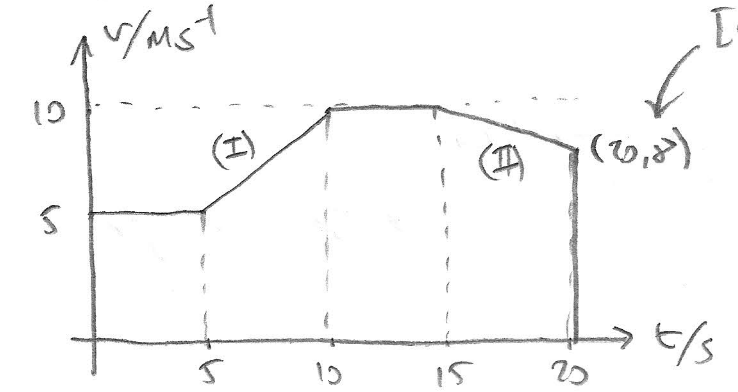
IGCSE PHYSICS – KNOW YOUR DEFINITIONS!

AR 14/1/20.

1/

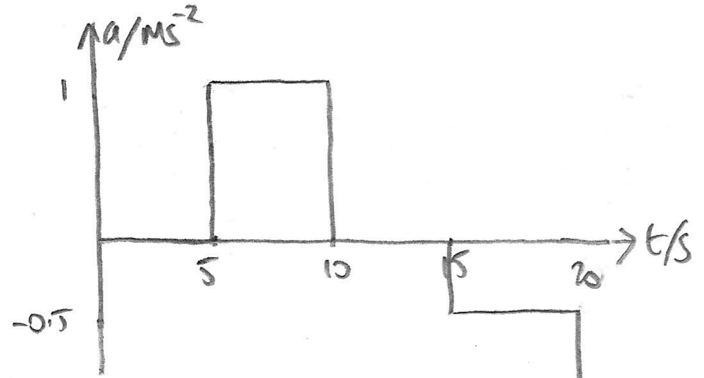


[change to 9 ms⁻¹]

Acceleration:

(I): $a = \frac{5\,ms^{-1}}{5s} = \boxed{1.0\ m/s^2}$

(II) $a = \frac{-2\,ms^{-1}}{5s} = \boxed{-0.4\ m/s^2}$

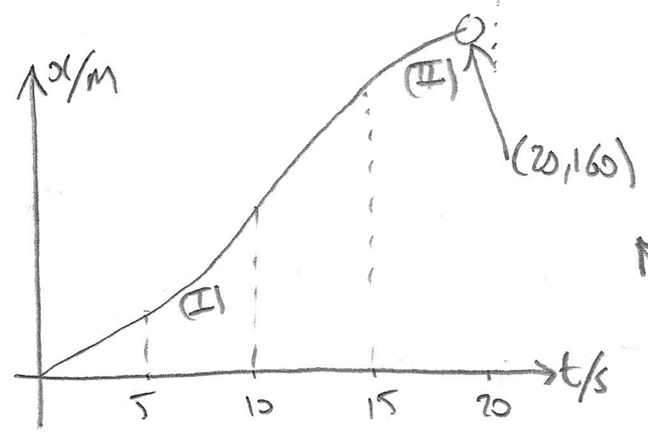


Total displacement is

$(5)(5) + \frac{1}{2}(5+10)(5)$

$+ (10)(5) + \frac{1}{2}(10+8)(5)$

$= \boxed{157.5\,m}$



[Better if last speed was $\boxed{9\ m/s}$, then

$x_{tot} = \boxed{160\,m}$

$a_{II} = -\frac{1}{5}\ ms^{-2} = -0.2\ m/s^2$]

(I), (II) are curved sections

The others are straight lines.

