



AP[®] Physics C 1984 Scoring Guidelines

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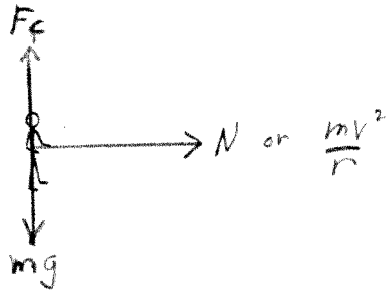
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SOLUTION

Distribution
of Points

Mech. 1. (a) 4 points



1 point for each of the three correctly identified forces

3 points

For no extraneous horizontal forces

1 point

(b) 5 points

$$F = \frac{mv^2}{r} \quad (1 \text{ point})$$

or

$$F = mr\omega^2$$

2 points

$$v = r\omega \quad (1 \text{ point})$$

$$F = 50 \cdot 5 \cdot (2)^2 = 1000 \text{ N}$$

2 points

(1 point for magnitude, 1 point for units)

The centripetal force is provided by the normal force.

1 point

(c) 4 points

$$\sum F_y = 0, \text{ therefore } F_f = mg$$

2 points

$$F_f = (50)(9.8) = 490 \text{ N}$$

1 point

The upward force is provided by friction

1 point

(d) 2 points

No

1 point

For correct justification involving recalculation with m replaced by $2m$ or by arguing that m cancels in appropriate equations, e.g., $\mu m r \omega^2 \geq mg$

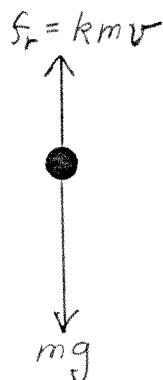
1 point

SOLUTION

Distribution
of Points

Mech. 2 (a)	5 points $F_{\text{grav}} = G \frac{m_1 m_2}{R^2}$	1 point
	$a_{\text{cent}} = \frac{v_o^2}{R}$	1 point
	$G \frac{m_1 m_2}{R^2} = \frac{m_2 v_o^2}{R}$	1 point
	$\therefore v_o^2 = \frac{GM}{R} \quad ; \quad \text{but } R = 2R_E$	1 point
	$\therefore v_o = \sqrt{\frac{GM_E}{2R_E}} \quad (\text{i.e., for correct algebra})$	1 point
(b)	4 points	
	Using conservation of momentum,	
	$(3m)v_o - (m)v_o = (4m)v$	3 points
	(2 points for correct values of momentums, and	
	1 point for minus sign. One point if only	
	$p = mv$ given)	1 point
	$\therefore v = \frac{1}{2}v_o$ (i.e., for correct algebra)	1 point
(c)	6 points	
	$E_{\text{mech}} = \frac{1}{2}(4m)\left(\frac{1}{2}v_o\right)^2 - G \frac{(M_E)(4m)}{2R_E}$	5 points
	Points in this equation include	
	1 point for knowing it's the sum of two energies	
	1 point for knowing the energies are kinetic and potential	
	1 point for correct substitution of $4m$ for mass	
	1 point for correct substitution of $2R_E$ for radius	
	1 point for the minus sign	
	$E_{\text{mech}} = -\frac{7}{4} \frac{G m M_E}{R_E} \quad (\text{i.e., for correct algebra})$	1 point

Mech. 3. (a) 3 points



1 point for each of the correctly identified forces

2 points

For having f_r up, opposite to mg

1 point

(b) 4 points

$$\frac{dv}{dt} = g - kv$$

4 points

Points in this equation include

1 point for knowing to use $F = ma$ 1 point for using derivative $a = \frac{dv}{dt}$ 1 point for $F = mg - kmv$ (signs reversed if use up as +)

1 point for putting together properly

(c) 3 points

$$\left. \begin{array}{l} F=0 \\ mg = kmv_T \\ v_T = \frac{g}{R} \end{array} \right\} \quad \text{or} \quad \left\{ \begin{array}{l} a=0 \quad (\text{or } v = \text{const}) \\ g = kv_T \\ v_T = \frac{g}{R} \end{array} \right.$$

2 points

1 point

Answer also commonly obtained after part (d) by letting $t \rightarrow \infty$. This approach also awarded full credit.

