15 points

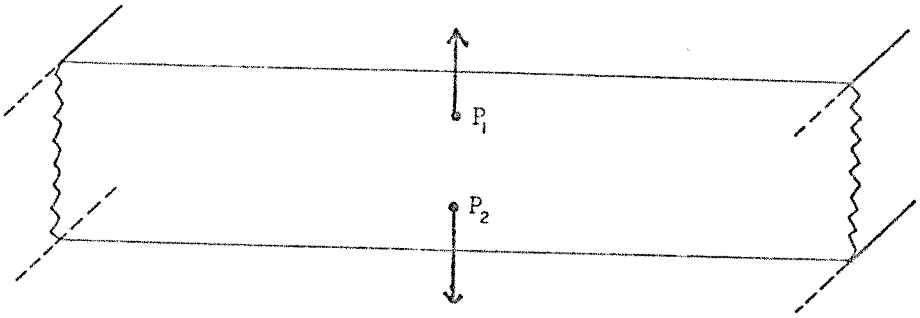
Alternate Solution

$V = q/4\pi\varepsilon_o r$ or Kq/r	1 point
$q = 2Q$ and $r = c$	1 point
$V = Q/2\pi\varepsilon_o c$ or $2KQ/c$	1 point

1979 C: E & M-2

Solution	Distribution of Points

a) 2 points



For Direction	1 point
For Approximately equal Magnitude	1 point

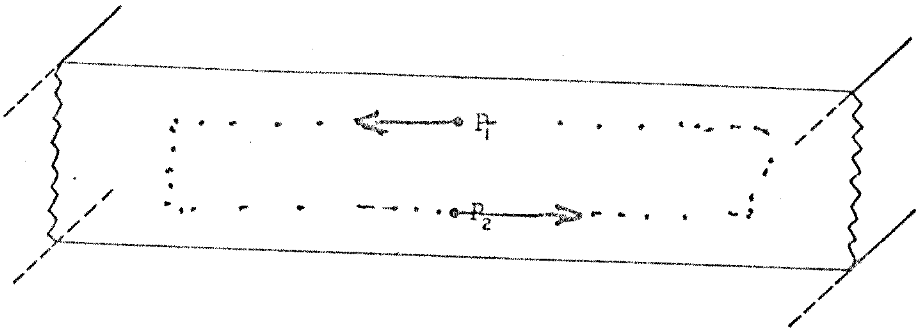
b) 5 points

For any statement that there are no horizontal components	1 point
For statement of Gauss's Law $\oint E \cdot ds = q/\varepsilon_o$	1 point

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, E is perpendicular to both ends, is directed outward, and is of equal magnitude (and is parallel to the sides). Thus

$2EA = A2\rho a/\varepsilon_o$	2 points
$E = \rho a/\varepsilon_o$	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

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

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 ω).

$$2BL = \mu_o i \quad \text{1 point}$$
$$= \mu_o 2aLj \quad \text{1 point}$$
$$B = \mu_o aj \quad \text{1 point}$$

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^o in the plane of the paper since it must be perpendicular to 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