



## AP<sup>®</sup> Physics C 1975 Scoring Guidelines

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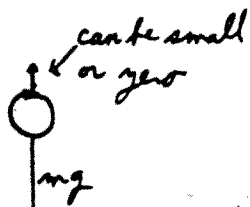
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1175C

Mech. 1

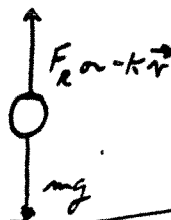
a)

(i)



1 pt for arrow + label

(ii)

1 point for  $F_R$  arrow (equal to  $mg$ )  
1 point for  $mg$  arrowb) At terminal velocity,  $\Sigma \vec{F} = 0$ 

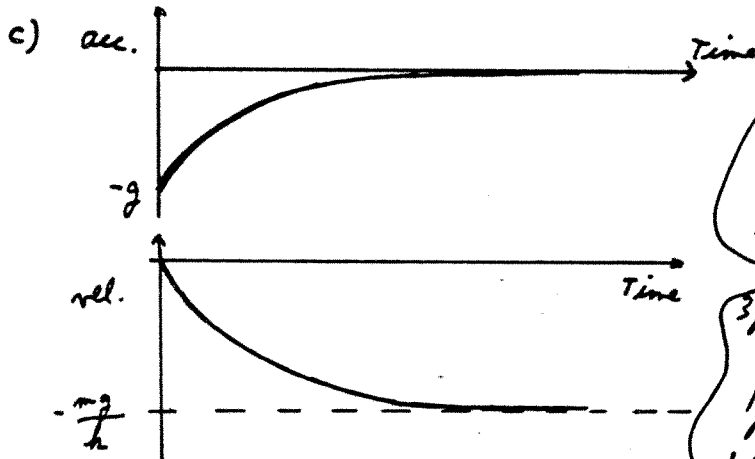
1 pt

 $\therefore$  (scalar eq.)

$$mg = k v_T$$

$$v_T = mg/k$$

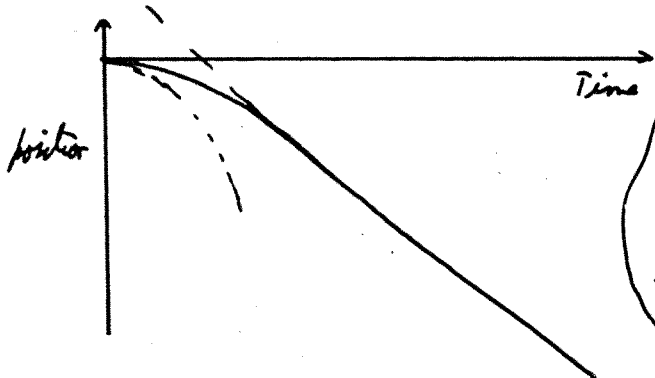
2 pts

NOTE:- no extra credit  
for minus sign  
 $v_T = -mg/k$ 

3 pts:

1 pt. for asymptotic character  
1 pt. for "exponential" shape  
1 pt. for labeled intercept

3 pts:

1 pt. for "negative slope" at origin  
1 pt. for "exponential" shape  
1 pt. labeled horizontal asymptote

3 pts:

1 pt. for zero slope at origin  
1 pt. for general shape  
1 pt. for asymptotic form as  $t$  gets large (slope =  $-mg/k$ )

1975 C

a) The angular momentum of the system is conserved. (2 pts)

$$|\vec{L}_0| = |\vec{r} \times \vec{p}_0| = m_0 v_0 R \sin \theta \quad (2 \text{ pts})$$

8 pts

$$|\vec{L}_F| = I \omega \quad (2 \text{ pts})$$

$$\omega = m_0 v_0 R \sin \theta / I \quad (2 \text{ pts})$$

Alternate solut: #1

The tangential component of linear momentum is conserved.