(d) 3 points

$$\int \frac{dv}{g - kv} = \int dt \quad (\text{i.e., for any correct integral set up}) \quad 1 \text{ point}$$

$$-\frac{1}{k} \ln(g - kv) = t + C \quad 1 \text{ point}$$

(i.e., for constant of integration, ^{correct} limits on integral,
or matching initial condition)

$$t = 0 \text{ implies } v = 0$$

$$\therefore C = -\frac{1}{k} \ln g$$

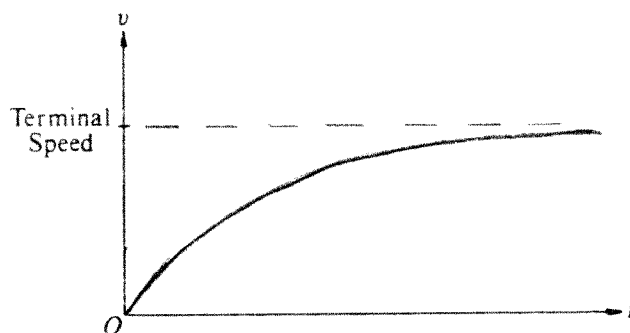
$$-\frac{1}{k} \ln(g - kv) = t - \frac{1}{k} \ln g$$

$$v = \frac{g}{k} (1 - e^{-kt})$$

$$\left. \begin{array}{l} \text{Correct evaluation} \\ \text{of} \\ \int_0^v \frac{dv}{g - kv} = \int_0^t dt \end{array} \right\} \text{or}$$

1 point

(e) 3 points

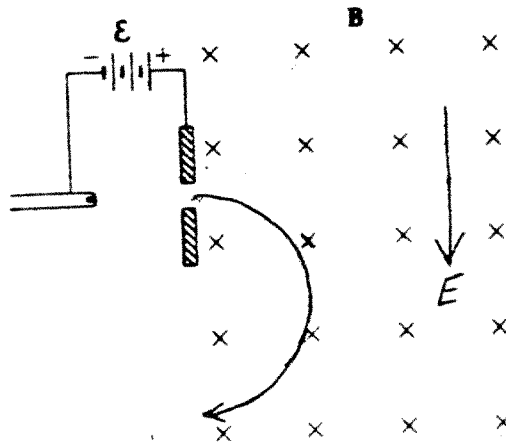


For curve having $v = 0$ at $t = 0$ 1 point

For curve being concave downward all the way 1 point

For curve being asymptotic to v_T 1 point

SOLUTION

Distribution
of Points

E&M1. (a) 3 points

$$\underbrace{\frac{1}{2}mv^2}_{1 \text{ point}} = \underbrace{\epsilon q}_{1 \text{ point}}$$

2 points

$$\epsilon = \frac{mv^2}{2e}$$


1 point

(b) 3 points

For curved path

1 point

For downward path

For correct curve beginning immediately upon
leaving slit, i.e., not 

1 point

1 point

(c) 4 points

$$\underbrace{qvB}_{1 \text{ point}} = \underbrace{\frac{mv^2}{r}}_{2 \text{ points}}$$

3 points

(1 point for recognition of
centripetal force, 1 point for correct form)

$$r = \frac{mv}{Be}$$

1 point

(d) 5 points

$$\text{i. } \underbrace{-qE}_{1 \text{ point}} = \underbrace{qvB}_{1 \text{ point}}$$

2 points

$$E = vB$$

1 point

ii. For \vec{E} vertical

1 point

For \vec{E} in the same direction as deflection due to \vec{B}

1 point

SOLUTION

Distribution
of Points

E&M 2. (a) 3 points

$$V_1 = E_1 a \text{ and } V_2 = E_2 b$$

1 point

$$V_1 = V_2, \text{ so } E_1 a = E_2 b$$

1 point

$$\therefore \frac{E_1}{E_2} = \frac{b}{a}$$

1 point

(b) 5 points

$$\oint \vec{E} \cdot d\vec{A} = q_{in}/\epsilon_0 \text{ (i.e., for correct statement of Gauss's law)}$$

