1998

1 (a) $$\int \frac{d^2s}{dt^2}\,dt = \int a.dt$$

$$\frac{ds}{dt} = at + k.$$ when $t=0$ $\frac{ds}{dt} = u.$

$$\int \frac{ds}{dt}dt = \int u + at\,.\,dt$$

$$s = ut + \tfrac{1}{2}at^2 + k.$$ when $t=0$ $s=0$

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

(b) not required.

2. (a) $$F = \frac{GMm}{r^2}$$

(b) $$m\omega^2 r = \frac{GMm}{r^2}$$ $\omega = \frac{2\pi}{T}$

$$\frac{m4\pi^2 r}{T^2} = \frac{GMm}{r^2}$$

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

$$T^2 = \text{Const.}\, r^3$$

$$T = \text{const}\, r^{3/2}$$

(c)

C · $T = 8.3$ days $r = 2.7.$ $\frac{T^2}{r^3} = 3.5$

G $T = 3.5$ days $r = 1.5$ $\frac{T^2}{r^3} = 3.6$

3.(a) $$F = \frac{Q_1Q_2}{4\pi\varepsilon_0 r^2}.$$

(b) (i) $$F = \frac{\frac{2}{3}\times\frac{1}{3}\times(1.6\times10^{-19})^2}{4\pi\varepsilon_0\ (10^{-15})^2} = \frac{\frac{2}{9}\times9\times10^9\times\ 2.56\times10^{-38}}{10^{-30}} = 5.12\times10$$
$$= 51.2\,N$$

(ii) Strong nuclear force.

4 (a) $E = 0$

$V = 2000V$

(b) $V = \frac{Q}{4\pi\varepsilon_0 r}$ $\quad Q = V \times 4\pi\varepsilon_0 \times r$

$= \frac{2\times10^3 \times 0.1}{9\times10^9}$

$= 2.2\times10^{-8}$ C.

5. (a) Force due to E equal and opposite to force due to

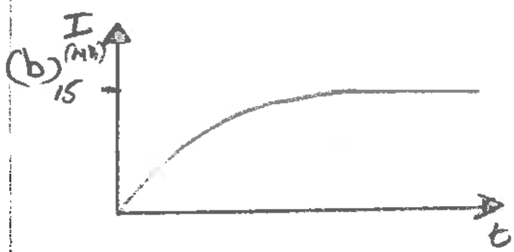
(b) $Bev = eE \Rightarrow v = \frac{E}{B}$.

(c) $v = \frac{5000}{28\times10^{-3}} = 1.79\times10^5$ m/s.

6. (a)(i) – 3V.

(ii) $I = \frac{V}{R} = \quad = 15$ mA

(b)



7. (a)(i) $mvr = \frac{h}{2\pi}$

$v = \frac{h}{2mr\pi} = \frac{6.63\times10^{-34}}{2\times9.11\times10^{-31}\times5.29\times10^{-11}\times\pi}$

$= 2.2\times10^6$ m/s

(b) $\frac{mv^2}{2}$ – E_K of electron

$\frac{e^2}{4\pi\varepsilon_0 r^2}$ – E_p(electrical) of electron.

8. (a) (i) $a = \omega^2 r = (0.57)^2 \times 30 = 9.7\ m/s^2$ towards centre.

(ii) $F = ma = 80 \times 9.7 = 776\ N$ produced by wall preventing astronaut travelling in straight line.

(b) (i) $I = mr^2 = 1.5 \times 10^4 \times (30)^2 = 1.35 \times 10^7\ kgm^2$

(ii) $I_{AST} = mr^2 = (8 \times 80) \times (30)^2 = 0.06 \times 10^7\ kgm^2$

$\Rightarrow I_{TOTAL} = 1.41 \times 10^7\ kgm^2$

$L = I\omega = 1.41 \times 10^7 \times 0.57 = 8.04 \times 10^6\ kgm^2 rad/s$

(iii)

$I_1 \omega_1 = I_2 \omega_2$

$1.41 \times 0.57 = 1.35 \times \omega_2$

$\omega_2 = 0.59\ rad/s$

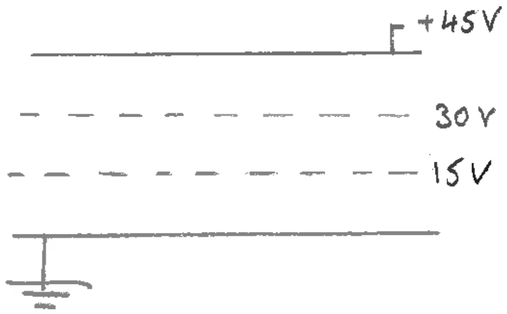
(iv)

$E_{K rot}$ before $= \frac{I\omega^2}{2} = \frac{1.41 \times 10^7 \times (0.57)^2}{2} = 2.29 \times 10^6\ J$

