



AP[®] Physics C 1987 Scoring Guidelines

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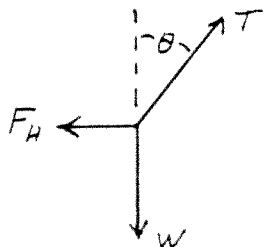
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Mech. 1.

(a) and (b) 7 points



If vector diagram shown,
1 point was awarded for
each vector correctly
drawn and labeled.

3 points

Summation of forces equal to zero. Taking components:

- | | |
|---|---|
| (1) in y-direction: $T \cos \theta - W = 0$ | } For correctly
obtaining any
two of these
three equations |
| (2) in x-direction: $T \sin \theta - F_H = 0$ | |
| (3) in direction of T:
$T - W \cos \theta - F_H \sin \theta = 0$ | |

2 points

(If vector diagram not shown, 5 points awarded for two of the 3 equations)

For correct simultaneous solution for T and F_H of any two of the equations (1), (2), or (3)

2 points

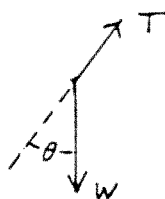
Example: from (1) $T = \frac{W}{\cos \theta}$

Substituting into (2) $\frac{W}{\cos \theta} \sin \theta - F_H = 0$

$$F_H = W \tan \theta$$

(-1 point for using wrong functions, -1 point for answers not in terms of W and θ)

(c) 3 points



For vector diagram

1 point

Summation of forces in direction of T equals zero

1 point

$$T = W \cos \theta$$

1 point

(Full 3-point credit given for simply stating the correct answer)

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Mech. 1 (continued)

(d) 5 points

$$a_c = \frac{v^2}{R} \quad 1 \text{ point}$$

$$T - W = ma_c$$

$$(1) \quad T - W = m \frac{v^2}{L} \quad 1 \text{ point}$$

From conservation of energy,

$$(2) \quad \underbrace{mgL(1 - \cos \theta)}_{1 \text{ point}} = \underbrace{\frac{1}{2}mv^2}_{1 \text{ point}} \quad 2 \text{ points}$$

Letting $mg = W$, and solving (1) and (2) for T , gives
 $T = W(3 - 2 \cos \theta)$

1 point

Mech. 2.

(a) 3 points

Points of equilibrium are:

$$x_E = 2 \text{ m} \quad 1 \text{ point}$$

$$x_E = 5 \text{ m} \quad 1 \text{ point}$$

No extraneous points indicated 1 point

(b) 3 points

$$E_{\text{tot}} = K + U = 4 \text{ J} \quad 1 \text{ point}$$

$$\text{At } x = 2.0 \text{ m: } K = 4 - U(2) = 4 - 1 = 3 \text{ J} \quad 1 \text{ point}$$

$$\text{At } x = 4.0 \text{ m: } K = 4 - U(4) = 4 - 3 = 1 \text{ J} \quad 1 \text{ point}$$

(c) 2 points

No, the particle cannot reach $x = 0.5 \text{ m}$ 1 point

The total energy is insufficient. 1 point

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Mech. 2 (continued)

(d) 2 points

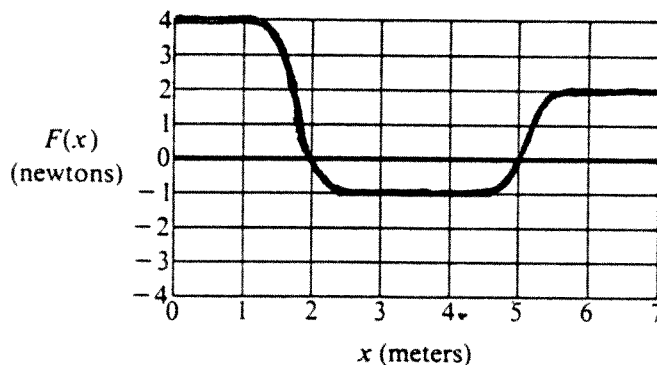
Yes, the particle can reach $x = 5.0$ m.

1 point

The total energy is sufficient

1 point

(e) 5 points



For rough slopes, or a shape indicating change between positive and negative values at 2 places

1 point

For having signs correct (i.e., positive values of F , then negative values, then positive values again)

1 point

For correct placement of zeros at $x = 2$ m and $x = 5$ m

1 point

For constant values (zero slopes) at appropriate places

1 point

For correct numerical values of F for regions of zero slope

1 point

(If no graph, +1 point was awarded for $F = dU/dx$, or +2 points were awarded for $F = -dU/dx$)

Mech. 3.

