AH Physics

2005

1. a.) $\omega = \frac{v}{r} = \frac{1.3}{2.3\times10^{-2}}$

$= 56.5 \text{ rad s}^{-1}$

b.) $\omega = \frac{v}{r} = \frac{1.3}{5.8\times10^{-2}}$

$= 22.4 \text{ rad s}^{-1}$

c.) $v = r\omega$.

v is constant and $= 1.3 \text{ ms}^{-1}$

$\therefore$ as $r\uparrow$ $\omega\downarrow$

d.) i.) $\theta = 2.8\times10^{4} \times 2\pi$

$= 1.76\times10^{5}$ rad.

ii.) $\omega^2 = \omega_0^2 + 2\alpha\theta$.

$\alpha = \frac{\omega^2 - \omega_0^2}{2\theta}$

$= \frac{22.4^2 - 56.5^2}{2\times1.76\times10^{5}}$

$= -7.64\times10^{-3} \text{ rad s}^{-2}$

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

$t = \frac{\omega - \omega_0}{\alpha} = \frac{22.4 - 56.5}{-7.64\times10^{-3}}$

$= 4.46\times10^{3}$ s.

2. a.) I(total) = I(roundabout) + I (child)

$= 500 + mr^2$

$= 500 \times 25\times2^2$

$= 600 \text{ kg m}^2$.

b.) If no external unbalanced torque acts on a system the total angular momentum of the system remains unchanged.

c.) i.) $p = mv = 25\times2.4$

$= 60 \text{ kg ms}^{-1}$

ii.) $L = rp$

$= 2\times60$

$= 120 \text{ kg m}^2\text{s}^{-1}$

d.) Total ang. mom. before = total after

$120 = 600\omega$

$\therefore \omega = \frac{120}{600}$

$= 0.2 \text{ rad s}^{-1}$

2. e.) Total K before $= \frac{1}{2}mv^2$

$= \frac{1}{2} \times 25 \times 2.4^2$

$= 72\,J$

Total K after $= \frac{1}{2} I \omega^2$

$= \frac{1}{2} \times 600 \times 0.2^2$

$= 12\,J.$

K lost $= 60\,J.$

f.) W.D. = K lost

$G \times \theta = \Delta K$

$G \times \pi = 60$

$G = \frac{60}{\pi} = 19.1\,Nm$

3. a.) i.) Centripetal force = grav. force

$$m\omega^2 r = \frac{GmM}{r^2}$$

$$\omega = \frac{2\pi}{T}$$

$$\therefore m \times \frac{4\pi^2}{T^2} r = \frac{GmM}{r^2}$$

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

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

ii.) $T = \left(\frac{4\pi^2 r^3}{GM}\right)^{\frac{1}{2}}$

$= \left[\frac{4\pi^2 \times (3.84 \times 10^8)^3}{6.67 \times 10^{-11} \times 6 \times 10^{24}}\right]^{\frac{1}{2}}$

$= 12 \times 10^5\,s.$

b.) i.) $U = -\frac{GmM}{r} = \frac{-6.67 \times 10^{-11} \times 6 \times 10^{24} \times 9 \times 10^2}{6.8 \times 10^6}$

$= -5.29 \times 10^{10}\,J.$

ii.) Total energy = K + U.

$K = \frac{1}{2}mv^2 = \frac{1}{2} \times 900 \times (7.7 \times 10^3)^2$

Total $= 2.67 \times 10^{10} + (-5.29 \times 10^{10})$

$= -2.62 \times 10^{10}\,J.$

4\. a.) Motion which obeys the relationship $\frac{d^2y}{dt^2} = -ky$ or similar relationship.

b.) i.) $y = a \sin \omega t$

$= a \sin 2\pi f t$.

$v = \frac{dy}{dt} = a \times 2\pi f \cos 2\pi f t$.

$\therefore \; 2\pi f = 625$

$\therefore \; f = 99.5 \text{ Hz}$.

ii.) $a \times 2\pi f = 0.5$

$a = \frac{0.5}{2\pi \times 99.5}$

$= 8 \times 10^{-4} \text{ m}$.

c.) Max. downward accn. sphere can attain $= 9.81 \text{ ms}^{-2}$.
If accn. of cap ≥ 9.81 as it moves down it leaves sphere behind and loses contact.

5\. a.) i.)

Q_1 $+4\mu C$ X $\xrightarrow{\bar{E}_1}$ $\xrightarrow[\bar{E}_2]{}$ Q_2 $-6\mu C$.

