PHYSICS - ADVANCED HIGHER 2002

Specimen Answers.

No.1. a.) $s = \int v\,dt = \int (u + at)\,dt.$

$= ut + \frac{1}{2}at^2 + c.$

At $t = 0, s = 0$

$\therefore 0 = 0 + 0 + c$

$\therefore c = 0.$

$\therefore s = ut + \frac{1}{2}at^2.$

b.) $m = \dfrac{m_o}{\sqrt{1 - \frac{(2\times10^8)^2}{(3\times10^8)^2}}} = \dfrac{m_o}{\sqrt{1 - \frac{4}{9}}} = \dfrac{m_o}{\sqrt{5/9}} = \dfrac{m_o}{0.745}$

$= 1.34m_o.$

$E = mc^2 = 1.34 \times 9.11 \times 10^{-31} \times (3\times10^8)^2$

$= 1.34 \times 9.11 \times 9 \times 10^{-15}$

$= 110 \times 10^{-15}$

$= 1.1 \times 10^{-13}$ J.

2. a.) i.) $\omega = \dfrac{\theta}{t} = \dfrac{2\pi \times 2500}{60} = 261$ rad s^{-1}

ii.) $E_K = \frac{1}{2} I \omega^2$

$= \frac{1}{2} \times 18 \times 260^2$

$= 6.084 \times 10^5$ J.

b.) i) $\omega = \omega_o + \alpha t.$

$0 = 260 + 40\alpha.$

$\alpha = \dfrac{-260}{40} = -6.5$ rad s^{-2}

ii.) $G = I\alpha.$

$\therefore Fr = I\alpha.$

$F = \dfrac{I\alpha}{r} = \dfrac{180 \times 6.5}{0.4} = 2925$ N.

No. 2 c.) I is greater for new fly wheel.

$G = Fr$ is the same

$G = I\alpha$.

$\therefore \alpha$ is smaller

$\therefore$ time taken $> 40s$.

No. 3. a.) $\frac{mv^2}{r} = \frac{GmM_E}{r^2}$

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

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

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

b.) i.) $r^3 = \frac{GM_E}{4\pi^2} T^2$.

$T = 24hr. = 24 \times 3600s.$

$\therefore r^3 = \frac{6.67 \times 10^{-11} \times 6 \times 10^{24} \times (24 \times 3600)^2}{4\pi^2}$

$= \frac{6.67 \times 6 \times 2.4^2 \times 3.6^2 \times 10^8 \times 10^{24} \times 10^{-11}}{4\pi^2}$

$= \frac{2987.5}{39.44} \times 10^{21}$

$= 75.75 \times 10^{21}$

$\therefore r = 4.23 \times 10^7$

Height $= r -$ Earth's radius

$= 4.23 \times 10^7 - 6.4 \times 10^6$

$= 3.59 \times 10^7 m.$

ii.) $v = \frac{2\pi r}{T} = \frac{2\pi \times 3.59 \times 10^7}{24 \times 3600} = \frac{2\pi \times 3.59}{2.4 \times 3.6} \times \frac{10^7}{10^4}$

$= 2.62 \times 10^3 ms^{-1}$

No.3 c.) i.) Vel. required by a body to escape Earth's grav. field (or pull)

or " " " " " to reach infinity.

ii.) $v = \sqrt{\frac{2GM}{r}}$

$= \left[\frac{2 \times 6.67 \times 10^{-11} \times 6 \times 10^{24}}{6.7 \times 10^{6}}\right]^{\frac{1}{2}}$

$= \left[\frac{2 \times 6.67 \times 6}{6.7} \times 10^{18}\right]^{\frac{1}{2}}$

$= 3.46 \times 10^{9}\ ms^{-1}$

No.4 a.) i.) $a = 8cm. = A.$

ii.) $t = 2.4s. = T$

b.) $t = 2.4 \therefore f = \frac{1}{2.4} \therefore \omega = \frac{2\pi}{2.4} = 2.62\ rad\ s^{-1}$.

$\therefore y = 8 \cos 2.62t.$

c.) i.) $\Sigma a = -\omega^2 y.$]

$y = 8 \cos 2.62t.$

$\therefore \frac{dy}{dt} =$ ~~8 sin~~ $8 \times 2.62 \sin 2.62t.$

$\therefore \frac{d^2y}{dt^2} = -8 \times (2.62)^2 \cos 2.62t.$

$= -54.9 \cos 2.62t$

ii.) $E_K = \frac{1}{2}mv^2.$

$\text{Max. } v = \text{Max } \frac{dy}{dt} = 8 \times 2.62.$

$\therefore \text{Max } E_K = \frac{1}{2} \times 0.4 \times (8 \times 2.62)^2$

$= 87.9 J.$

No.5

No. 5. a.) i.) Diffraction patterns produced by electron beams.

ii.) Photo-electric effect.

b.) i.) $\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-34}}{6 \times 10^{-2} \times 55}$

$= \frac{6.63}{3.3} \times 10^{-34}$

$= 2 \times 10^{-34}$ m.

ii.) Diffraction only occurs for a slit width $\approx 10\lambda$.
In this case slit width required is too small physically.