2/ (i) $W = mg$

$W = 75\ kg \times 9.81\ N/kg$

$W = \boxed{736\ N}$

EARTH

(ii) $W = 75\ kg \times 3.72\ N/kg$

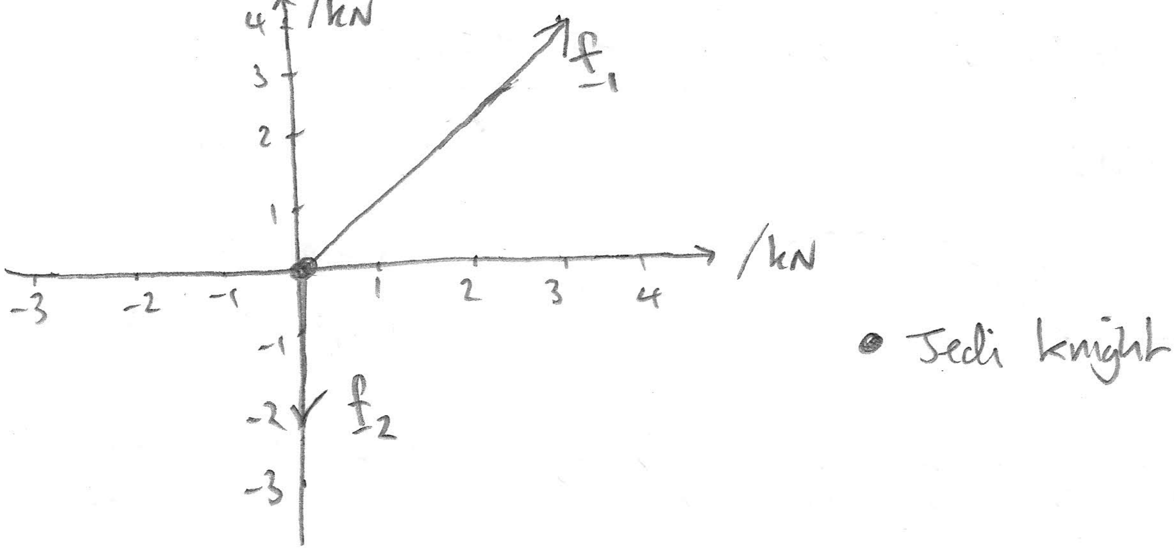
$W = \boxed{279\ N}$

MARS

3/ $1000\, g_J = 6664 \times 3.72$ $\therefore g_J = 6.664 \times 3.72\ N/kg$

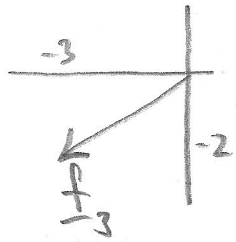
$= \boxed{24.79\ N/kg}$

4/



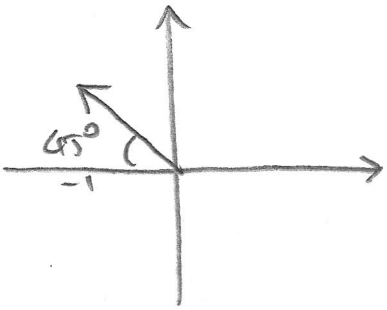
(i) if net force is $\begin{pmatrix}0\\0\end{pmatrix} = \underbrace{\begin{pmatrix}F_x\\F_y\end{pmatrix}}_{\underline{f}_3} + \underbrace{\begin{pmatrix}3\\4\end{pmatrix}}_{\underline{f}_1} + \underbrace{\begin{pmatrix}0\\-2\end{pmatrix}}_{\underline{f}_2}$

$\Rightarrow \begin{pmatrix}F_x\\F_y\end{pmatrix} = \begin{pmatrix}0\\2\end{pmatrix} - \begin{pmatrix}3\\4\end{pmatrix} = \begin{pmatrix}-3\\-2\end{pmatrix}$



(ii) if $\underline{f}_3$ is $\begin{pmatrix}-4\\-1\end{pmatrix}$ and

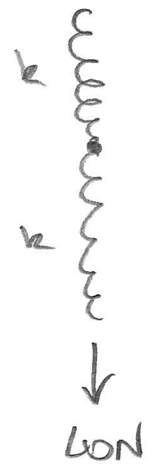
so $\begin{pmatrix}d_x\\d_y\end{pmatrix} = \begin{pmatrix}3\\4\end{pmatrix} + \begin{pmatrix}0\\-2\end{pmatrix} + \begin{pmatrix}-4\\-1\end{pmatrix} = \begin{pmatrix}-1\\1\end{pmatrix}$



Net force is $\sqrt{2} = 1.41$ kN at a bearing of $\boxed{315°}$

if Jedi has a mass of 80kg, acceleration is $\boxed{17.7\ \text{m/s}^2}$

5/



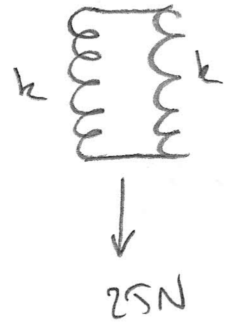
Each spring stretches 10cm, for total stretch of 20cm.

∴ Since each spring experiences 40N of force:

$$40 = k \times 0.1$$

$$\boxed{400\,N/m = k}$$

6/



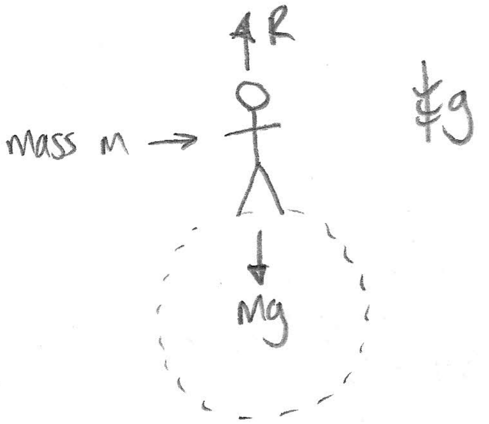
$k = 50\,N/m$

Each spring experiences a force of $\frac{25}{2}$ N

So $x = F/k = \dfrac{25/2}{50}$

$\therefore x = 0.25$ ie $\boxed{25\text{ cm}}$

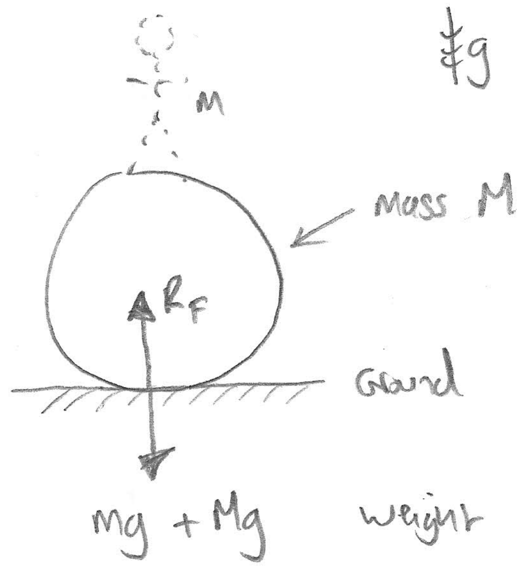
7/



R is normal contact force

$\boxed{R = Mg}$ in eq.

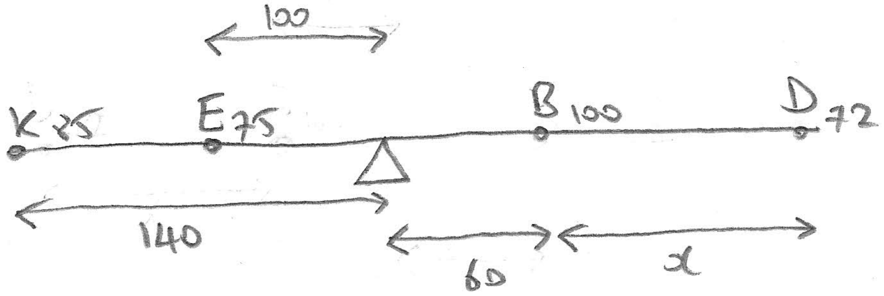
{ NIII: The force of the gymnast on the ball is R = Mg downwards }



$\boxed{R_F = (m + M)g}$ in eq.