$\bar{E} = \bar{E}_1 + \bar{E}_2$

$= \frac{4 \times 10^{-6}}{4\pi\varepsilon_0 (3\times10^{-3})^2} + \frac{6\times10^{-6}}{4\pi\varepsilon_0(2\times10^{-3})^2}$

$= \frac{1}{4\pi\varepsilon_0}\left[\frac{4\times10^{-6}}{9\times10^{-6}} + \frac{6\times10^{-6}}{4\times10^{-6}}\right]$

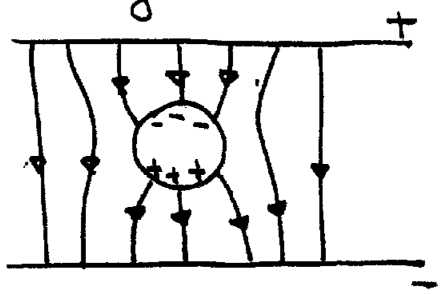
$= \frac{1}{4\pi\times8.85\times10^{-12}}\left[\frac{4}{9} + \frac{6}{4}\right]$

$= \frac{1.94}{4\pi\times8.85\times10^{-12}}$

$= 1.75\times10^{10} \text{ NC}^{-1}$

ii) Towards the right.

b.) i.)



ii.) The mesh acts as a shield. No field is set up inside the field to interfere with the electrical signal in the central wire.

6. a.) $E = QV = \frac{1}{2}mv^2$

$$v^2 = \frac{2QV}{m}$$

$$v = \left[\frac{2QV}{m}\right]^{\frac{1}{2}}$$

$$= \left[\frac{2 \times 1.6 \times 10^{-19} \times 1.5 \times 10^{3}}{9.11 \times 10^{-31}}\right]^{\frac{1}{2}}$$

$$= 2.3 \times 10^{7}\, ms^{-1}.$$

b.) $t = \frac{s}{v} = \frac{9 \times 10^{-2}}{2.3 \times 10^{7}}$

$$= 3.91 \times 10^{-9}\, s.$$

c.) i.) $F = QE = \frac{QV}{d}$

$$= \frac{1.6 \times 10^{-19} \times 600}{5 \times 10^{-2}}$$

$$= 1.92 \times 10^{-15}\, N.$$

ii.) $a = \frac{F}{m} = \frac{1.92 \times 10^{-15}}{9.11 \times 10^{-31}}$

$$= 0.21 \times 10^{16}\, ms^{-2}.$$

$$s = ut + \tfrac{1}{2}at^2$$

$$= \tfrac{1}{2} \times 0.21 \times 10^{16} \times (3.91 \times 10^{-9})^2$$

$$= 1.6 \times 10^{-2}\, m.$$

d.) i.) No U.F. acts in horizontal plane ∴ uniform hor. speed.
Constant U.F. " " vertical plane ∴ uniform accn.
The 2 motions combine to produce a curved path.

ii.) No U.F. acts. ∴ Electrons obey N.1 and travel with uniform velocity.

e.) The hor. speed of the electrons is reduced ∴ time taken to travel between // plates increases. Electrical force and accn. act for longer on the electrons. Deflection increases.

7. a.) i.) Use R.H. Rule. → charge +ve.

ii.) Centripetal force = magnetic force.

$$\frac{mv^2}{r} = QvB.$$

$$\frac{Q}{m} = \frac{v}{rB.} = \frac{2 \times 10^{6}}{1.39 \times 10^{-2} \times 1.5}$$

$$= 0.96 \times 10^{8}\, C\,kg^{-1}$$

iii.) Proton.

7. a.) iii.) From data table $\frac{Q}{m}$ for proton $= \frac{1.6\times10^{-19}}{1.673\times10^{-27}}$

$= 0.96\times10^{8}\ \mathrm{C\,kg^{-1}}$.

b.) Vel. has component ⊥r to $\underline{B}$ which gives rise to a centripetal force producing ⊙ar motion
Vel. has component ∥ to $\underline{B}$. Hor. speed constant
2 motions combine to produce helical motion

c.) Vel. is ⊥r to $\underline{B}$. A centripetal force acts on the particles and they move in a ⊙ar path. They penetrate no further into the atmosphere but spiral back out into space.