No. 6. a.) $F = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} = \frac{(1.6 \times 10^{-19})^2}{4\pi \times 8.85 \times 10^{-12} \times (10^{-5})^2}$

$= \frac{1.6^2}{4\pi \times 8.85} \times \frac{10^{-38}}{10^{-22}}$

$= 0.023 \times 10^{-16}$

$= 2.3 \times 10^{-18}$ N.

b.) i.) Strong nuclear force.

ii.) Strong force only acts for v. small separations $\approx 10^{-14}$ m.

c.) $\Delta U = -\Delta K$.

$\Delta K = 0 - \frac{1}{2} \times (4 \times 1.67 \times 10^{-27}) \times (2 \times 10^{6})^2$
(α)

$= -2 \times 1.67 \times 4 \times 10^{-27} \times 10^{12}$

$= -1.28 \times 10^{-14}$ J.

$\Delta U = \frac{q_1 q_2}{4\pi\varepsilon_0 r} - 0 = \frac{2 \times 1.6 \times 10^{-19} \times 79 \times 1.6 \times 10^{-19}}{4\pi \times 8.85 \times 10^{-12} \times r}$

$= \frac{2 \times 1.6 \times 79 \times 1.6}{4\pi \times 8.85 \times r} \times \frac{10^{-38}}{10^{-12}}$

$= \frac{3.64}{r} \times 10^{-26}$

$\therefore \frac{3.64}{r} \times 10^{-26} = -(-1.28 \times 10^{-14})$.

$\therefore r = \frac{3.64 \times 10^{-26}}{1.28 \times 10^{-14}} = 2.84 \times 10^{-12}$ m.

No. 7. a.) $E = qV$

$= 1.6\times10^{-19} \times 2\times10^{3} = E_K$

$E_K = \frac{1}{2}mv^2 = \frac{1}{2}\times9.11\times10^{-31}\times v^2$

$\therefore \quad v^2 = \dfrac{1.6\times10^{-19}\times2\times10^{3}}{\frac{1}{2}\times9.11\times10^{-31}}$

$= 0.7\times10^{15}$

$\therefore v = 0.84\times(10^{15})^{\frac{1}{2}}$

$= 2.65\times10^{7}\ ms^{-1}$

b.) i.) A.) electron travels at constant speed hor. - no unbalanced hor. force acts.

electron travels with uniform accn. vert. - constant vert. U.F acts.

2 motions combine to give curved path.

B.) No U.F. acts $\therefore$ electron travels at constant vel.

ii.) Field int. $E = \dfrac{V}{d}$

$F = qE = \dfrac{qV}{d} = ma$

$\therefore a = \dfrac{qV}{md} =$ ~~1.6×10^{-19}~~

$= \dfrac{1.6\times10^{-19}\times2.5\times10^{2}}{9.11\times10^{-31}\times2\times10^{-2}}$

$= \dfrac{1.6\times2.5}{9.11\times2}\times10^{16}$

$= 0.18\times10^{16}$

$= 1.8\times10^{15}\ ms^{-2}$

c.) i.) Force exerted by magnetic field is a right angles to velocity $\therefore$ Force is centripetal, producing circular motion.

ii.) Electrical force is upward $\therefore$ magnetic force is downward. Magnetic induction is at right angles to the page and points into page.

$F_E = qE \qquad F_M = qvB$

$\therefore qE = qvB$

$\therefore E = vB$

No. 8. c.) ii.) $B = \frac{E}{v}$

$$= \frac{\frac{V}{d}}{v} = \frac{V}{vd} = \frac{250}{2.65\times10^{7}\times2\times10^{-2}}$$

$$= \frac{2.5}{2.65\times2}\times10^{-3}$$

$$= 0.47\times10^{-3}\ \text{T}.$$

No. 8 a.) i.) $F = Bil$.

$$B = \frac{F}{il} = \frac{\bar{F}}{il}$$

$$\bar{F} = 3.5\times10^{-3}$$

$$\therefore B = \frac{3.5\times10^{-3}}{2.5\times5\times10^{-2}} = 0.28\times10^{-1}\ \text{T}. = 2.8\times10^{-2}\ \text{T}$$

ii.) %age unc. in l = ~~$\frac{0.05}{0.001}$~~ $\times \frac{0.001}{0.05}\times100 = 2\%$.