R_F is the contact force of the ground on the ball.

8/



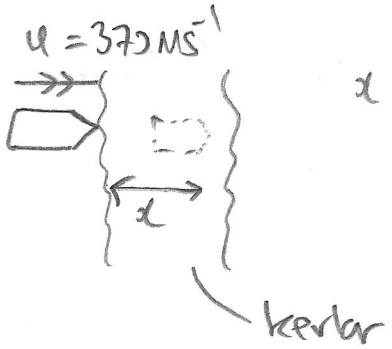
$\circlearrowright$+ moments (in eq) is net $\underline{\text{zero}}$

$\therefore \quad (100)(60) + (72)(60+x) = (85)(140) + (75)(100)$

$\therefore \quad x = \dfrac{11900 + 7500 - 6000}{72} - 60$

$$\boxed{x = 126.1 \text{ cm} \quad \text{behind Boris}}$$

9/



$x = 5$ mm to stop bullet.

$v^2 = u^2 + 2ax$ let $v = 0$
$u = 370$
$x = 5$ mm

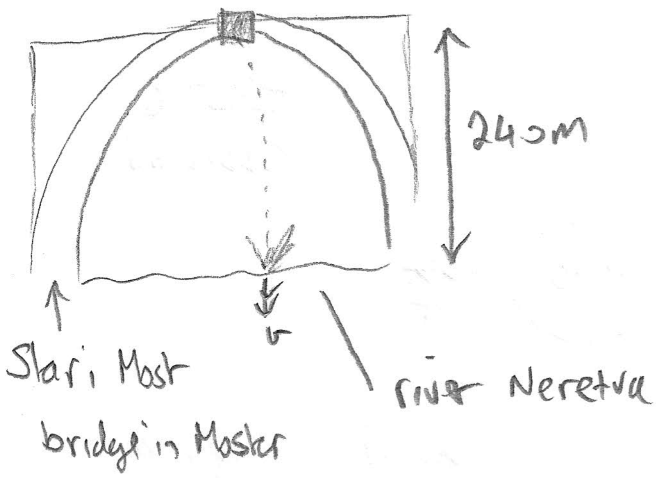
$\therefore \quad a = \dfrac{-370^2}{2 \times 5 \times 10^{-3}}$

(i) $\boxed{a = 1.37 \times 10^7\ m/s^2}$

(ii) $v = u + at$ so when $v = 0$, $t = -u/a$

$= \dfrac{-370}{1.37 \times 10^7} = \boxed{2.70 \times 10^{-5}\ s}$

10/



$g = 9.81\ m/s^2$

$$\boxed{x = \tfrac{1}{2}gt^2} \qquad \boxed{v = gt}$$

$$\therefore\ t = \sqrt{\frac{2x}{g}}$$

$$\therefore\ t = \sqrt{\frac{2 \times 24.0}{9.81}}$$

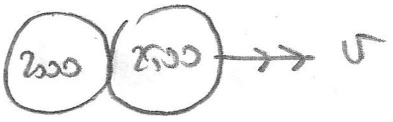
$$\boxed{t = 2.21\ s}$$

$$\therefore\ v = 9.81 \times 2.21 = \boxed{21.7\ m/s}$$

11/ (i)

BEFORE

"inelastic collision"



(speeds in mph
mass in kg)

AFTER

Conservation of momentum $\longrightarrow$ +ve

$$(2000)(55) + (2500)(-10) = (4500)v$$

$$\therefore\ \boxed{v = 18.9\ mph}$$

(Total momentum $\boxed{\text{Before}}$ is $\underline{\underline{85000}}$)

(ii) AFTER

ELASTIC
COLLISION

$$\frac{v+u}{65} = 1 \qquad \text{ie} \quad \frac{\text{speed of separation}}{\text{speed of approach}} = 1$$

$\therefore$ $\boxed{v = 65 - u}$

conservation of momentum: $2500(65-u) - 2000u = 85000$

$\therefore$ $77500 = 4500u$

$\therefore$ $\boxed{u = 17.2 \text{ mph}}$

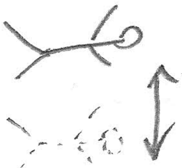
$\therefore$ $\boxed{v = 47.8 \text{ mph}}$

12/ Impulse provided to bullet is the change in momentum.

ie $0.03\,kg \times 370\,m/s = \boxed{11.1\ kg\,ms^{-1}}$

If stopping time is 2.70×10^{-5} s, then average force is $\dfrac{11.1\ kg\,ms^{-1}}{2.70 \times 10^{-5}\,s} = \boxed{4.1 \times 10^{5}\ N}$

Q13/



$h = 0.30\,m$

$g = 9.81\ N/kg$

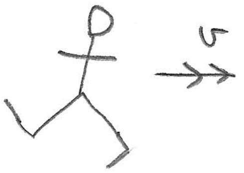
$E = mgh$

$\frac{E}{gh} = m$

$\therefore \frac{200}{9.81 \times 0.30} = m$

$\boxed{68\ kg = m}$

14/



Usain Bolt
$M = 94\,kg$

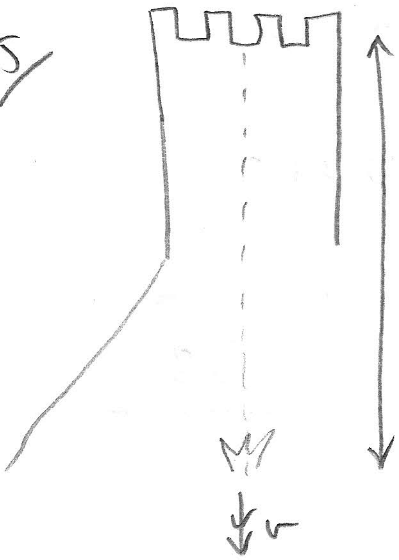
$v = \frac{200\,m}{19.19\,s} = \boxed{10.42\ ms^{-1}}$

