PHYSICS - ADVANCED HIGHER

2001

1. a.) i.) $s = ut + \frac{1}{2}at^2$.

$100 = 0 + \frac{1}{2}a \times 8^2$

$= 32a$

$\therefore a = \frac{100}{32} = 3.125 \, ms^{-2}$

ii.) $s = \frac{1}{2}at^2$

~~$t^2 = \frac{2s}{a}$~~

$a = \frac{2s}{t^2}$.

%age uncertainty in $s = \frac{1}{100} \times 100 = 1\%$

%age uncertainty in $t^2 = 2 \times \frac{0.4}{8} \times 100$

$= 10\%$.

$\therefore$ %age uncertainty in $a = 10\%$. (4.)

b.) $a_T = r\alpha$.

$\alpha = \frac{a_T}{r} = \frac{3.125}{0.3} = 10.4 \, rad \, s^{-2}$ (2.)

c.) i.) Cent. force $= \frac{mv^2}{r}$.

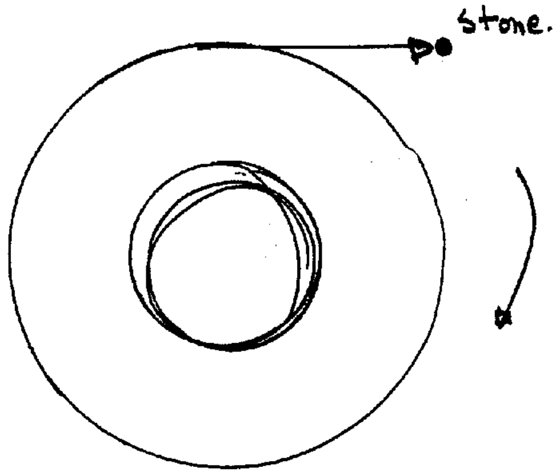
Max. cent. force = 3 N.

V increases. Eventually $\frac{mv^2}{r} > 3$. Friction is too small to supply the necessary cent. force and stone moves off in a straight line.

ii.) $3 = \frac{mv^2}{r}$ $v^2 = \frac{3r}{m} = \frac{3 \times 0.3}{4 \times 10^{-3}} = \frac{9 \times 100}{4}$

$v = 15 \, ms^{-1}$

1\. c.) iii.) Stone obeys N1 and moves off in a straight line as below.



2\. a.) i.) $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$.

$\theta = 8 \times 2\pi = 16\pi$.

$\therefore 16\pi = 0 + \frac{1}{2}\alpha 6^2$

$= 18\alpha$.

$\therefore \alpha = \frac{16\pi}{18} = 2.8 \text{ rad s}^{-2}$.

ii.) $\omega = \omega_0 + \alpha t$.

$\omega = 0 + 2.8 \times 6$

$= 16.8 \text{ rad s}^{-1}$. (4.)

b.) i.) $G = I\alpha$.

Applied $G = Fr = 3 \times 20 \times 10^{-3}$

$= 0.06 \text{ Nm}$.

$\therefore$ Unbalanced $G = 0.06 - 0.01 = 0.05 \text{ Nm}$.

$\therefore 0.05 = 2.8 \times I$

$\therefore I = \frac{0.05}{2.8} = 0.018 \text{ kgm}^2$

ii.) A.) $G = I\alpha$.

$0.01 = 0.018\,\alpha$

$\alpha = \frac{0.01}{0.018} = 0.56 \text{ rad s}^{-2}$.

B.) $\omega = \omega_0 + \alpha t$.

~~16.8~~ $0 = 16.8 - 0.56t$

$t = \frac{16.8}{0.56} = 30\text{s}$. (6.)

2. c.) $\tau = Fr$.

r is greater $\therefore$ τ is greater.

$\tau = I\alpha$.

$\therefore$ α is greater

$\therefore$ takes less time to unwrap

3. a.) i.) $g = \frac{GM}{r^2} = \frac{6.67\times10^{-11} \times 2.18\times10^{20}}{(261\times10^3)^2}$

$= \frac{6.67\times2.18}{261^2} \times 10^3$

$= 2.13\times10^{-4}\times10^3$

$= 0.213\ N\,kg^{-1}$.

ii.) Cent. force $= mg = \frac{mv^2}{r}$.

$\therefore \frac{v^2}{r} = g$.

