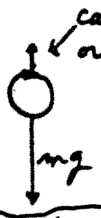
AP® Physics C
1975 Scoring Guidelines

1975C

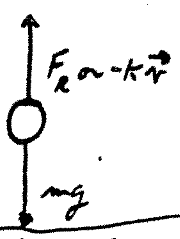
Mech. 1

a) (i)



1 pt for arrow + label

(ii)



1 point of F_R arrow (equal to mg)
1 point for mg arrow

3 pts

b) At terminal velocity, $\Sigma \vec{F} = 0$ (1 pt)

$\therefore$ (scalar eq.)

$$mg = k v_T$$

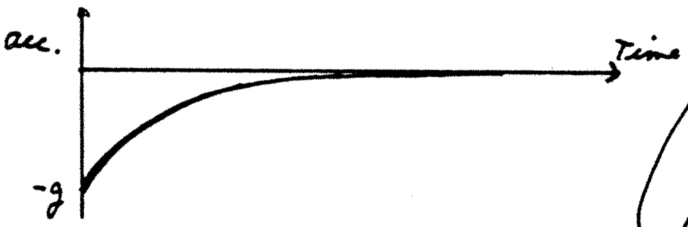
$$v_T = mg/k$$

(2 pts)

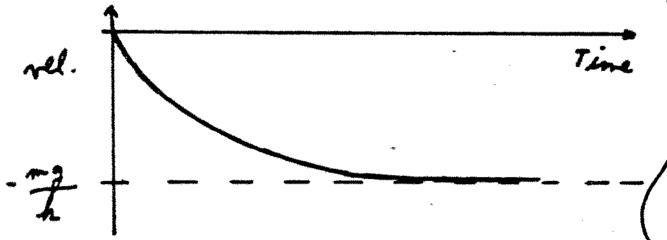
NOTE:- no extra credit for minus sign $v_T = -mg/k$

3 pts

c)

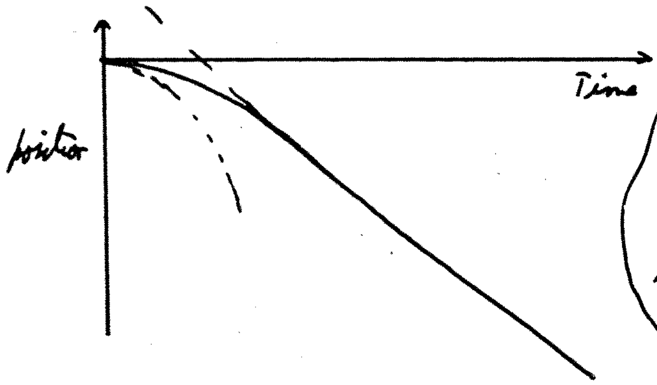


3 pts:
1 pt. for asymptotic character
1 pt. for "exponential" shape
1 pt. for labeled intercept



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

9 pts.



3 pts:
1 pt for zero slope at origin
1 pt. for general shape
1 pt. for asymptotic form as t gets large (slope $= -\frac{mg}{k}$)

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Mech. 2

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

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

$\boxed{8\text{ pts}}$

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

$$\omega = m_0 v_0 R \sin\theta / I$$ (2 pts)

<u>Alternate solut: #1</u>

The tangential component of linear momentum is conserved.

$$p_{T_0} = m_0 v_0 \sin\theta \qquad v_f = \frac{m_0 v_0 \sin\theta}{(m_0 + M)}$$

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

$$\omega = v_f / R$$

<u>Alternate solut: #2</u> IMPULSE METHOD

On the wheel: $\int \text{Torque}\, dt = I_w \Delta\omega$ $\qquad$ $\text{Torque} = \vec{r} \times \vec{F}$

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

$$\therefore -\int R F_t\, dt = I_w \Delta\omega \longrightarrow \int F_t\, dt = \frac{-1}{R} I_w \omega_f$$

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

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

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

b) $$E_{k\,int} = E_{k\,dart} = \frac{1}{2} m_0 v_0^2$$ (2 pts)

$\boxed{5\text{ pts}}$

$$E_{k_f} = E_{k\,wt} = \frac{1}{2} I\omega^2$$ (2 pts)

$$E_{kf}/E_{k\,int} = \frac{I\omega^2}{m_0 v_0^2} = \frac{m_0 \sin^2\theta}{(m_0 + M)}$$ (1 pt)

$\boxed{2\text{ pts}}$

$$\underline{I} = (m_0 + M) R^2$$ (NOTE: value given wherever introduced into problem)

