



AP[®] Physics C 1980 Scoring Guidelines

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(a) 3 points

The “no slip” condition is

$$a_1 = a_2$$

1 point

From Newton’s second law,

$$a_1 = \frac{f}{m_1}$$

1 point

Thus,

$$a_2 = \frac{f}{m_1}$$

1 point

(b) 5 points

The general equation of motion is given by $m\ddot{x} = -kx$

For the “no slip” maximum amplitude

$$m = (m_1 + M_2)$$

1 point

$$x = A$$

1 point

$$\ddot{x} = \frac{f}{m_1}$$

1 point

Solving for the amplitude

$$A = \frac{(m_1 + M_2)}{k} \frac{f}{m_1}$$

2 points

(c) 3 points

Any discussion or graph that describes the frictional force as proportional to the sinusoidal acceleration received full credit.

3 points

(d) 4 points

i.

$$f = m_1 a_1$$

1 point

$$a_1 = \frac{f}{m_1}$$

1 point

ii.

$$F_{\text{spring}} - f = M_2 a_2$$

1 point

$$a_2 = \frac{F_s - f}{M_2}$$

1 point

where $F_s = kA'$ or $k(A + A')$ depending on how the student interpreted the statement of the problem.Total 15 points

Solution

(a) 4 points

From conservation of linear momentum

$$mv_0 = mv_i + 3mv_i$$

3 points

$$v_i = \frac{v_0}{4}$$

1 point

(b) 5 points

From conservation of mechanical energy

$$\frac{1}{2}mv_0^2 = \frac{1}{2}(m + 3m)v_i^2 + mgh$$

4 points

Substituting for v_i and solving for the height h

$$h = \frac{3}{8} \frac{v_0^2}{g}$$

1 point

(c) 6 points

From conservation of linear momentum

$$mv_0 = mv' + 3mv_f$$

From conservation of mechanical energy

3 points

$$\frac{1}{2}mv_0^2 = \frac{1}{2}mv'^2 + \frac{1}{2}(3m)v_f^2$$

Solving for the final velocities

$$v_f = \frac{v_0}{2}$$

1 point

$$v' = -\frac{v_0}{2}$$

1 point

The block moves to the left.

1 point

Total 15 points

1980 C: Mech.-3

(a) 4 points

Under the action of the constant force of friction the velocity is given by

$$v = v_0 - at$$

1 point

From Newton's second law

$$F = Ma$$

1 point

From the definition of the frictional force

$$F = f = \mu N = \mu Mg$$

1 point

Thus,

$$v = v_0 - \mu gt$$

1 point

(b) 4 points

Under the action of the constant torque about the center of mass due to the frictional force, the angular velocity is given by

$$\omega = \omega_0 + \alpha t \quad 1 \text{ point}$$

From Newton's second law, the torque τ is given by

$$\tau = I_c \alpha \quad 1 \text{ point}$$

The torque is given by

$$\tau = R (\mu Mg) \quad 1 \text{ point}$$

Thus, since $\omega_0 = 0$,

$$\omega = \left(\frac{5}{2}\right) \left(\frac{\mu g}{R}\right) t \quad 1 \text{ point}$$

(c) 4 points

The slipping stops when the tangential velocity v_t is equal to the velocity of the center of mass v .

$$v_t = v \quad 1 \text{ point}$$

and

$$v_t = \omega R \quad 1 \text{ point}$$

Thus,

$$v_0 - \mu g T = \omega R \quad 1 \text{ point}$$

where T is the time required for the slipping to stop. Solving for T ,

$$T = \left(\frac{2}{7}\right) \left(\frac{v_0}{\mu g}\right) \quad 1 \text{ point}$$

(d) 3 points

Since the line of action of the frictional force passes through P , the net torque about point P (due to all forces) is zero.

Thus, the time rate of change of the angular momentum is zero.

Thus, the angular momentum is a constant.

1 point

1 point

1 point

Total 15 points

1980 C: E&M-1

(a) 3 points

The differential potential at point O due to an incremental charge dq is given by

$$dV_0 = \frac{dq}{4\pi\epsilon_0 R} \quad 1 \text{ point}$$

where

$$dq = \lambda R d\theta \quad 1 \text{ point}$$

Thus,

$$V_0 = \frac{\lambda}{4\pi\epsilon_0} \int_0^\pi d\theta = \frac{\lambda}{4\epsilon_0} = k\lambda R \quad 1 \text{ point}$$

(Any equivalent argument received full credit.)

(b) 3 points

Because of the symmetry of the charge distribution, all the horizontal (x) components of the field cancel.

2 points

Thus, the field is directed downward.

1 point

(c) 6 points

The differential electric field at point O is given by

$$dE_0 = \frac{dq}{4\pi\epsilon_0 R^2}$$

1 point

The magnitude of the y component of the field is given by

$$dE_{0y} = dE_0 \cos \theta$$

1 point

Thus,

$$dE_{0y} = \frac{\lambda \cos \theta d\theta}{4\pi\epsilon_0 R}$$

2 points

(or any equivalent expression involving a different variable)

$$E_0 = \frac{\lambda}{4\pi\epsilon_0 R} (2) \int_0^{\pi/2} \cos \theta d\theta$$

1 point

(or any other equivalent integral)

Thus,

$$E_0 = \frac{\lambda}{2\pi\epsilon_0 R} = \frac{2 \times 10^{-12}}{R}$$

1 point

(d) 3 points

The work W_P required to bring a positive point charge q from infinity to the point P is given by

$$W_P = qV_P$$

The work required to bring q from P to O is given by

$$W_{OP} = q(V_0 - V_P)$$

1 point

If the field E is approximately constant between points O and P, then the work is also given by

$$W_{OP} = qE_0 s$$

1 point

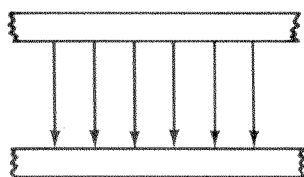
Thus,

$$W_P = qV_P = q(V_0 - E_0 s)$$

Total $\frac{1 \text{ point}}{15 \text{ points}}$

Solution

(a) 3 points



Straight
Evenly spaced
Directed down

1 point
1 point
1 point

(b) 7 points

Gauss's Law

$$\oint \vec{E} \cdot d\vec{A} = \oint E \cos \theta dA = \frac{q_{\text{IN}}}{\epsilon_0}$$

1 point

The enclosed charge is given by

$$q_{\text{IN}} = \sigma A$$

1 point

where A is the area of the top and bottom of the box.

The field E_{top} in the metal is zero.

1 point

The vector $d\vec{A}$ on the sides of the box is normal to the field; thus $\cos \theta$ here is zero.

1 point

The field along the bottom of the box is a constant and perpendicular to the surface (i.e., parallel to the vector $d\vec{A}$).

1 point

Thus,

$$\oint \vec{E} \cdot d\vec{A} = EA = \frac{\sigma A}{\epsilon_0}$$

1 point

And

$$E = \frac{\sigma}{\epsilon_0}$$

1 point

(c) 5 points

The electric field is less.

2 points

The bound charge distribution in the dielectric has a net negative charge on the top surface and positive on the bottom. Thus, the combined charge is less and so is the electric field.

3 points

Total 15 points

1980 C: E&M-3

(a) 3 points

The induced current will be clockwise.

1 point

According to Lenz's law, the emf induced by a changing magnetic field will generate a current in a closed loop such that the induced magnetic field will oppose the initial change of flux. In this case, the field increases out of the page; thus, the induced field must be into the page. Thus, the induced current must be clockwise.

2 points