(a) 4 points

K.E. of rod at bottom of swing = P.E. of rod at top

$$\frac{1}{2}I\omega^2 = mgh$$

1 point

$$\frac{1}{2}\left(\frac{m\ell^2}{3}\right)\omega^2 = Mg\left(\frac{\ell}{2}\right)$$

1 point

$$\omega^2 = \frac{3g}{\ell} = \frac{(3)(10)}{1.2} = 25$$

$$\omega = 5 \frac{\text{radians}}{\text{sec}}$$

2 points

(1 point for numerical answer, 1 point for units of radians/second or seconds⁻¹)

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Mech. 3 (continued)

(b) 4 points

K.E. before collision = K.E. after collision

$$\underbrace{\frac{1}{2}m_0v_0^2}_{1 \text{ pt.}} = \underbrace{\frac{1}{2}m_0v^2}_{1 \text{ pt.}} + \underbrace{\frac{1}{2}I\omega^2}_{1 \text{ pt.}} \quad 3 \text{ points}$$

$$\frac{1}{2}(1)(10)^2 = \frac{1}{2}(1)v^2 + \frac{1}{2}\left(\frac{3(1.2)^2}{3}\right)(5)^2$$

$$50 = \frac{1}{2}v^2 + 18$$

$$v^2 = 64$$

$$v = 8 \text{ m/s} \quad 1 \text{ point}$$

(c) 4 points

$$L = mvr \sin \theta \quad \underline{\text{or}} \quad L = mvr \quad \underline{\text{or}} \quad \vec{L} = \vec{r} \times \vec{P} \quad 2 \text{ points}$$

$$L = (1)(10)(1.2)$$

$$L = 12 \text{ kg}\cdot\text{m}^2/\text{s} \quad 2 \text{ points}$$

(1 point for numerical answer, 1 point for correct units)

(d) 3 points

Angular momentum is conserved during collision, so

$$L \text{ (before)} = L \text{ (after)} \quad 1 \text{ point}$$

$$m_0v_0\ell = m_0(v \cos \theta)\ell + I\omega \quad 1 \text{ point}$$

$$12 = (1)(8)(1.2) \cos \theta + (1.44)(5)$$

$$12 = 9.6 \cos \theta + 7.2$$

$$\cos \theta = 0.5$$

$$\theta = 60^\circ \quad 1 \text{ point}$$

Alternately, angular momentum of ball after collision

may be written $m_0v\ell \sin \phi$, where ϕ is the angle between

v and ℓ . The solution yields $\phi = 30^\circ$, but

$$\theta = 90^\circ - \phi = 90^\circ - 30^\circ = 60^\circ.$$

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E & M 1.

(a) 4 points

Gauss's law for $r > R$

$$\int \vec{E} \cdot d\vec{A} = Q/\epsilon_0 \quad 1 \text{ point}$$

$$E \int dA = Q/\epsilon_0 \quad 1 \text{ point}$$

$$E(4\pi r^2) = Q/\epsilon_0 \quad 1 \text{ point}$$

$$E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2} \quad 1 \text{ point}$$

(-1 point for answer in terms of R , -3 points for answer only without showing details)

(b) 5 points

Show or mention Gaussian surface as inside sphere with radius r . 1 point

Charge enclosed by Gaussian surface

$$Q = \underbrace{\left(\frac{Q}{\frac{4}{3}\pi R^3} \right)}_{1 \text{ pt.}} \underbrace{\left(\frac{4}{3}\pi r^3 \right)}_{1 \text{ pt.}} = \frac{Qr^3}{R^3} \quad 2 \text{ points}$$

From Gauss's law,

$$E(4\pi r^2) = \frac{q}{\epsilon_0} = \frac{Q}{\epsilon_0} \frac{r^3}{R^3} \quad 1 \text{ point}$$

$$E = \frac{Q}{4\pi\epsilon_0} \frac{r}{R^3} \quad 1 \text{ point}$$

Alternate solution in terms of density ρ (Alternate Points)

Show or mention Gaussian surface as above (1 point)

$$\rho = \frac{Q}{\frac{4}{3}\pi R^3} \quad (1 \text{ point})$$

$$q = \rho V = \rho \left(\frac{4}{3}\pi r^3 \right) \quad (1 \text{ point})$$

$$E(4\pi r^2) = \frac{q}{\epsilon_0} = \frac{\rho}{\epsilon_0} \left(\frac{4}{3}\pi r^3 \right) \quad (1 \text{ point})$$

$$E = \frac{\rho r}{3\epsilon_0} \quad (1 \text{ point})$$

(-1 point for using ρ without defining it, -3 points for answer only without showing details)

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E & M 1 (continued)

(c) 2 points

$$V = \frac{Q}{4\pi\epsilon_0 R} \quad 2 \text{ points}$$

(-1 point for answer in terms of r)

(d) 4 points

$$V_{\text{center}} = V_{\text{surface}} + \underbrace{\int_R^0 \vec{E} \cdot d\vec{r}}_{1 \text{ pt.}} \quad (1 \text{ point for sum}) \quad 2 \text{ points}$$

$$= \frac{Q}{4\pi\epsilon_0 R} + \frac{Q}{4\pi\epsilon_0 R^3} \left[-\frac{r^2}{2} \right]_R^0 \quad 1 \text{ point}$$

$$= \frac{Q}{4\pi\epsilon_0 R} + \frac{Q}{8\pi\epsilon_0 R} = \frac{3Q}{8\pi\epsilon_0 R} \quad 1 \text{ point}$$

E & M 2.