$v = \frac{2\pi r}{T}$

$\therefore \frac{\frac{4\pi^2 r^2}{T^2}}{r} = g$.

$\therefore \frac{4\pi^2 r^3}{T^2} = g$

$\therefore T^2 = \frac{4\pi^2 r^3}{g}$.

$\therefore T = \sqrt{\frac{4\pi^2 r^3}{g}} = \sqrt{\frac{39.4\times10^{12}}{0.213}}$.

$= \sqrt{185\times10^{12}}$

$= 13.6\times10^6\ s$.

(5)

3. b) i.) $m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$

$$10 m_0 = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$\sqrt{1-\frac{v^2}{c^2}} = 0.1$$

$$1-\frac{v^2}{c^2} = 0.01$$

$$\frac{v^2}{c^2} = 0.99$$

$$v = \sqrt{0.99}\ c.$$

$$= 0.995c.$$

$$= 2.985 \times 10^8 ms^{-1}.$$

ii.) Let $v = c$, then $m = \frac{m_0}{\sqrt{1-\frac{c^2}{c^2}}} = \frac{m_0}{0} = \infty.$

Energy required to be converted into mass is infinite
$\therefore$ $v = c$ impossible. (3)

4. a.) i.) $\frac{d^2y}{dt^2} = -\omega^2 y.$

$$T = 500 \times 10^{-3} s.$$

$$f = \frac{1}{T} = \frac{1}{500 \times 10^{-3}} = 2Hz.$$

$$\therefore \frac{d^2y}{dt^2} = -(4\pi)^2 y. = -158y.$$

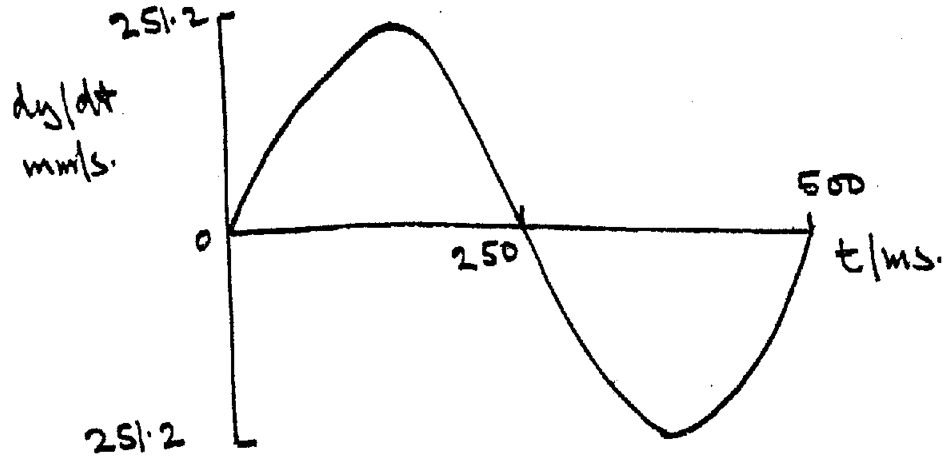
Max. value for $y = 20$ mm.
$\therefore$ " " for $\frac{d^2y}{dt^2} = -(4\pi)^2 \times 20 =$

Not needed.

4\. a.) ii.) Let $y = a\cos\omega t$

Then $\frac{dy}{dt} = a\omega\sin\omega t$

Max. value for $\frac{dy}{dt} = a\omega = 20 \times 2\pi \times 2 = 80\pi = 251.2 \text{ mms}^{-1}$.



(5.)

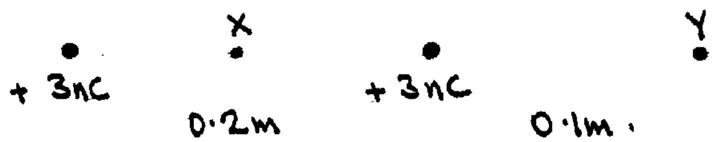
b.) For SHM $\frac{dy}{dt} = a\omega\sin\omega t$.

Thus vel. varies with time.

Vel. of given object is constant and does not vary with time.

∴ Motion is not SHM. (2.)

5\. a.) i.)