%age unc. in i = $\frac{0.01}{2.5}\times100 = 0.4\%$.

%age unc. in ~~B~~ F = $\frac{3.8-3.3}{5}\times100 = 10\%$

$\therefore$ % age in B = $\pm10\%$.

$$\therefore\ 10 = \frac{\text{abs. unc.}}{2.8\times10^{-2}}\times100$$

$$\therefore\ \text{abs. unc.} = 0.28\times10^{-2}\ \text{T}.$$

iii.) Carry out experiment a larger no. of times. This reduces random unc. in F which is dominant.

b) i.) 2 halves of side QR move thro' field in opposite directions.

Forces on each half are equal and in opposing directions.
Forces cancel $\therefore$ net force = 0.

No. 8. b.) ii.) Force on PQ = Force on SR

$= i\ell B.$

$= 2.2 \times 5 \times 10^{-2} \times 0.1$

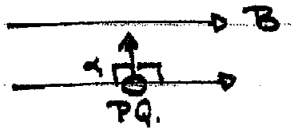
$\therefore$ Torque = Fr $= 2 \times 2.2 \times 5 \times 10^{-2} \times 0.1 \times 2 \times 10^{-2}.$

$= 44 \times 10^{-5}$ Nm

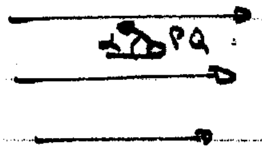
$= 4.4 \times 10^{-4}$ Nm.

iii.) Force on PQ $= i\ell B \sin\alpha.$

Initially $\alpha = 90°$ F is a max



As coil rotates α decreases and $\sin\alpha$ decreases



$\therefore$ F decreases and Torque decreases.

No. 9 a.) 12V.

b.) $\dfrac{dI}{dt} = \dfrac{10 \times 10^{-3}}{2 \times 10^{-3}} = 5\ As^{-1}$

c.) $E = -L\dfrac{dI}{dt}$ $\therefore \dfrac{dI}{dt} = (-)\dfrac{E}{L} = \dfrac{12}{5} = 2.4$ H.

d.) $R = \dfrac{V}{I}$ $(E = 0)$

$= \dfrac{12}{96 \times 10^{-3}} = 125\Omega.$

e.) $E = \frac{1}{2}LI^2 = \frac{1}{2} \times 2.4 \times (96 \times 10^{-3})^2.$

$= 11,059.2 \times 10^{-6}.$

$= 1.106 \times 10^{-2}$ J.

No. 10 a.) i.) $y = a \sin 2\pi\left(\dfrac{x}{\lambda} - ft\right)$

$\lambda = \dfrac{v}{f} = \dfrac{0.5}{3} = 0.167$ m.

No.10. a) i.) ∴ $y = 0.04 \sin 2\pi \left(\frac{x}{0.167} - 3t \right)$.

ii.) Int. $\propto a^2$.

a halves. ∴ a^2 is $\frac{1}{4}$ original value

∴ I is $\frac{1}{4}$ original value.

b.) At a node incident and reflected waves always interfere destructi[vely]

" an anti-node " " " " " " constructi[vely]

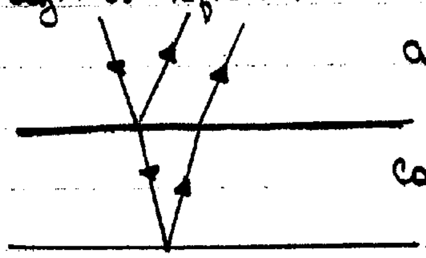
c.) i.) $f' = f \left(\frac{V}{V - V_s} \right)$

$= 200 \left(\frac{340}{340+30} \right) = 200 \times \frac{340}{370} =$ ~~219 kHz~~ 184 Hz.

ii.) λ has increased ∴ f decreases.

∴ source moves away from observer.

11 a.) i.) light strikes upper face of coating and is partially reflected and transmitted.
light strikes lower face of coating and is reflected again.
The 2 reflected rays meet and interfere destructively
Thus no light is reflected.



ii.) $t = \frac{\lambda}{4n} = \underline{500 \times 10^{-9}}$

iii) Destr. intfce. occurs only for $\lambda = 500$ nm. It will not occur for red and blue/violet. ∴ these colours are reflected and mix to produce reflected purple light.

b.) $\lambda = \frac{d \Delta x}{L}$

$\Delta x = \frac{100 \times 10^{-3}}{4} = 25 \times 10^{-3}$ m.

$\therefore \lambda = \frac{5 \times 10^{-5} \times 25 \times 10^{-3}}{2} = 62.5 \times 10^{-8}$
$= 625 \times 10^{-9}$
$= 625$ nm.