AH Physics - 2004.

Specimen Answers.

1. a.) $m = \dfrac{m_o}{\sqrt{1 - v^2/c^2}}$

$\therefore 3m_o = \dfrac{m_o}{\sqrt{1 - v^2/c^2}}$

$\therefore \sqrt{1 - \dfrac{v^2}{c^2}} = \dfrac{1}{3}.$

$\therefore 1 - \dfrac{v^2}{c^2} = \dfrac{1}{9}.$

$\therefore \dfrac{v^2}{c^2} = \dfrac{8}{9}$

$\therefore v^2 = \dfrac{8}{9} c^2$

$\therefore v = \sqrt{\dfrac{8}{9}} c$

$= 2.83 \times 10^8 \text{ ms}^{-1}.$

b.) $E = mc^2.$

$m = \dfrac{m_o}{\sqrt{1 - \frac{v^2}{c^2}}} = \dfrac{m_o.}{\sqrt{1 - \frac{(0.9c)^2}{c^2}}}$

$= \dfrac{m_o}{\sqrt{1 - \left(\frac{0.9}{1}\right)^2}}$

$= \dfrac{m_o}{\sqrt{1 - 0.81}}$

$= \dfrac{m_o}{\sqrt{0.19}} = \dfrac{m_o}{0.436}$

$= \dfrac{9.11 \times 10^{-31}}{0.436}$

$= 2.09 \times 10^{-30}$

$E = 2.09 \times 10^{-30} \times (3 \times 10^8)^2$

$= 2.09 \times 9 \times 10^{-14}$

$= 1.88 \times 10^{-13} \text{ J}.$

2. a.) i.) Potential + Kinetic (rotn. + trans)
ii.) Kinetic (rotn.)

b.) $I = 2 \times \frac{1}{2} m r^2$
$= 0.1 \times 0.05^2$
$= 2.5 \times 10^{-4}$ kgm²

c.) $K = \frac{1}{2} I \omega^2$
$= \frac{1}{2} \times 2.5 \times 10^{-4} \times 120^2$
$= \frac{1}{2} \times 2.5 \times 10^{-4} \times 1.44 \times 10^4$
$= 1.8$ J
$U = mgh = K.$
$0.1 \times 9.8 \times h = 1.8$
$h = \frac{1.8}{0.1 \times 9.8}$
$= 1.84$ m.

d.) i.) Spring force < centripetal force needed to maintain pads in ○ar path.
ii.) $F_R = m\omega^2 r.$

$5 = 12 \times 10^{-2} \times \omega^2 \times 10^{-2}.$
$\omega^2 = \frac{5}{12 \times 10^{-4}} = 0.417 \times 10^4$
$\omega = 64.5$ rads⁻¹.

3. a.) $\omega = \frac{600 \times 2\pi}{60}$
$= 20\pi$
$= 62.8$ rads⁻¹

b.) $\omega = \omega_0 + \alpha t$
$0 = 62.8 + 30\alpha.$
$30\alpha = -62.8$
$\alpha = -\frac{62.8}{30}$
$= -2.09$ rad s⁻²

c.) $\omega^2 = \omega_0^2 + 2\alpha\theta.$
$0 = (62.8)^2 - 2 \times 2.09\theta.$
$\theta = \frac{62.8^2}{2 \times 2.09} = 944$ rad.

d.) $T = I\alpha$
$= 2.16 \times 10^{-3} \times 2.09$
$= 4.5 \times 10^{-3}$ Nm.

3. e.) $I_0 = \frac{1}{2} m_0 r_0^2$.

$I = \frac{1}{2} \times 2m_0 \times \left(\frac{r_0}{2}\right)^2$

$= \frac{1}{2} \times m_0 r_0^2 \times \frac{2}{4}$.

$\therefore I = \frac{1}{2} I_0$.

$T = I\alpha$.

T is unchanged, I is halved, $\therefore \alpha$ doubles.

$\therefore$ disc comes to rest in < 30s.

4 a.) $\frac{mv^2}{r} = \frac{GmM_E}{r^2}$.

$v^2 = \frac{GM_E}{r}$.

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

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

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

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

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

$r = 6.4 \times 10^6 + 8 \times 10^4$

$= 6.48 \times 10^6$

$\therefore T = 2\pi \sqrt{\frac{(6.48 \times 10^6)^3}{6.67 \times 10^{-11} \times 6 \times 10^{24}}}$

$= 5160$s.

$= 86$min.

ii.) Time interval between mappings $= 5160$s.

Angle earth rotates thro' $= 5160 \times 7.3 \times 10^{-5}$.