(a) 4 points

$$\Phi = BA \text{ (or } \Phi = \int \vec{B} \cdot d\vec{A} \text{ or } \Phi = \int \vec{B} \cdot d\vec{s}) \quad 1 \text{ point}$$

$$\Phi = \underbrace{(2e^{-4t})}_{1 \text{ pt.}} \underbrace{(.09)}_{1 \text{ pt.}} \quad 2 \text{ points}$$

$$\Phi = 0.18e^{-4t} \quad 1 \text{ point}$$

(However, no points were awarded for going from $\int \vec{B} \cdot d\vec{A}$ to a time integral such as $\int e^{-4t} dt$)

(b) 1 point

For statement or arrows indicating counterclockwise direction 1 point

(c) 4 points

$$\mathcal{E} = -\frac{d\Phi}{dt} \quad 1 \text{ point}$$

$$= 0.72e^{-4t} \quad 1 \text{ point}$$

$$i = \frac{\mathcal{E}}{R} \quad 1 \text{ point}$$

$$i = 0.12e^{-4t} \quad 1 \text{ point}$$

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E & M 2 (continued)

(d) 6 points

$$P = i^2 R \quad (\text{or } P = \xi^2/R \text{ or } P = i\xi) \quad 1 \text{ point}$$

$$W = \int_0^{\infty} i^2 R dt \quad (+1 \text{ point for indication of integral. If integral is shown, then +1 point for correct limits}) \quad 2 \text{ points}$$

$$W = \int_0^{\infty} 0.864 e^{-8t} dt \quad 1 \text{ point}$$

$$= 0.108 e^{-8t} \Big|_0^{\infty} \quad 1 \text{ point}$$

$$W = 0.108 \text{ J} \quad 1 \text{ point}$$

E & M 3.

(a) 3 points

Immediately after the switch is closed, there is no current in the inductor; its impedance is infinite.

$$R_{\text{tot}} = 10 + 90 = 100 \, \Omega \quad 1 \text{ point}$$

$$i = \frac{\xi}{R_{\text{tot}}} = \frac{20}{100} = 0.2 \text{ A} \quad 1 \text{ point}$$

The potential difference across the 90-ohm resistor, V_{90} , is given by

$$V_{90} = iR = (0.2)(90) = 18 \text{ V} \quad 1 \text{ point}$$

(b) 3 points

$$\xi = -L \frac{di}{dt} \quad 1 \text{ point}$$

$$\xi = V_{90} = 18 \text{ V} \quad 1 \text{ point}$$

$$\left| \frac{di}{dt} \right| = \frac{\xi}{L} = \frac{18}{0.5} = 36 \text{ A/s} \quad 1 \text{ point}$$

(Students who used the emf of the battery, 20 V, and obtained $di/dt = 40 \text{ A/s}$ received 2 points)

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E & M 3 (continued)

(c) 2 points

After a long time, the inductor acts as a short circuit

$$R_{\text{tot}} = 10 \, \Omega \quad 1 \text{ point}$$

$$i = \frac{\mathcal{E}}{R_{\text{tot}}} = \frac{20}{10} = 2 \text{ A} \quad 1 \text{ point}$$

(d) 2 points

$$\text{Energy} = \frac{1}{2} i^2 L \quad 1 \text{ point}$$

$$= \frac{1}{2} (4) (0.5) = 1.0 \text{ J} \quad 1 \text{ point}$$

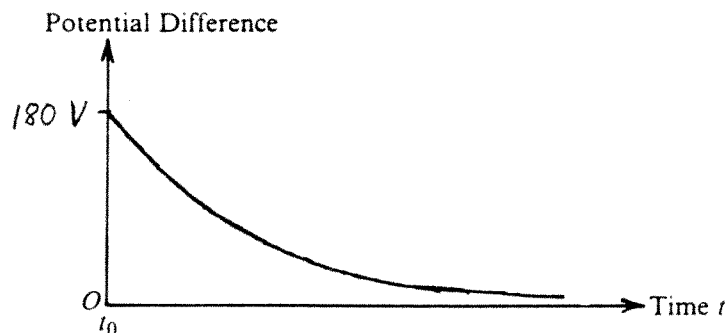
(e) 2 points

Immediately after the switch is opened, the current in the inductor is the same as in part (c). All the current must go through the 90-ohm resistor.

$$V_{90} = V_{\text{inductor}} = iR = (2)(90) \quad 1 \text{ point}$$

$$= 180 \text{ V} \quad 1 \text{ point}$$

(f) 2 points



For curve decreasing in value and concave upward 1 point

For 180 V starting point or any carefully derived answer to part (e) 1 point

Extra 1 point

For obtaining three out of five correct units for answers to parts (a) and (e) 1 point