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Mech. 3

a) Using the ceiling as reference point:

$$E_{p\,init} = -\tfrac{1}{2} mg\ell \qquad \text{2 pts}$$

[5 pts]

$$E_{p\,final} = -\tfrac{1}{4} mg\ell \qquad \text{2 pts}$$

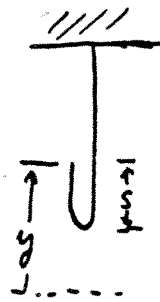
$$\Delta E_p = E_{p_f} - E_{p_i} = +\tfrac{1}{4} mg\ell \qquad \text{1 pt}$$

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

$$W = \Delta E_p = (\tfrac{1}{2}m) g \tfrac{\ell}{2} = +\tfrac{1}{4} mg\ell$$

Alternate solut. #2:

$$\Delta E_p = +mg\,\Delta y_{CM} = +mg\left(\tfrac{\ell}{2} - \tfrac{\ell}{4}\right) = +\tfrac{1}{4} mg\ell$$

b) 

ρ = Linear density of chain = mg/ℓ 2 pts

[7 pts]

$y = 2s$ $\quad F = \rho s$ 3 pts

$$F = \frac{mg}{2\ell} s \qquad \text{2 pts}$$

c)

$$\int_0^\ell \vec{F} \cdot d\vec{y} = \frac{mg}{2\ell} \int_0^\ell y\,dy = \frac{mg}{2\ell}\left[\frac{\ell^2}{2} - 0\right] = \tfrac{1}{4} mg\ell$$

[3 pts]

1 pt - for correct limits [for the student]

1 pt - for correct integration

1 pt - for correct algebra.

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8F

E.&M. 1

a) A statement of the idea $U = \int_\infty^0 \vec{F}\cdot d\vec{s}$ or $q\int_\infty^0 \vec{E}\cdot d\vec{s}$

or $U = \Sigma qV$ or $\Sigma \frac{Kqq'}{r}$ (3 pts)

5 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)

b) $\vec{F} = \frac{Kq^2}{r^2}\hat{r} = \frac{Kq^2}{(x^2+l^2)}\hat{r}$ (1 pt)

5 pts

The y-components cancel; the x-components add

use $\cos\theta = x/\sqrt{x^2+l^2}$ (3 pts)

$$F_{x=l} = \frac{2Kq^2}{(2l^2)}\frac{1}{\sqrt{2}} = \frac{\sqrt{2}}{2}\frac{Kq^2}{l^2} = \frac{\sqrt{2}}{8\pi\epsilon_0}\frac{q^2}{l^2} = \frac{1}{4\pi\epsilon_0}\frac{q^2}{\sqrt{2}l^2}$$ (1 pt)

c) $W = qV = \int \vec{F}\cdot d\vec{s} = q\int \vec{E}\cdot d\vec{s} = \Sigma qV$ (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.&M. 2

a) at equilibrium $Q_1 = \mathcal{E}C_1$ (2 pts)

3 pts

$= (100V)(12\times10^{-6}F) = 12\times10^{-4}C$ (1 pt)

b) Total capacitance $C = C_1 + C_2$ (2 pts)

$= 36\times10^{-6}F$ (1 pt)

6 pts

$$\frac{Q_1'}{C_1} = \frac{Q_2'}{C_2} = \frac{Q}{C} = \frac{12\times10^{-4}}{36\times10^{-6}}$$ (2 pts)

$$Q_1' = \frac{C_1}{C}Q = \frac{12\times10^{-6}}{36\times10^{-6}}12\times10^{-4} = 4\times10^{-4}C$$ (1 pt)

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Alternate solution:

Since charge divides proportionately, 2:1 (6 pts)

Then $Q_1 = 4\times10^{-4}C$ or $Q_2 = 8\times10^{-4}C$

c) $V = Q/C$ (1 pt)

[3 pts] $= \frac{4\times10^{-4}C}{12\times10^{-6}F} = 33.3V$ (1 pt) + (1 pt)

d) $C_T = 36\times10^{-6}F$

$Q_T = \mathcal{E}C_T = (100V)(36\times10^{-6}) = 36\times10^{-4}C$ (1 pt)

[3 pts] $\therefore \Delta Q = Q_T - Q_0 = (36-12)\times10^{-4}$ (1 pt)

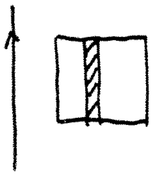
$\Delta Q = 24\times10^{-4}C$ (1 pt)

E.&M.3 a) Indicate on diagram counterclockwise current (1 pt)

Flux, Φ_B, is increasing down into page because I is increasing [right hand rule gives direction] (3 pt)

[6 pts]

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

b) 

$d\Phi_B = B\,dA = \frac{\mu_0 I}{2\pi r}(l\,dr)$ (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)

$Emf = -\frac{d\Phi_B}{dt} = I_n R$ (1 pt)

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