$KE = \frac{1}{2}mv^2$

$= \frac{1}{2} \times 94 \times \left(\frac{200}{19.19}\right)^2$

$= \boxed{5105\ J}$

15/



$h = 49.1\,m$

$g = 9.81\ m/s^2$

$\frac{1}{2}mv^2 = mgh$

$v = \sqrt{2gh}$

$v = \sqrt{2 \times 9.81 \times 49.1}$

$= \boxed{31.0\ m/s}$

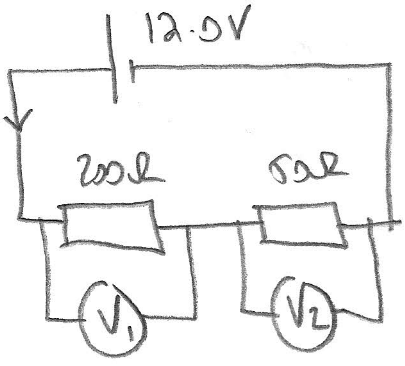
16/ $P = fv$ $\quad f = P/v$ $\quad f = \frac{400}{12}$

$f = \boxed{33.3\ N}$

In one hour, spend $400 \times 3600 = \boxed{1.44 \times 10^6\ J}$

17/

(i)



$$V_1 = \frac{200}{250} \times 12.0$$

$$\boxed{V_1 = 9.6\,V}$$

$$V_2 = \frac{50}{250} \times 12.0$$

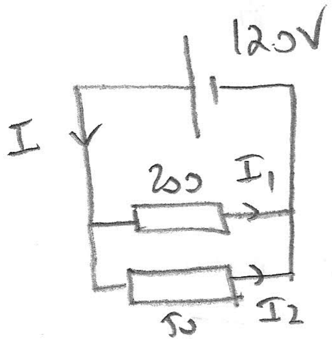
$$\boxed{V_2 = 2.4\,V}$$

$$I = \frac{12.0\,V}{250\,\Omega} = \boxed{0.048\,A}$$

So in 5 mins, $Q = It = 0.048 \times 5 \times 60$ C

$= \boxed{14.4\,C}$ drawn from power supply

(ii)



* Voltage across both is now 12.0V

* $I_1 = \frac{12.0}{200} = 0.06\,A$

$I_2 = \frac{12.0}{50} = 0.24\,A$

So total current is $I = I_1 + I_2$

$$\boxed{I = 0.3\,A}$$

$$\left(R = \frac{1}{\frac{1}{200} + \frac{1}{50}} = 40\,\Omega \right.$$

$$\left. \therefore\ I = \frac{12.0}{40} = 0.3\,A \right)$$

So total charge drawn in 5 mins is $0.3 \times 5 \times 60$

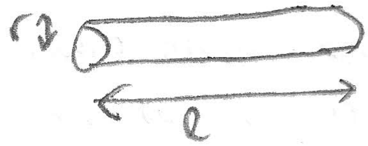
$= \boxed{90\,C}$

18/ $P = I^2 R$

$$0.8P = 1200$$
$$P = \frac{1200}{0.8}$$
$$\boxed{P = 1500\,W}$$

$$R = P/I^2 \quad \therefore \quad R = \frac{1500}{1.23^2} = \boxed{991.5\,\Omega}$$

19/ $R = \rho l / \pi r^2$



$$R = \frac{2.82 \times 10^{-8} \times 100 \times 10^{3}}{\pi \times (1.50 \times 10^{-2})^2}$$

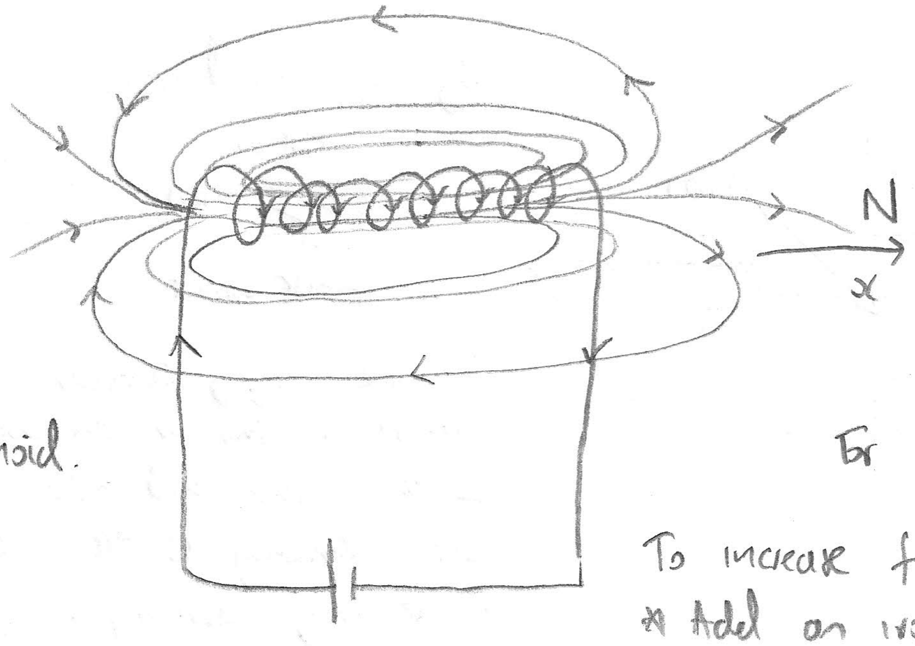
$$\boxed{R = 3.99\,\Omega}$$

20/ $R = \rho l / \pi r^2 \quad \therefore \quad l = \frac{R \pi r^2}{\rho}$

$$l = \frac{0.01 \times \pi \times (1.00 \times 10^{-3})^2}{1.68 \times 10^{-8}}$$

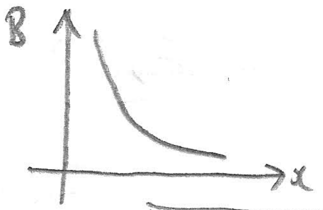
$$l = \boxed{1.87\,M}$$

21/



Solenoid.