$$p_{t0} = m_0 v_0 \sin \theta \quad v_f = \frac{m_0 v_0 \sin \theta}{(m_0 + M)}$$

$$p_{tF} = (m_0 + M) v_f$$

$$\omega = v_f / R$$

Alternate solut: #2 IMPULSE METHOD

$$\text{On the wheel: } \int \text{Torque } dt = I \Delta \omega \quad \text{Torque} = \vec{r} \times \vec{F}$$

$$\text{On the dart: } \int F dt = \Delta(m_0 v) \quad \text{Torque} = -R F_t$$

$$\therefore -\int R F_t dt = I \Delta \omega \rightarrow \int F_t dx = \frac{I}{R} \omega_f$$

$$\text{But } \int F_t dx = \Delta(m_0 v)_t = m_0 v_f - m_0 v_0 \sin \theta = m_0 \{ \omega_f R - v_0 \sin \theta \}$$

$$- \frac{MR^2 \omega_f}{R} = m_0 R \omega_f - m_0 v_0 \sin \theta$$

$$\omega_f = \frac{m_0 v_0 \sin \theta}{(m_0 + M) R}$$

$$b) E_{h \text{ int}} = E_{h \text{ dart}} = \frac{1}{2} m_0 v_0^2 \quad (2 \text{ pts})$$

5 pts

$$E_{hs} = E_{h \text{ rot}} = \frac{1}{2} I \omega^2 \quad (2 \text{ pts})$$

$$E_{hs} / E_{h \text{ int}} = \frac{I \omega^2}{m_0 v_0^2} = \frac{m_0 \sin^2 \theta}{(m_0 + M)} \quad (1 \text{ pt})$$

2 pts

$$I = (m_0 + M) R^2$$

(NOTE: value given wherever introduced into problem)

1975 C

a) Using the ceiling as reference point:

$$E_{p \text{ init}} = -\frac{1}{2} m g l$$

(2 pts)

[5 pts]

$$E_{p \text{ final}} = -\frac{1}{4} m g l$$

(2 pts)

$$\Delta E_p = E_{p f} - E_{p i} = +\frac{1}{4} m g l$$

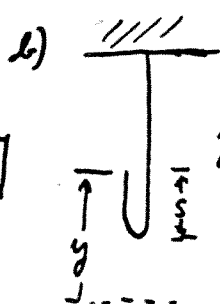
(1 pt)

Alternate soln. #1:Bottom  $\frac{1}{2}$  of chain only moves up  $\frac{1}{2} l$ ;

$$W = \Delta E_p = \left(\frac{1}{2} m\right) g \frac{l}{2} = +\frac{1}{4} m g l$$

Alternate soln. #2:

$$\Delta E_p = +m g \Delta y_{CM} = +m g \left(\frac{l}{2} - \frac{l}{4}\right) = +\frac{1}{4} m g l$$

 $\rho$  = Linear density of chain =  $m g / l$ 

(2 pts)

$$y = 2s$$

$$F = \rho s$$

(3 pts)

$$F = \frac{m g}{2l} s$$

(2 pts)

c)

$$\int_0^l \vec{F} \cdot d\vec{y} = \frac{m g}{2l} \int_0^l y dy = \frac{m g}{2l} \left[ \frac{y^2}{2} - 0 \right] = \frac{1}{4} m g l$$

[3 pts]

(1 pt) - for correct limits [for the student]

(1 pt) - for correct integration

(1 pt) - for correct algebra.

E.&amp;M.1

- a) A statement of the idea  $U = \int_{\infty}^{\infty} \vec{F} \cdot d\vec{z}$  or  $q \int_{\infty}^{\infty} \vec{E} \cdot d\vec{z}$   
 or  $U = \sum qV$  or  $\sum kq \frac{q'}{r}$

(3 pts)

Carry through the algebra:

$$U = 2Kq^2/r$$

(1 pt)

obtain answer as function of  $x$ , with  $r = \sqrt{x^2 + l^2}$ 

$$U = \frac{2Kq^2}{\sqrt{x^2 + l^2}} = \frac{2q^2}{4\pi\epsilon_0 \sqrt{x^2 + l^2}}$$

(1 pt)

5 pts

b)  $\vec{F} = \frac{kq^2}{r^2} \hat{n} = \frac{kq^2}{(x^2 + l^2)} \hat{n}$

(1 pt)