$E_{K rot}$ after $= \frac{I\omega^2}{2} = \frac{1.35 \times 10^7 \times (0.59)^2}{2} = 2.34 \times 10^6\ J$

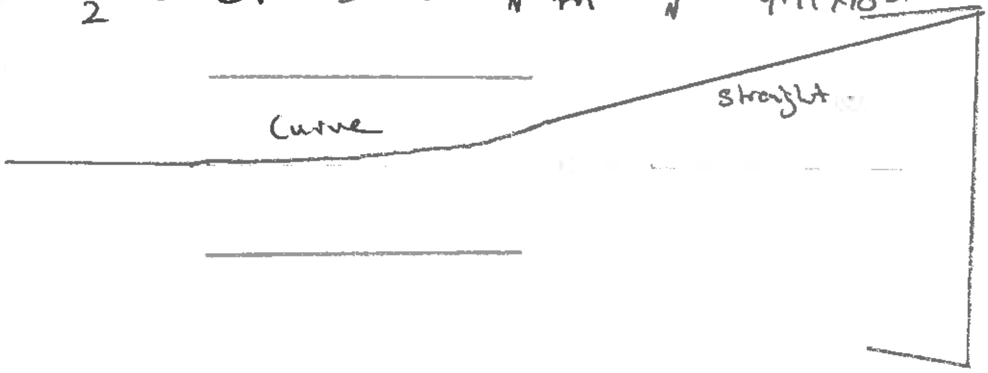
astronauts supply energy by moving inwards.

9. (a) $E = \frac{V}{d} = \frac{45}{0.03} = 1500\ V/m$



(b) (i) $\frac{mv^2}{2} = eV \Rightarrow v = \sqrt{\frac{2eV}{m}} = \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 300}{9.11 \times 10^{-31}}} = 1.02 \times 10^7\ m/s$

(ii)



(iii) $a = \frac{F}{m} = \frac{Ee}{m} = \frac{1500 \times 1.6 \times 10^{-19}}{9.11 \times 10^{-31}} = 2.63 \times 10^{14}\ m/s^2$

(iv) $t = \frac{S_H}{v_H} = \frac{0.1}{1.02 \times 10^{7}} = 9.8 \times 10^{-9}\ s$

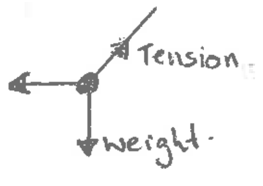
$s = \frac{1}{2}at^2 = \frac{1}{2} \times 2.63 \times 10^{14} \times (9.8 \times 10^{-9})^2$

$= 0.0126\,m$

$= 12.6\ mm$

10.

(a) (i)



(ii) Repulsion force $= mg\tan\theta$

$= 12 \times 10^{-3} \times 9.8 \times 0.03$

$= 3.5 \times 10^{-3}\ N/m$

(iii)

$F = B_1 I_2 l = \frac{\mu_0 I_1 I_2 l}{2\pi r}$

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

(iv) $\frac{F}{l} = \frac{\mu_0 I^2}{2\pi r}$ $\quad 3.5 \times 10^{-3} = \frac{4\pi \times 10^{-7} \times I^2}{2\pi \times 60 \times 10^{-3}}$

$3.5 \times 10^{-3} = 3.3 \times 10^{-6}\ I^2$

$I^2 = 1050$

$I = 32.4\ A$

(b) (i) $F = Bev = 2 \times 10^{-3} \times 1.6 \times 10^{-19} \times 1 \times 10^{7}$

$= 3.2 \times 10^{-15}\ N$

(ii) $\frac{mv^2}{r} = F \Rightarrow r = \frac{mv^2}{F} = \frac{9.11 \times 10^{-31} \times (10^{7})^2}{3.2 \times 10^{-15}}$

$= 0.028\ m$

(c) (i) Particle loses energy, v reduces so r reduces.

(ii) Particles will have opposite charges.

11. (a) (i) Not required.

(ii) (A) a – amplitude of waves

f – frequency of waves.

(B) $y = a \sin 2\pi\left(ft + \frac{x}{\lambda}\right)$

(b) (i) $y = A \sin \omega t$ — A – amplitude of vibration.

ω – $\frac{2\pi}{T}$ where T is period of osc.

(ii)

$$a = -\omega^2 y$$
$$= -4\pi^2 f^2 A$$
$$= 4 \times 10 \times (1.2)^2 \times 0.1$$
$$= -5.76 \text{ m/s}^2$$

(iii) $-9.8 = 4 \times 10 \times (1.2)^2 \times A$.

$A = 0.17\text{m}$. top of board.

(iv) Not required (oscillation will have greater frequency mass oscillating has been reduced).