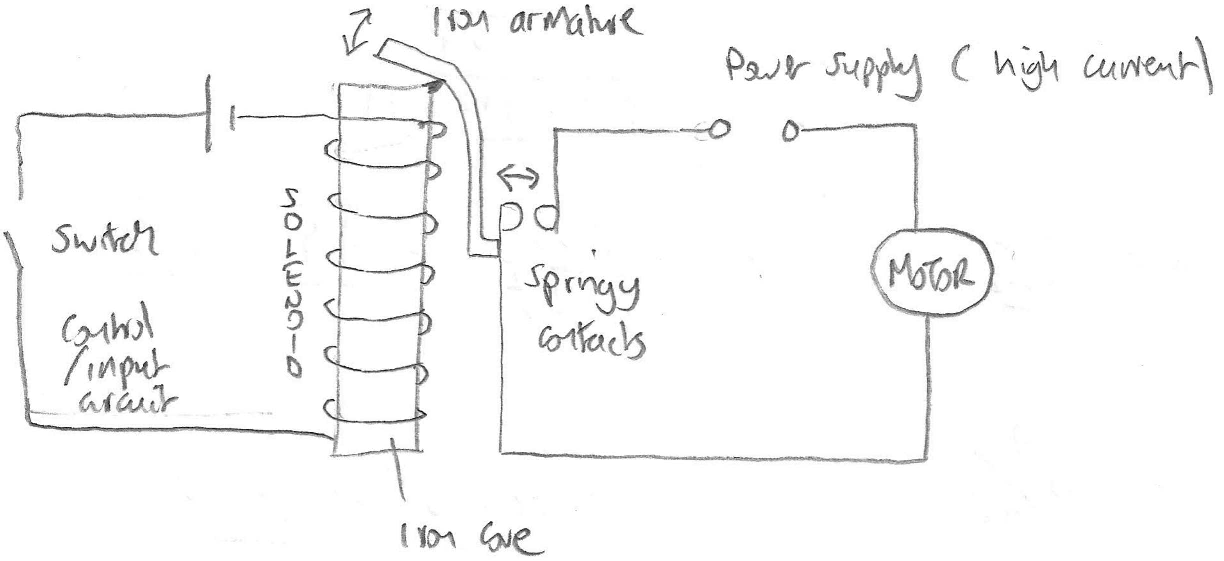
* Use right hand grip rule to determine pole



For a solenoid $\boxed{B \propto \frac{1}{x^3}}$

To increase field strength:
* Add an iron core
* More turns / unit length
* Increase current.

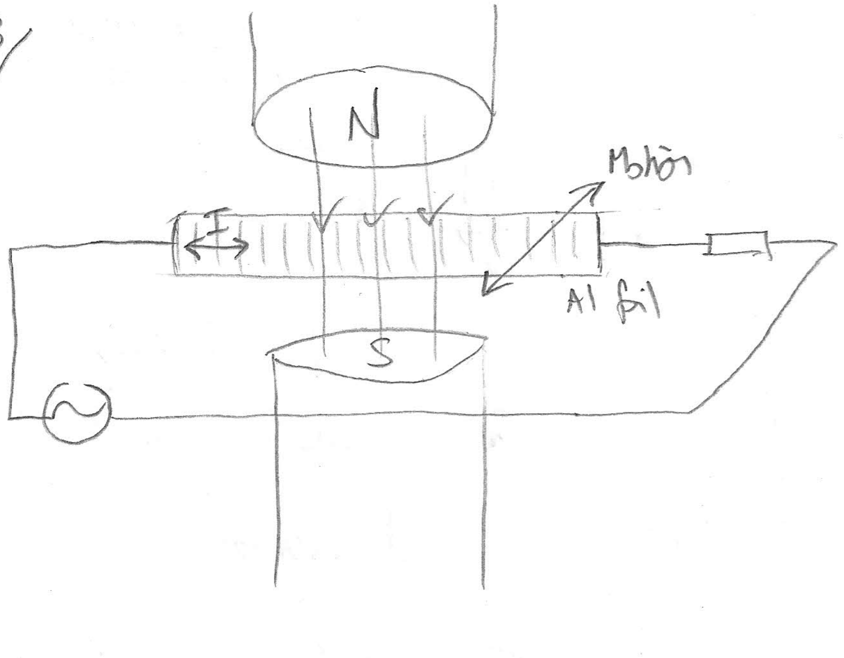
22/ Electromagnetic relay



Idea is that a low voltage, low current control circuit can switch on or off a higher current circuit without being in direct electrical contact. This saves weight, cost and makes circuits safer.

* Switch on control circuit. Current flows through solenoid.
* Magnetic field in solenoid, made stronger by iron core. This attracts the iron armature.
* Armature pivots towards the solenoid, which pushes the springy contacts of the high current circuit closed.
* Electricity flows through high current circuit.

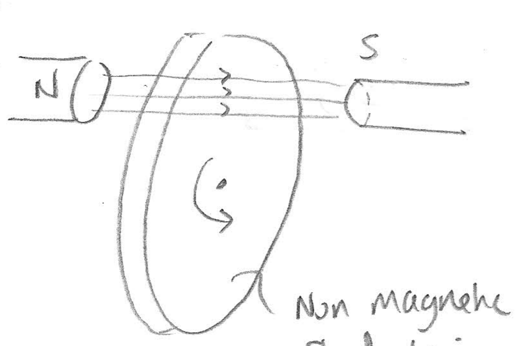
23/



By left hand rule

A time varying current through Al foil ⇒ an oscillation ⊥ to current and field, at same frequency as the AC (Alternating current).