A.) $E = E_1 + E_2 = \frac{q_1}{4\pi\varepsilon_0 r_1} + \frac{q_2}{4\pi\varepsilon_0 r_2}$

$= \frac{3\times10^{-9}}{4\pi\varepsilon_0 \times 0.1} - \frac{3\times10^{-9}}{4\pi\varepsilon_0 \times 0.1}$

$= 0$.

B.) $E = E_1 + E_2 = \frac{3\times10^{-9}}{4\pi\varepsilon_0 \times 0.3} + \frac{3\times10^{-19}}{4\pi\varepsilon_0 \times 0.1}$

$= \frac{3\times10^{-9}}{4\pi\varepsilon_0}\left[\frac{1}{0.3} + \frac{1}{0.1}\right] = \frac{3\times10^{-9}}{4\pi\varepsilon_0} \times \frac{4}{0.3}$

$= \frac{10^{-8}}{\pi \times 8.85\times10^{-11}} = \frac{10^{3}}{8.85\pi} = 36 \text{ NC}^{-1}$

5. a.) ii.) Potl. Energy possessed by 1C of charge at that point

iii.) $\Delta V = V_x - V_y$.

$$V_x = V_1 + V_2 = \frac{q_1}{4\pi\varepsilon_0 r_1} + \frac{q_2}{4\pi\varepsilon_0 r_2}.$$

$$= \frac{3\times10^{-9}}{4\pi\varepsilon_0\times0.1} + \frac{3\times10^{-9}}{4\pi\varepsilon_0\times0.1}.$$

$$= \frac{6\times10^{-9}}{4\pi\varepsilon_0\times0.1}.$$

$$V_y = V_1 + V_2 = \frac{3\times10^{-9}}{4\pi\varepsilon_0\times0.4} + \frac{3\times10^{-9}}{4\pi\varepsilon_0\times0.1}$$

$$= \frac{3.75\times10^{-9}}{4\pi\varepsilon_0\times0.1}$$

$$\Delta V = \frac{6\times10^{-9}}{4\pi\varepsilon_0\times0.1} - \frac{3.75\times10^{-9}}{4\pi\varepsilon_0\times0.1}.$$

$$= \frac{2.25\times10^{-8}}{4\pi\times8.85\times10^{-12}}$$

$$= \frac{2.25\times10^{4}}{4\pi\times8.85} = 0.0202\times10^{4}.$$

$$= 202\text{ V}.$$

b.) Charge is due to a surplus or deficit of electrons.

Charge = integral no. of electronic charges

$= n \times 1.6\times10^{-19}$ C.

$\therefore$ -4.5×10^{-19} is suspect. (2.)

6. a.) Force on magnet assembly is down $\therefore$ force on wire is <u>up</u>.

Current flows from X → Y $\therefore$ X -ve, Y +ve. (1.)

b.) i.) Gradient $= \frac{60\text{mg}}{600\text{mA}} = 0.1\text{g/A}$

ii.).

6. c.) $F = I l B \sin\theta$

$= I l B \sin 90°$

$= I l B$.

F = Balance reading × g.

$\frac{F}{I} = lB$.

$\frac{F}{I} = \frac{\text{Balance reading} \times g}{I} = \text{gradient} \times g$

gradient = $0.1\,g/A = 0.1 \times 10^{-3}\,kg/A$.

$\therefore \frac{F}{I} = 10^{-4} \times 9.8$

$B = \frac{F}{Il} = \frac{10^{-4} \times 9.8}{6 \times 10^{-2}} = \frac{9.8}{6} \times 10^{-2} = 1.63 \times 10^{-2}\,T$. (3)

7 a.) At rt. Ls to plane of page. (1.)

b.) El. Force = and opposite to mag. force as ions are undeviated by the crossed fields

$\therefore qE = qvB$

$\therefore v = \frac{E}{B}$ $E = \frac{V}{d} = \frac{2 \times 10^3}{4 \times 10^{-2}} = 0.5 \times 10^5 = 5 \times 10^5$

$\therefore v = \frac{5 \times 10^5}{B}$ (2.)

c.) i.) The only force now acting is due to the magnetic field. Ion velocity and B are at rtLs. Thus magnetic force is ⊥r to both. i.e mag. force is at rtLs to velocity. Thus magnetic force acts as a centripetal force and ions move in a circular orbit.

ii.) $F = QvB = \frac{mv^2}{R}$

$\therefore R = \frac{mv^2}{QvB} = \frac{mv}{QB}$.

iii.) $SX = 2R = \frac{2 \times 3.65 \times 10^{-26} \times \frac{5 \times 10^4}{0.5}}{1.6 \times 10^{-19} \times 0.5}$.