The y-components cancel; the x-components add  
 use  $\cos \theta = x/\sqrt{x^2 + l^2}$ 

(3 pts)

$$F_x = \frac{2Kq^2}{(2l^2)} \frac{1}{\sqrt{2}} = \frac{\sqrt{2}}{2} \frac{kq^2}{l^2} = \frac{\sqrt{2}}{8\pi\epsilon_0 l^2} \frac{q^2}{\sqrt{2}} = \frac{1}{4\pi\epsilon_0} \frac{q^2}{\sqrt{2} l^2}$$

(1 pt)

5 pts

c)  $W = qV = \int \vec{F} \cdot d\vec{z} = q \int \vec{E} \cdot d\vec{z} = \sum qV$

(1 pt)

5 pts

$$= -[U_0 - U_{\infty}] = -U_0 = -\frac{1}{4\pi\epsilon_0} \frac{2q^2}{l}$$

(1 pt)

(1 pt for ans)

Relation to work of the field

(2 pts)

E.&amp;M.2

- a) at equilibrium  $Q_1 = \epsilon C_1$

(2 pts)

3 pts

$$= (100V)(12 \times 10^{-6} F) = 12 \times 10^{-4} C$$

(1 pt)

- b) Total capacitance  $C = C_1 + C_2$

(2 pts)

$$= 36 \times 10^{-6} F$$

(1 pt)

6 pts

$$\frac{Q_1}{C_1} = \frac{Q_2}{C_2} = \frac{Q}{C} = \frac{12 \times 10^{-4}}{36 \times 10^{-6}}$$

(2 pts)

$$Q_1 = \frac{C_1}{C} Q = \frac{12 \times 10^{-6}}{36 \times 10^{-6}} 12 \times 10^{-4} = 4 \times 10^{-4} C$$

(1 pt)

1975 C

Alternate solution:

Since charge divides proportionately, 2:1

Then  $Q_1 = 4 \times 10^{-4} \text{ C}$  or  $Q_2 = 8 \times 10^{-4} \text{ C}$  (6 pts)

c)

$V = Q/C$  (1 pt)

[3 pts]

$= \frac{4 \times 10^{-4} \text{ C}}{12 \times 10^{-6} \text{ F}} = 33.3 \text{ V}$  (1 pt) + (1 pt)

d)

$C_T = 36 \times 10^{-6} \text{ F}$  (1 pt)

$Q_T = \mathcal{E} C_T = (100 \text{ V})(36 \times 10^{-6}) = 36 \times 10^{-4} \text{ C}$  (1 pt)

[3 pts]

$\therefore \Delta Q = Q_T - Q_0 = (36 - 12) \times 10^{-4}$  (1 pt)

$\Delta Q = 24 \times 10^{-4} \text{ C}$  (1 pt)

E. &amp; M. 3

a)

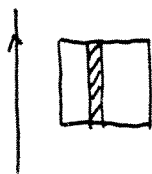
Indicate on diagram counterclockwise current (1 pt)

Flux,  $\Phi_B$ , is increasing down into page because  $I$  is increasing [right hand rule gives direction] (3 pts)

[6 pts]

From Lenz' Law emf induced to oppose change in flux through [right hand rule gives direction] (2 pts)

b)



$d\Phi_B = \beta dA = \frac{\mu_0 I}{2\pi r} (l dr)$  (3 pts)

$\Phi_B = \frac{\mu_0 I l}{2\pi} \int_a^b \frac{dr}{r} = \frac{\mu_0 I l}{2\pi} \ln\left(\frac{b}{a}\right)$  (1 pt)

[9 pts]

$\frac{d\Phi_B}{dt} = \frac{\mu_0 l}{2\pi} \ln\left(\frac{b}{a}\right) \frac{dI}{dt}$  (2 pts)

$\mathcal{E}_{\text{ind}} = -\frac{d\Phi_B}{dt} = -\frac{l}{a} R$  (1 pt)

$I_{\text{ind}} = -\frac{\mu_0 l}{2\pi R} \ln\left(\frac{b}{a}\right) \frac{dI}{dt}$  (2 pts)