$= 5.16 \times 7.3 \times 10^{-2}$

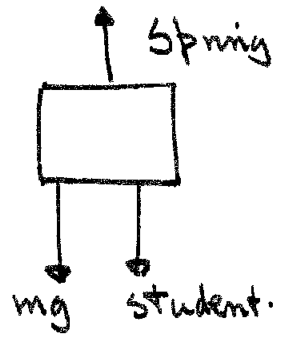
$= 0.377$ rad.

$s = r\theta$

$= 6.4 \times 10^6 \times 0.377$

$= 2.41 \times 10^6$ m.

5. a.)



$T = 0.5 \times 9.8 +$ student force

$\therefore$ Student force $= 7 - 4.9$

$= 2.1N.$

b.) i.) $F \propto -y$ (or $F = -m\omega^2 y$).
(or $F = -ky$)

ii.) Spring constant $= \frac{7}{0.06}$ Nm^{-1}

$F = ma$

$\therefore a = \frac{F}{m} = \frac{2.1}{0.5} = 4.2ms^{-2}.$

iii.) $60mm = 0.06m.$

c.) i.) Accn. of system.

ii.) $4.2 = -\omega^2 \times 0.06$

$\omega^2 = \frac{4.2}{0.06}$

$\omega = 8.37$

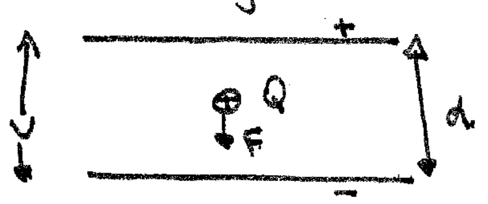
$2\pi f = 8.37$

$f = \frac{8.37}{2\pi}$

$= 1.33 Hz.$

6. a.) i.) E → Force acting on each Coulomb of a body's charge.

ii.)



$F = QE$

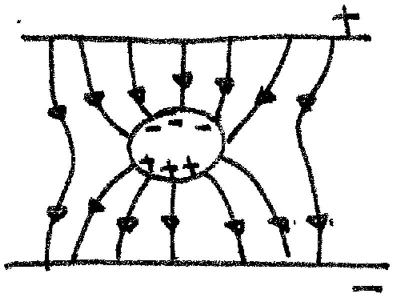
$W.D. = Fd = QEd.$

$W.D. = QV$

$\therefore \cancel{Q}V = \cancel{Q}Ed$

$\therefore E = \frac{V}{d}.$

6. b.) i.), ii.)



iii.) $E = 0$.

7. a.) $F = \frac{Q_1 Q_2}{4\pi \varepsilon_0 r^2}$

b.) Bring R, S in contact.

Bring +ve rod close to spheres as shown.
Separate spheres, holding rod in position.

c.) i.) $F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2} = \frac{Q^2}{4\pi \varepsilon_0 r^2}$

$Q^2 = F \times 4\pi \varepsilon_0 r^2$
$= 3\times10^{-5} \times 4\pi \times 8{\cdot}85\times10^{-12} \times (4\times10^{-2})^2$

$\therefore Q = 2{\cdot}3\times10^{-9}$ C

ii.) $V = \frac{Q}{4\pi\varepsilon_0 r}$
$= \frac{2{\cdot}3\times10^{-9}}{4\pi\times 8{\cdot}85\times10^{-12}\times 4\times10^{-2}}$
$= \frac{2{\cdot}3}{4\pi\times8{\cdot}85\times4} \times 10^5$
$= 517{\cdot}3$ V.

iii.)

d.) i.) $T\sin\theta = mg$.
$T\cos\theta = F_E$.

$T^2\cos^2\theta + T^2\sin^2\theta = (mg)^2 + F_E^2$
$T^2(\cos^2\theta + \sin^2\theta) = (mg)^2 + F_E^2$

7\. i.) $T^2 = (mg)^2 + (F_E)^2$

$= (2.5\times10^{-5}\times9.8)^2 + (3\times10^{-5})^2$

$= 6\times0^{-10} + 9\times10^{-10}$

$= 15\times10^{-10}$

$\therefore T = 3.87\times10^{-5}$ N.

ii.) $T\cos\alpha = F_E$.

$\cos\alpha = \frac{F_E}{T} = \frac{3\times10^{-5}}{3.87\times10^{-5}}$

$= 0.775$

$\therefore \alpha = 39.2°$.

8\. a.) $F_R = \frac{mv^2}{r} = qvB$.

$\therefore r = \frac{mv^2}{qvB} = \frac{mv}{qB}$.

b.) $t = \frac{\pi r}{v}$.

$= \frac{\pi}{v} \times \frac{mv}{qB}$.

$= \frac{m\pi}{qB}$.

$\therefore$ t is independent of v.