24/



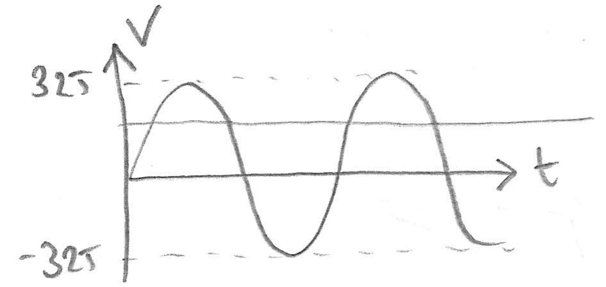
* Steel is a conductor
* If a conductor moves through a magnetic field, Faraday's law states, "EMF induced ∝ rate of change of magnetic flux linked".
∴ voltage induced across wheel
⇒ eddy currents circulate within it.

* The eddy currents cause a magnetic field to be formed.
* This field (by Lenz's law) opposes the effect of the applied field, and ∴ the wheel must slow down i.e. a braking effect.
* The KE of the wheel is transformed to heat loss I^2R where I is the eddy current and R the resistance of the wheel.

Electrical power dissipated

25/ Power line : $V_{rms} = 11\,kV$ (11,000 V)
Domestic : $V_{rms} = 230\,V$

(i)



ROOT MEAN SQUARE (RMS) voltage

AC $\boxed{\text{Alternating current}}$

$$V_{rms} = \sqrt{\tfrac{1}{2}\, 325^2}$$ for domestic electricity

$$= \frac{325}{\sqrt{2}} \simeq \boxed{230\,V}$$

(ii) $$\frac{230}{11{,}000} = \frac{50}{N_p}$$ Transformer equation.

$$\Rightarrow N_p = \frac{50 \times 11{,}000}{230} = \boxed{2391}$$

(iii) $P = IV$ $\therefore$ $I = P/V$

$$I = \frac{9200\,W}{230\,V} = \boxed{40\,A}$$

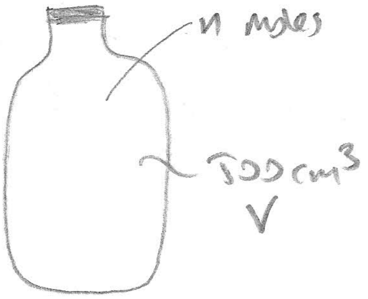
(iv) $321 \times 9200 = P$

So for power line : $I = \dfrac{321 \times 9200}{11{,}000}$ (A)
($V = 11{,}000$)

$$\boxed{I = 268.5\,A}$$

(268A to 3 s.f.)

26/



At 3500 M
$T = 273.15 - 20$
$p = 72\,kPa$

At 0 M
$T_0 = 273.15 + 5$
$p_0 = 101\,kPa$

So $pV = nRT$
$p_0V_0 = nRT_0$

$\boxed{\text{Ideal gas equation}}$

$\therefore \dfrac{p_0V_0}{pV} = \dfrac{T_0}{T}$

$\therefore V_0 = \left(\dfrac{p}{p_0}\right)\left(\dfrac{T_0}{T}\right)V$

$\therefore V_0 = \left(\dfrac{72}{101}\right)\left(\dfrac{273.15 + 5}{273.15 - 20}\right) \times 500$

$$\boxed{V_0 = 392\ cm^3}$$

27/ $Pt \simeq cm\Delta T$

$\therefore t = cm\Delta T / P$

$$t = \frac{4200 \times 1.23 \times 90}{2000} \quad (s)$$

$t = 232\,s$ or $\boxed{3\,min\ 52\,s}$

28/ Energy transferred is $\underbrace{(1200-1063)(0.1)(129)}_{cm\Delta T \text{ for liquid}}$

(Assume liquid c is the same as solid gold)

$+ \underbrace{(0.1)(62.8 \times 10^3)}_{mL_{fus}}$

$+ \underbrace{(1063-20)(0.1)(129)}_{cm\Delta T \text{ for solid}} = \underbrace{15222}_{\text{"}cm\Delta T\text{"}} + \underbrace{6280}_{mL_{fus}} \quad (J)$

[2.0 kg of gold is more realistic, so × by 20 ie $\boxed{430\,kJ}$] $= \boxed{21.5\,kJ}$

29/ McMurdo Antarctic base:

	T/F	T/C
winter	-18	-27.8
summer	33	0.6

$T_F = \frac{9}{5}T_C + 32$

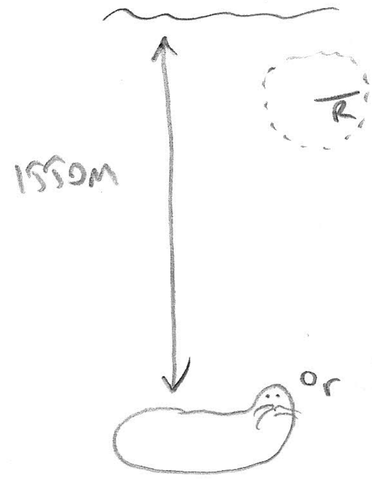
$\therefore \frac{5}{9}(T_F - 32) = T_C$

30/ $\Delta P = \rho g \Delta h$ so $\Delta h = \Delta P / \rho g$

If $\Delta P = 101 \times 10^3\,Pa \Rightarrow \Delta h = \frac{101 \times 10^3}{1029 \times 9.81} = \boxed{10.01\,m}$

Dive 10 m to gain an extra atm of pressure

31/



pV = constant if T constant (Boyle's law)

pV at 1550m

so $\quad 101 \times \left(\frac{1550}{10.01} + 1\right) \times \frac{4}{3}\pi r^3$

$$= \underbrace{101 \times \frac{4}{3}\pi R^3}_{pV \text{ at surface}}$$

so $\quad \sqrt[3]{\frac{1550}{10.01} + 1} = R/r \quad$ {using 101 hPa for every 10.01m of depth} ↑ Q30.