1 point

$$\oint \vec{E} \cdot d\vec{A} = E_1 A + E_2 A$$

2 points

(i.e., 1 point for no flux on the sides and 1 point
for recognizing two fields involved)

$$q_{in} = \sigma A$$

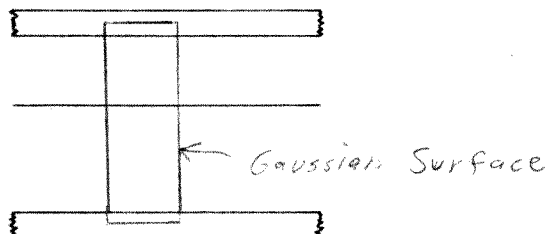
1 point

$$\therefore E_1 A + E_2 A = \sigma A/\epsilon_0$$

$$E_1 + E_2 = \sigma/\epsilon_0$$

1 point

(c) 4 points



Correct Gaussian surface

1 point

 $\vec{E} = 0$ in a conductor

1 point

$$\text{Since } \oint \vec{E} \cdot d\vec{A} = 0, q_{in} = 0$$

1 point

$$\therefore \oint \vec{E} \cdot d\vec{A} = \sigma_1 A + \sigma_2 A + \sigma A = 0$$

$$\sigma_1 + \sigma_2 = -\sigma$$

1 point

or

Since there was some ambiguity about whether the σ 's
included the sign or meant just absolute value,
full credit also given for obtaining $\sigma_1 + \sigma_2 = \sigma$

SOLUTION

Distribution
of Points

(d) 3 points

$$\left. \begin{array}{l} E_1 a = E_2 b \\ E_1 + E_2 = \sigma / \epsilon_0 \end{array} \right\} \text{(i.e., to assemble these equations)} \quad 1 \text{ point}$$

$$E_1 = \frac{\sigma b}{\epsilon_0 (a+b)} \quad \text{or} \quad E_2 = \frac{\sigma a}{\epsilon_0 (a+b)} \quad (\text{i.e., to find a field}) \quad 1 \text{ point}$$

$$V = E_1 a \quad \text{or} \quad V = E_2 b$$

$$\therefore V = \frac{\sigma ab}{\epsilon_0 (a+b)} \quad 1 \text{ point}$$

Alternate Solutions to (d) - Also worth full credit

$$1) E_1 + E_2 = \sigma / \epsilon_0$$

$$E_1 = V/a, \quad E_2 = V/b$$

$$\therefore \frac{V}{a} + \frac{V}{b} = \frac{\sigma}{\epsilon_0}$$

$$V = \frac{\sigma ab}{\epsilon_0 (a+b)}$$

2) This situation is the same as two parallel-plate capacitors in parallel, so

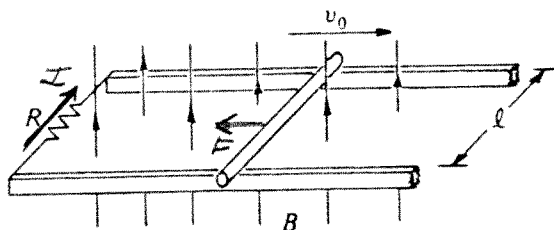
$$C = C_1 + C_2 = \frac{\epsilon_0 A}{a} + \frac{\epsilon_0 A}{b}, \quad \text{where } A \text{ is the plate area}$$

$$\text{But } C = \frac{Q}{V} = \frac{\sigma A}{V}$$

$$\therefore \frac{\sigma A}{V} = \epsilon_0 A \left(\frac{1}{a} + \frac{1}{b} \right)$$

$$V = \frac{\sigma ab}{\epsilon_0 (a+b)}$$

SOLUTION

Distribution
of Points

E&M 3. (a) 2 points

For correct identification of current in diagram

2 points

(b) 4 points

$$\mathcal{E} = - \frac{d\Phi}{dt}$$

1 point

$$= - \frac{d(BA)}{dt} = - B \frac{d(lx)}{dt}$$

$$\mathcal{E} = -Blv_0$$

(2 points also awarded for
beginning with $\mathcal{E} = Blv_0$,
without derivation)

1 point

$$IR = -Blv_0$$

1 point

$$I = - \frac{Blv_0}{R}$$

1 point

However, sign was ignored in grading. In essence it
was $|I| = \frac{Blv_0}{R}$ that was looked for. Full credit also
given for using v instead of v_0 .