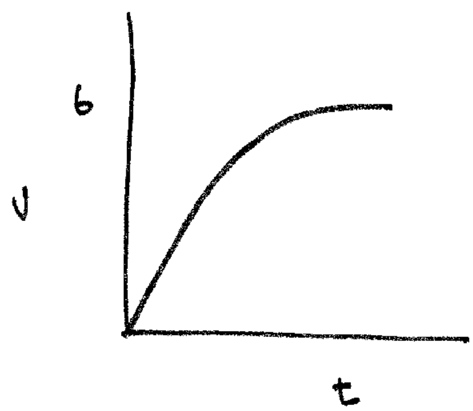
c.) $t = \frac{m\pi}{qB}$

$= \frac{9.11\times10^{-31}\times\pi}{1.6\times10^{-19}\times5\times10^{-3}}$.

$= \frac{9.11\pi}{8}\times10^{-9}$

$= 3.58\times10^{-9}$ s.

9\. a.)



9. b.) $V_R = IR$
$= 0.2 \times 12$
$= 2.4V$

V across L $= 6 - 2.4 = 3.6$.

$$\mathcal{E} = -\frac{L}{\frac{dI}{dt}}$$

$$\frac{dI}{dt} = \frac{-L}{\mathcal{E}} = \frac{-4}{3.6} = 1.11\ A\,s^{-1}$$

10. a) $B = \frac{\mu_0 I}{2\pi r}$

$B_1 = \frac{\mu_0 I_1}{2\pi r}$

$F_2 = I_2 l B_1$

$= \frac{\mu_0 I_1}{2\pi r} \times I_2 l$

$= \frac{\mu_0 I_1 I_2 l}{2\pi r}$

$\therefore \frac{F}{l} = \frac{\mu_0 I_1 I_2 l}{2\pi r l}$

$= \frac{\mu_0 I_1 I_2}{2\pi r}$

b.) i.) $F = \frac{\mu_0 I_1 I_2}{2\pi r}$

$= \frac{4\pi \times 10^{-7} \times 850^2}{2\pi \times 4}$

$= \frac{10^{-7} \times 850^2}{2}$

$= 7.225 \times 10^{-2}\ N\,m^{-1}$.

ii.) Apart (unlike currents repel)

iii.) $B = \frac{\mu_0 I}{2\pi r}$

$= \frac{4\pi \times 10^{-7} \times 850}{2\pi \times 2}$

$= 8.5 \times 10^{-5}\ T$

$=$ B due to 1 cable

Applying LHrule B due to each current is up.

$\therefore$ Total $B = 2 \times 8.5 \times 10^{-5}$
$= 17 \times 10^{-5}\ T$

10. c.) $F = I\ell B \sin\theta$.

$= 850 \times 1 \times 52\times10^{-6} \times \sin 60°$

$= 3.83 \times 10^{-2}\ Nm^{-1}$

11. a.) i.) $2\pi f = 12$

$f = \frac{12}{2\pi}$

$= 1.91\ Hz$

ii.) $\frac{2\pi}{\lambda} = 0.5$

$\lambda = \frac{2\pi}{0.5} = 12.56\,m.$

b.) i.) $\phi = \frac{2\pi}{\lambda} \times x$

$= \frac{2\pi}{12.56} \times 1$

$= 0.5$ rad.

ii.) $T = \frac{1}{f} = \frac{1}{1.91}$.

$t = \frac{1}{1.91}$

$v = f\lambda = 1.91 \times 12.56$

$t = \frac{x}{v} = \frac{1}{1.91\times12.56}$

$= 4.17 \times 10^{-2}$ s.

c.) $y = a\sin(12t + 0.50x)$

a - slightly less than 0.8.

12. a.) i.) Electric vector, E, lies in one plane only.

ii.) Picture becomes less clear and is finally extinguished.

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

$= \tan i_p$

ii.) $n = \tan i_p$

$1.49 = \tan i_p$

$i_p = 56.1°$

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

$\Delta x = \frac{26}{10} = 2.6 \times 10^{-3}$

$\lambda = \frac{0.52 \times 10^{-3} \times 2.6 \times 10^{-3}}{2}$

$= 0.676 \times 10^{-6}$ m.

$= 676$ nm.

b.) % age unc. in slit sepn. $= \frac{0.02}{0.52} \times 100 = 3.85\%$.

" " " $L = \frac{0.01}{2} \times 100\% = 0.5\%$.

" " " $\Delta x = \frac{2}{26} \times 100\% = 7.7\%$.

" " " $\lambda = \sqrt{7.7^2 + 3.85^2}$ [ignore unc. in L]

$= \sqrt{59.2 + 14.8}$

$= 8.6\%$.

c.) Biggest uncertainty is due to measurement of fringe separation. If the screen is moved further away this separation increases. Absolute uncertainty will be the same but %age unc. decreases.
OR. Use more sensitive instruments to measure this sepn.

d.) Division of wavefront.