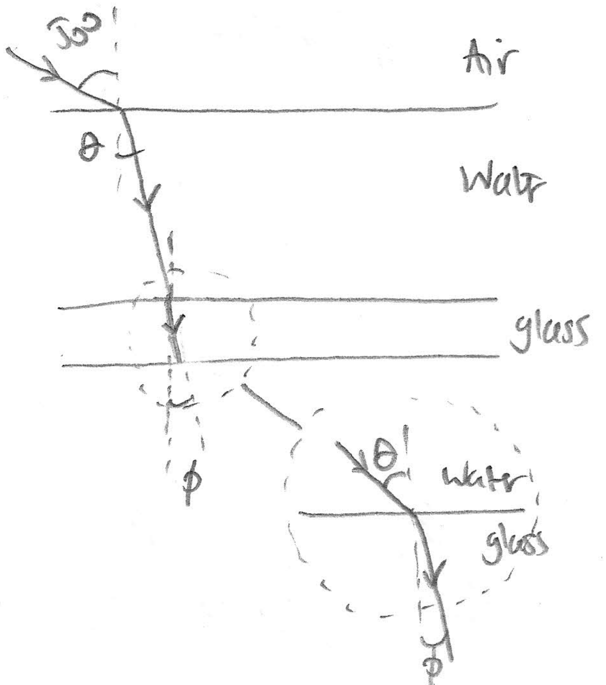
$\Rightarrow \quad R/r = \boxed{5.38}$

32/ $\Delta P = \rho g \Delta h \quad \therefore \Delta h = \frac{\Delta P}{\rho g}$

$\Delta h = \frac{10 \times 10^3}{13593 \times 9.81} = 0.075 \text{ m}$

$= \boxed{75.0 \text{ mm of Hg}}$

33/



Snell: $1.33 \sin\theta = 1.00 \sin 50°$
$1.33 \sin\theta = 1.52 \sin\phi$

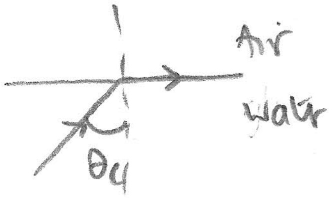
so don't actually need θ!

(it is $\theta = \sin^{-1}\left(\frac{\sin 50°}{1.33}\right) = 35.2°$)

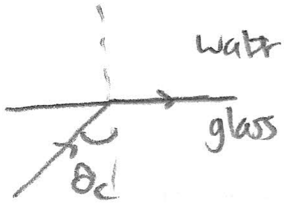
$\phi = \sin^{-1}\left(\frac{\sin 50°}{1.52}\right) = \boxed{30.3°}$)

34/ $1.33 \sin\theta_c = \underbrace{1.00 \sin 90^\circ}_{1}$ $\therefore\ \theta_c = \sin^{-1}\left(\frac{1}{1.33}\right)$

$= \boxed{48.8^\circ}$



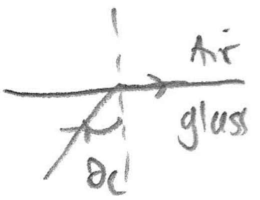
(i)



$1.52 \sin\theta_c = 1.33 \sin 90^\circ$

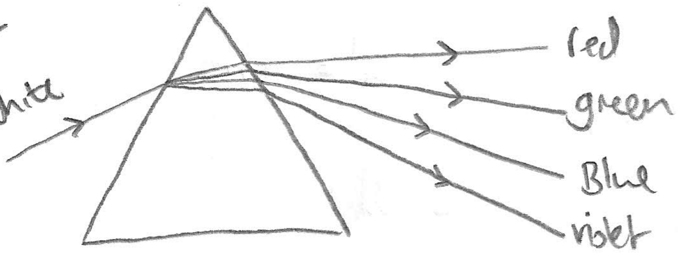
$\therefore\ \theta_c = \sin^{-1}\left(\frac{1.33}{1.52}\right) = \boxed{61.0^\circ}$

(ii)

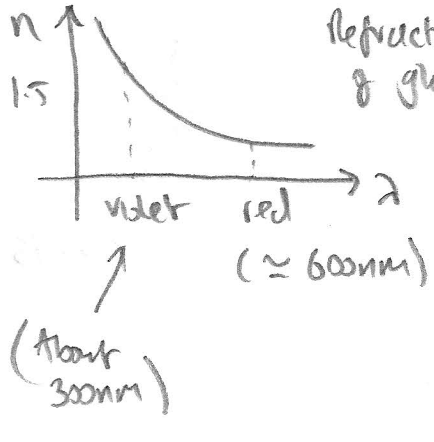


$\theta_c = \sin^{-1}\left(\frac{1}{1.52}\right) = \boxed{41.1^\circ}$

35/

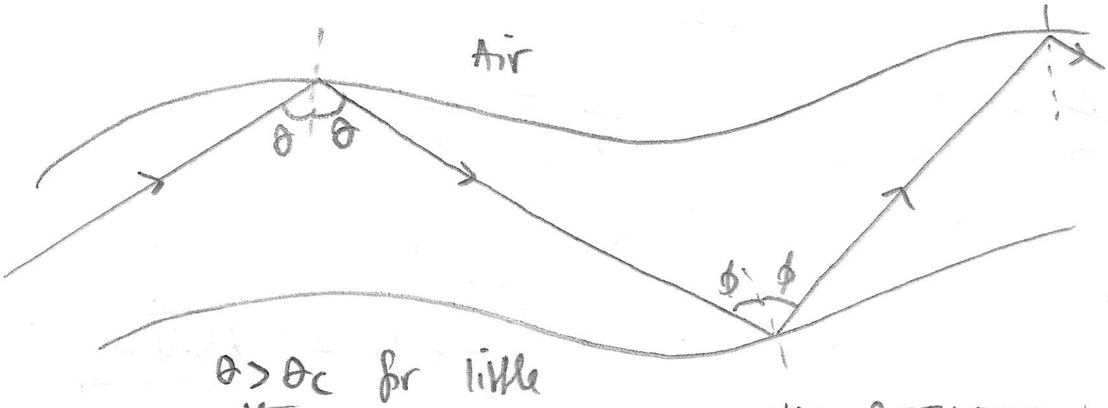


$\boxed{\text{Dispersion}}$ of white light via a triangular prism.