7. iii.) $sx = \frac{7.3 \times 5}{1.6 \times 0.5^2} \times \frac{10^{-26} \times 10^4}{10^{-19}} = \frac{36.5}{0.4} \times 10^{-3}$

$= 91.25 \times 10^{-3}$ m

$= 91.25$ mm. (6.)

d.) i.) Charges are the same on both ions. The vel. v depends only on the charge and $= \frac{5 \times 10^4}{B}$.

ii.) ~~Electrica~~ Magnetic force (QvB) is the same on both ions.

∴ Centripetal force is the same for both ions.

Cent. force $= \frac{mv^2}{R}$.

v is same for both ions.

∴ $\frac{m}{R}$ is same for both.

R for 1st ion > R for 2nd.

∴ m " " " > m " " (4.)

8. a.) Self induced emfs are set up which oppose the applied emf (2.)

b.) i.) $V = IR = 400 \times 10^{-3} \times 25$.

$= 10V$.

ii.) $\mathcal{E} = -L \frac{dI}{t}$.

$10 = -2 \frac{dI}{dt}$.

∴ $\frac{dI}{dt} = 5$ A/s.

iii.) $E = \frac{1}{2} LI^2$

$= \frac{1}{2} \times 2 \times (4 \times 10^{-1})^2$

$= 4 \times 10^{-2}$ J. (6)

8\. c.) When S is opened. L's magnetic field collapses rapidly setting up a v. large self induced emf in L which causes a spark. (2.)

9\. a.) $y = a \sin 2\pi f\left(t - \frac{x}{f\lambda}\right)$

$y = 3.5 \sin(62.8t - 1.25x)$

i.) A.) $2\pi f t = 62.8t$

$f = \frac{62.8}{2\pi} = 10Hz.$

B.) $\frac{2\pi f x}{f\lambda} = 1.25x$

$\frac{2\pi}{\lambda} = 1.25$

$\lambda = \frac{2\pi}{1.25} = 5.23m.$

ii.) A.) Amplitude

B.) $I \propto a^2$.

If I doubles a^2 doubles $\therefore$ a increases by factor of $\sqrt{2}$.

$\therefore$ New ampl. $= \sqrt{2} \times 3.5 = 4.95m.$

$\therefore y = 4.95 \sin(62.8t - 1.25x)$ (7.)

b.) $f = f_s \frac{v}{v \pm v_s}$

$f = f \frac{v}{v - v_s}$

$= 1020 \times \frac{340}{340 - 22} = 1020 \times \frac{340}{318}$

$= 1090.6 Hz.$

10. a.) D.O. of amplitude. (1)

b.) $\Delta x = \frac{\lambda}{2\tan\theta}$

$\tan\theta = \frac{\lambda}{2\Delta x} = \frac{589\times10^{-9}}{2\times8\times10^{-5}}$

$= \frac{589}{16}\times10^{-4}$

$= 36.8\times10^{-4}$

$\tan\theta = \frac{\text{Diam. of wire}}{\text{plate length}}$

Diam. of wire $= 36.8\times10^{-4}\times75\times10^{-3}$

$= 2760\times10^{-6}$

$= 2.76\times10^{-4}$ m. (2.)

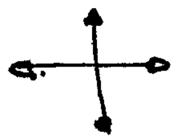
c.) i.) Fringes are closer together.

ii.) Condition for bright fringes is $2nd = (m+\frac{1}{2})\lambda$.

n - R.I. of wedge material

d - sepn. of 2 adjacent fringes.

$n\uparrow \therefore d\downarrow$. (3)

11. a.) Unpolarised - E has, in effect, 2 components. 

Polarised - E has 1 component  (1)

b.) $n = \frac{\sin i_p}{\sin r} = \frac{\sin i_p}{\sin(90-i_p)} = \frac{\sin i_p}{\cos i_p} = \tan i_p$. (2.)

c.) $n = \tan i_p$.

$1.33 = \tan i_p$

$\therefore i_p = 53.1°$.

$\theta = 90 - i_p = 36.9°$. (2.)