



AP[®] Physics C 1978 Scoring Guidelines

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b) Partial credit:

Nodes at either end of a system
(can be pictorial) leads to

3

$$L = \frac{n}{2} \lambda$$

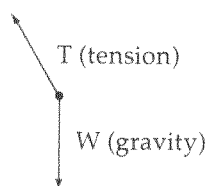
$$\lambda = \frac{2L}{n}$$

1978 C: Mech.-1

Distribution
of Points

a) 3 points

Solution



Each force with correct direction

1

If no extraneous forces were shown

1

b) 7 points

$$T \cos \theta = mg$$

2

(1 point for any use of $F = ma$)

$$T \sin \theta = ma$$

1

$$= m\omega^2 r$$

1

$$= m\omega^2 (A + \ell \sin \theta)$$

1

$$mg \tan \theta = m\omega^2 (A + \ell \sin \theta)$$

1

$$\omega = \sqrt{\frac{g \tan \theta}{A + \ell \sin \theta}}$$

1

Alternate:

$$\tan \theta = \frac{m\omega^2 r}{mg} = \frac{\omega^2 r}{g}$$

4

$$g \tan \theta = \omega^2 (A + \ell \sin \theta)$$

2

etc.

c) 5 points

$$W = \Delta E \text{ (or any mention of work-energy theorem)}$$

1

$$\Delta E = \Delta K + \Delta U$$

1

$$\Delta K = \frac{1}{2} mv^2 \text{ per rider}$$

1

$$\Delta U = mg\ell (1 - \cos \theta) \text{ per rider}$$

1

$$W = 6 (\frac{1}{2} mv^2 + mg\ell (1 - \cos \theta))$$

1

1978 C: Mech.-2

	<i>Solution</i>	<i>Distribution of Points</i>
a) 4 points		
	$L_{\text{before collision}} = L_{\text{after collision}}$	1
	$L_{\text{before}} = I\omega = (1/3 M_1 \ell^2) \omega$	1
	$L_{\text{after}} = \ell M_2 v$	1
	$v = M_1 \ell \omega / 3M_2$	1
b) 3 points		
	Most common solution employed the concept of center of mass:	
	$P_{\text{CM}} = M_1 v_{\text{CM}} = M_1 (\omega \ell / 2) = P_{\text{system}}$	3
	Full credit also given for direct integration:	
	$\left[\begin{array}{l} P = \int v \, dM, \text{ where } dM = \rho \, dV = \rho A \, dr \\ \text{and } v = r\omega \text{ thus} \\ P = \int_0^\ell r \rho A \, dr = \omega \rho A \int_0^\ell r \, dr = \omega \rho A \ell^2 / 2 \\ \text{Thus, since } M_1 = \rho A \ell, P = \omega \ell M_1 / 2 \end{array} \right]$	
c) 2 points		
	$P_{\text{after}} = M_2 v_{\text{after}}$	2
	where from part a, $v_{\text{after}} = M_1 \ell \omega / 3M_2 = \frac{\omega M_1 \ell}{3}$	
d) There is a net external force acting on the system at the pivot P. Hence, the linear momentum is <i>not</i> conserved.		3
e) Since the net external force in the plane of rotation acts at the pivot P, the net torque about the pivot P is zero. Hence, angular momentum is conserved.		3

1978 C: Mech.-3

	<i>Solution</i>	<i>Distribution of Points</i>
a) 4 points		
	$F = -kx$	1
	$x = L\theta$ (or $\sin \theta$)	1
	$F = -kL\theta$	
	Torque = FL ($\cos \theta$ or 1)	1
	Torque = $-kL^2\theta$ (or $\sin \theta \times \cos \theta$)	1

b) 4 points

$$\text{Torque} = I\alpha \quad 2$$

$$I = 2mL^2 \quad 2$$

$$\alpha = \frac{T}{I} = -\frac{k}{2m}\theta$$

c) 3 points

$$\alpha = \frac{d^2\theta}{dt^2} \quad 1$$

$$\text{Thus, } \frac{d^2\theta}{dt^2} = -\frac{k}{2m}\theta \quad 2$$

d) 4 points

$$\theta = \theta_0 \cos\left(\sqrt{\frac{k}{2m}}t\right) \quad 4$$

or any equivalent solutions with appropriate constants

1978 C: E & M-1

Solution

*Distribution
of Points*

a) 4 points

From energy consideration

$$\Delta PE = \Delta KE$$

$$eV_g = \frac{1}{2}mv_e^2 \quad 3$$

$$v_e = \sqrt{2eV_g/m} \quad 1$$

b) 5 points

Again from energy consideration

Total energy upon entering = total energy at y_{\max}

$$\frac{1}{2}mv_e^2 = \frac{1}{2}mv_e^2 \cos^2\theta + e\frac{V_p}{d}y_{\max} \quad 3$$

$$\text{Thus, } y_{\max} = d\frac{V_g}{V_p}\sin^2\theta \quad 2$$

(Full credit also given for alternate correct solution,
e.g., using Newton's Laws or a modified work- ΔKE
attack)

c) 3 points

The speed at impact is unchanged.