8. a.) $L = -\frac{\mathcal{E}}{\frac{dI}{dt}}$

Thus if $\frac{dI}{dt} = 1\,\mathrm{A s^{-1}}$ the induced voltage $\mathcal{E} = 2\mathrm{V}$

(or similar).

b.) $\frac{dI}{dt} = \frac{\mathcal{E}}{L} = \frac{12}{2} = 6\,\mathrm{A\,s^{-1}}$.

c.) i.) L is smaller ∴ I increases more rapidly
V less ∴ final I less.

ii) $E = \tfrac{1}{2}LI^2$
$= \tfrac{1}{2}\times1.5\times2.5^2$
$= 4.69\,\mathrm{J}$.

d.) i.) The conducting bracelet moves rel. to the magnetic field
ii.) The current in the bracelet sets up a magnetic field. This moves thro' coil 2 and induces a current in coil 2.

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

∴ $2\pi f = 1570$.
∴ $f = 250\,\mathrm{Hz}$.

ii) Int. $\propto a^2$
∴ a must double.
∴ $y = 4\times10^{-4}\sin(1570t + 4.6x)$.

b.) i.) When train is opposite person, frequency heard = true frequency
As train approaches person frequency heard > true frequency
" " moves away from " " " < " "

9. b.) ii) As source approaches distance b'n wavefronts is reduced.
i.e. λ is reduced.
$v = f\lambda$, $\therefore$ f is increased

As source moves away distance b'n wavefronts increases.
i.e. λ increases.
$v = f\lambda$ $\therefore$ f is reduced.

iii.) $f' = \dfrac{v}{v \pm v_s} \times f.$

$f' < f$ $\therefore$ $f' = \dfrac{v}{v + v_s} \times f.$

$$760 = \frac{v}{v + v_s} \times 800.$$

$$760v + 760v_s = 800v.$$

$$760v_s = 40v$$

$$v_s = \frac{40}{760} \times 340$$

$$= 17.9 \text{ ms}^{-1}.$$

10. a.) i.) $\lambda = \dfrac{d\,\Delta x}{L}$

$$= \frac{0.25 \times 8 \times 10^{-6}}{3.91}$$

$$= 511.5 \times 10^{-9} \text{ m}.$$

ii.) % age unc. in $d = \dfrac{0.01}{0.25} \times 100 = 4\%.$

" " in $\Delta x = \dfrac{0.5}{8} \times 100 = 6.25\%$

" " " $L = \dfrac{0.01}{3.91} \times 100\% = 0.26\%.$

Ignore % age unc. in L.
% age unc. in $\lambda = \sqrt{4^2 + 6.25^2}$
$= 7.4\%.$

$\therefore$ Absolute unc. in λ = 3.8 nm.
= 4 nm.

10. a.) iii.) Too many significant figures.

b.) % age unc. in measurement = $\frac{0.5}{64} \times 100\%$

$= 0.78\%$

This can be ignored as << than % age unc. in d.

∴ % age unc. in λ = % age unc. in d = 4%.

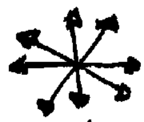
∴ Unc. in λ = $\frac{514.5}{100} \times 4 = 20.5$ nm.

c.) i.) % age unc. in this measurement is less than previously and can again be ignored.

ii.) Measurement of slit separation.

11 a.) Polarised light. $\underline{E}$ always lies in same plane

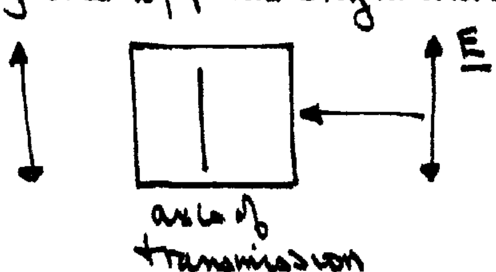
Unpolarised. $\underline{E}$ lies in randomly varying plane



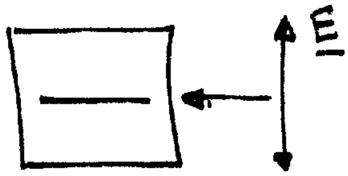
b.) i.) No light reaches mirror ∴ no light reflected and crystal appears dark.

ii.) S is closed.

c.) Reflected light is polarised. Initially area surrounding the figures appears bright and figures (segments) are visible



As polarising material rotates less light is transmitted. After a rotation of 90° no light is transmitted. Whole screen is dark and no numbers visible.



On rotating further light is transmitted once more. After 180° surrounding area appears bright again and numbers are visible once more.