(c) 2 points

For correct identification of force to left on
diagram

2 points

(d) 2 points

$$F = IlB$$

$$= \left(\frac{Blv_0}{R} \right) lB$$

1 point

$$F = \frac{B^2 l^2 v_0}{R}$$

1 point

SOLUTION

Distribution
of Points

Alternate Solution

Alternate
points

$$F = ma = m \frac{dv}{dt}$$

$$F(t) = m \frac{d}{dt} \left(v_0 e^{-\frac{B^2 \ell^2 t}{Rm}} \right) = m \left(-\frac{B^2 \ell^2 v_0}{R} e^{-\frac{B^2 \ell^2 t}{Rm}} \right) \quad (1 \text{ point})$$

$$F(0) = -\frac{B^2 \ell^2 v_0}{R} \quad (1 \text{ point})$$

If the answer was left as $F(t)$, rather than $F(0)$,
full credit was still awarded.

(e) 3 points

$$P = I^2 R \quad 1 \text{ point}$$

$$I = \frac{B \ell v}{R} \text{ (from part (b), except cannot use } v_0 \text{)}$$

$$\therefore P = \left(\frac{B \ell v}{R} \right)^2 R \quad 1 \text{ point}$$

$$P = \frac{B^2 \ell^2}{R} \left(v_0 e^{-\frac{B^2 \ell^2 t}{mR}} \right)^2 = \frac{B^2 \ell^2 v_0^2}{R} e^{-\frac{2B^2 \ell^2 t}{mR}} \quad 1 \text{ point}$$

Either form of the last two steps was acceptable.

Alternate solutions

Alternate
points

$$1) P = Fv$$

$$P = \left(\frac{B^2 \ell^2 v}{R} \right) v \quad \text{or} \quad P = (I \ell B) v = \left(\frac{B \ell v}{R} \right) \ell B v \quad (1 \text{ point})$$

$$P = \frac{B^2 \ell^2 v^2}{R} \quad (1 \text{ point})$$

$$P = \frac{B^2 \ell^2}{R} \left(v_0 e^{-\frac{B^2 \ell^2 t}{mR}} \right)^2 = \frac{B^2 \ell^2 v_0^2}{R} e^{-\frac{2B^2 \ell^2 t}{mR}} \quad (1 \text{ point})$$

Again either form of the last two steps was acceptable.

If $F = \frac{B^2 \ell^2 v_0}{R}$ was substituted at 2nd step, a maximum
of 2 points given, because it meant that a factor of
2 was missing from the exponent.

SOLUTION

Distribution
of Points

$$\begin{aligned}
 2) \quad P &= \frac{dW}{dt} = \frac{d}{dt} \left(\frac{1}{2} m v^2 \right) & (1 \text{ point}) \\
 &= m v \frac{dv}{dt} = m v \left(-\frac{B^2 \ell^2}{m R} v \right) & (1 \text{ point}) \\
 &= -\frac{B^2 \ell^2}{R} v^2
 \end{aligned}$$

(rest of solution as in previous alternate;
minus sign was ignored)

(1 point)

(f) 2 points

$$P = \frac{dW}{dt} \quad \text{or} \quad W = \int_0^\infty P(t) dt$$

1 point

$$W = \int_0^\infty \frac{B^2 \ell^2 v_0^2}{R} e^{-\frac{2B^2 \ell^2 t}{m R}} dt$$

$$W = \frac{1}{2} m v_0^2$$

1 point

If student used a form for $P(t)$ missing the factor of 2 in the exponent, full credit was given for answer of $m v_0^2$ (correct calculation), but only 1 point was given for $\frac{1}{2} m v_0^2$ (incorrect calculation, or "forcing" the answer).