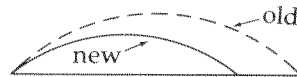
1

The magnetic force is always at 90° to the displacement (velocity) and thus does no work.

2

Hence, the speed depends only on height y .

d) 3 points



2

Along the old path, the magnetic force on an electron always has a downward component; thus y_{\max} is lower and the time of flight shorter. Further, since the magnetic force has a positive component in the x direction during the first half and a negative component during the second half, the range is shorter because the time of flight is shorter.

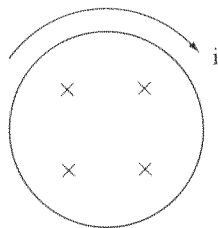
1

1978 C: E & M-2

Solution

Distribution of Points

a) 3 points

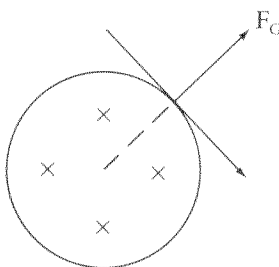


Since the magnetic flux through the loop is decreasing, Lenz's Law states that the flux associated with the induced current will be increasing through the loop. Hence, a clockwise current.

2

1

b) 3 points



Expand

1

At every point the force is outward since

2

$$\mathbf{F}_G = i\vec{\ell} \times \vec{B}$$

c) 4 points

$$Q = \int_0^\infty I dt = \int_0^\infty \frac{V}{R} dt$$

1

$$V = -\frac{d\Phi}{dt} = -A \frac{dB}{dt} = \alpha AB_0 e^{-\alpha t}$$

2

$$\text{Thus, } Q = \frac{\alpha B_0 A}{R} \int_0^\infty e^{-\alpha t} dt = \frac{AB_0}{R}$$

1

d) 5 points

$$H = \int_0^{\infty} I^2 R \, dt = \int_0^{\infty} \frac{V^2}{R} \, dt \quad 2$$

$$\text{From c) } V = \alpha A B_0 e^{-\alpha t} \quad 1$$

$$\text{Thus, } H = \frac{A^2 \alpha^2 B_0^2}{R} \int_0^{\infty} e^{-2\alpha t} \, dt \quad 1$$

or

$$H = A^2 B_0^2 \alpha / 2R \quad 1$$

1978 C: E & M-3

Solution

*Distribution
of Points*

a) 3 points

$$\oint \vec{E} \cdot d\vec{s} = Q/\epsilon_0 \quad 1$$

$$\oint \vec{E} \cdot d\vec{s} = E_0 \cdot \text{area of sphere} \quad 1$$

$$Q = \epsilon_0 \cdot E_0 \cdot 4\pi a^2 \quad 1$$

(Only 1 point was awarded if Gauss's Law was not used.)

b) 3 points

$$E = E_0 a^2 / r^2$$

$$1/r^2 \text{ dependence} \quad 1$$

$$E = E_0 \text{ when } r = a \quad 1$$

$$\text{Expression in terms of } E_0 a \text{ and } r \quad 1$$

No work was required, but partial credit was awarded when some correct work was shown.

c) 3 points

$$V = E_0 a^2 \left(\frac{1}{a} - \frac{1}{b} \right)$$

No work was required.

1 point off for wrong sign

1 point off for not expressing answer in terms of E_0 , a , and b

d) 3 points

$$U = \frac{1}{2} QV \text{ or } U = \frac{1}{2} CV^2 \text{ and } C = Q/V \quad 1$$

$$\text{Substitution for } Q \text{ or } V \text{ from above} \quad 1$$

$$\text{Answer expressed in terms of } E_0, a, \text{ and } b \quad 1$$

$$U = \frac{1}{2} \epsilon_0 E_0 4\pi a^2 \cdot E_0 a^2 \left(\frac{1}{a} - \frac{1}{b} \right) = 2\pi \epsilon_0 E_0^2 \left(a^3 - \frac{a^4}{b} \right)$$

e) 3 points

$$dU/da = 0 \quad 1$$

Correct differentiation 1

Correct algebra and answer 1

$$3a^2 - \frac{4a^3}{b} = 0 \implies a = \frac{3}{4}b$$