Refractive index of glass vs λ

36/



if n is refractive index:

$\boxed{\theta_c = \sin^{-1}\left(\frac{1}{n}\right)}$

optic fibre

$\theta > \theta_c$ for little attenuation. i.e. TOTAL INTERNAL REFLECTION

37/ $c = f\lambda \quad \therefore \quad \lambda = c/f$

$$\lambda_{air} = \frac{344}{440} = \boxed{78.2\text{ cm}}$$

$$\lambda_{water} = \frac{1482}{440} = \boxed{3.37\text{ m}}$$

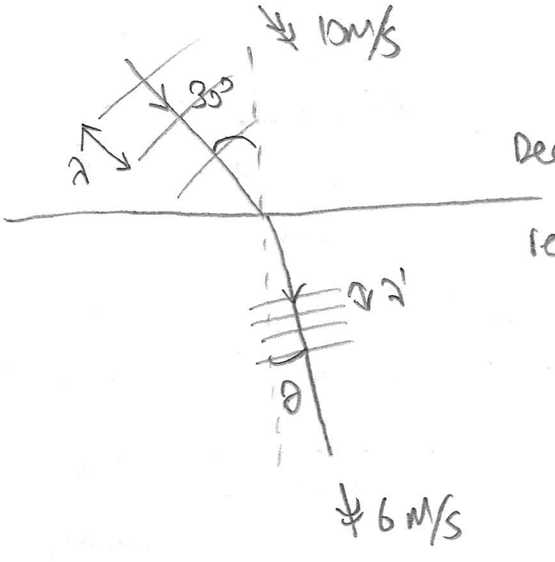
38/ $f = c/\lambda \quad \therefore \quad f = \frac{1482}{1.23\times10^{-2}}$

$$\boxed{f = 1.32\times10^{5}\text{ Hz}}$$

(132 kHz)

$$T = 1/f = \boxed{7.58\times10^{-6}\text{ s}}$$

39/



$\lambda' = 16\text{ m}$

Snell:

$$\frac{\sin\theta}{6} = \frac{\sin 30^\circ}{10}$$

$$\therefore \theta = \sin^{-1}\left(\frac{6}{10}\sin 30^\circ\right)$$

$$\theta = \boxed{17.5^\circ}$$

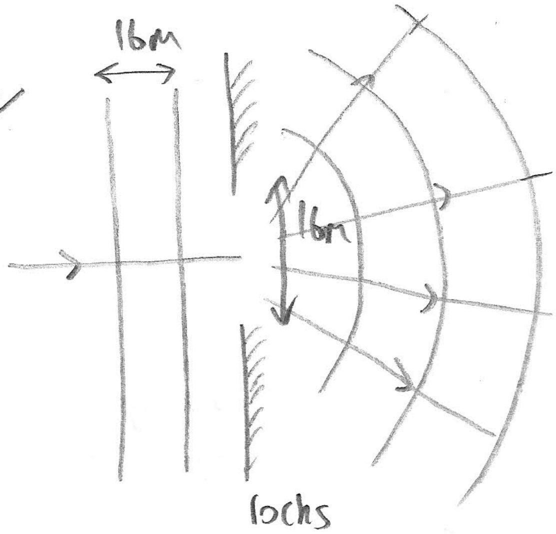
f the same so $f = c/\lambda$

$$\therefore \frac{10}{\lambda} = \frac{6}{\lambda'} \quad \therefore \quad \frac{\lambda}{10} = \frac{\lambda'}{6}$$

$$\therefore \lambda = \frac{10}{6}\lambda'$$

$$\lambda = \frac{10}{6}\times 16 = \boxed{26.7\text{ m}}$$

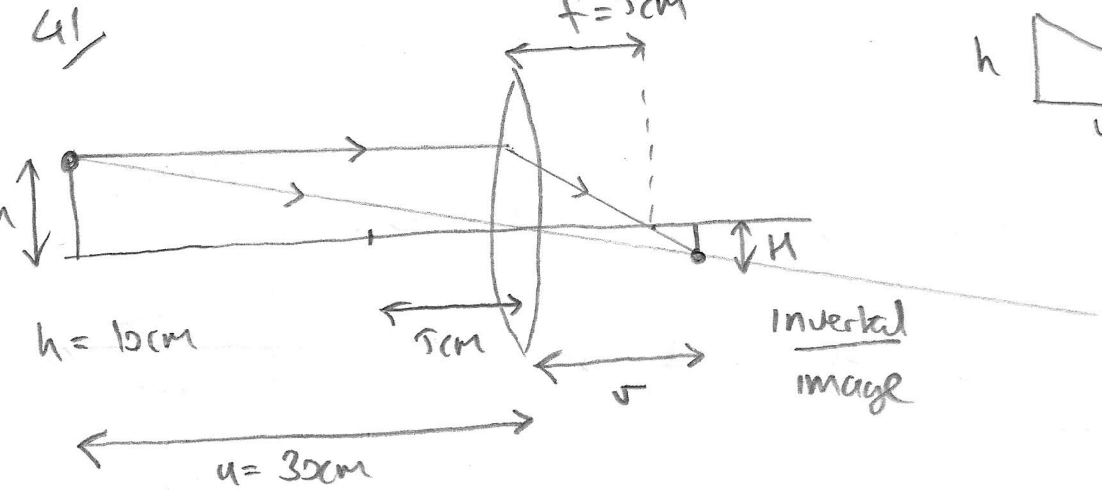
40/

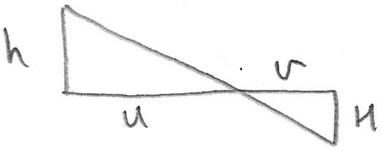


Wavefronts will be diffracted by the 16m aperture in the locks

Since aperture $\simeq \lambda$, the "maximum" amount of diffraction will occur.

41/





Similar triangles

$$\frac{H}{v} = \frac{h}{u}$$

$$\therefore \boxed{H = \frac{v}{u}h}$$

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

$$\therefore \frac{1}{v} = \frac{1}{f} - \frac{1}{u}$$

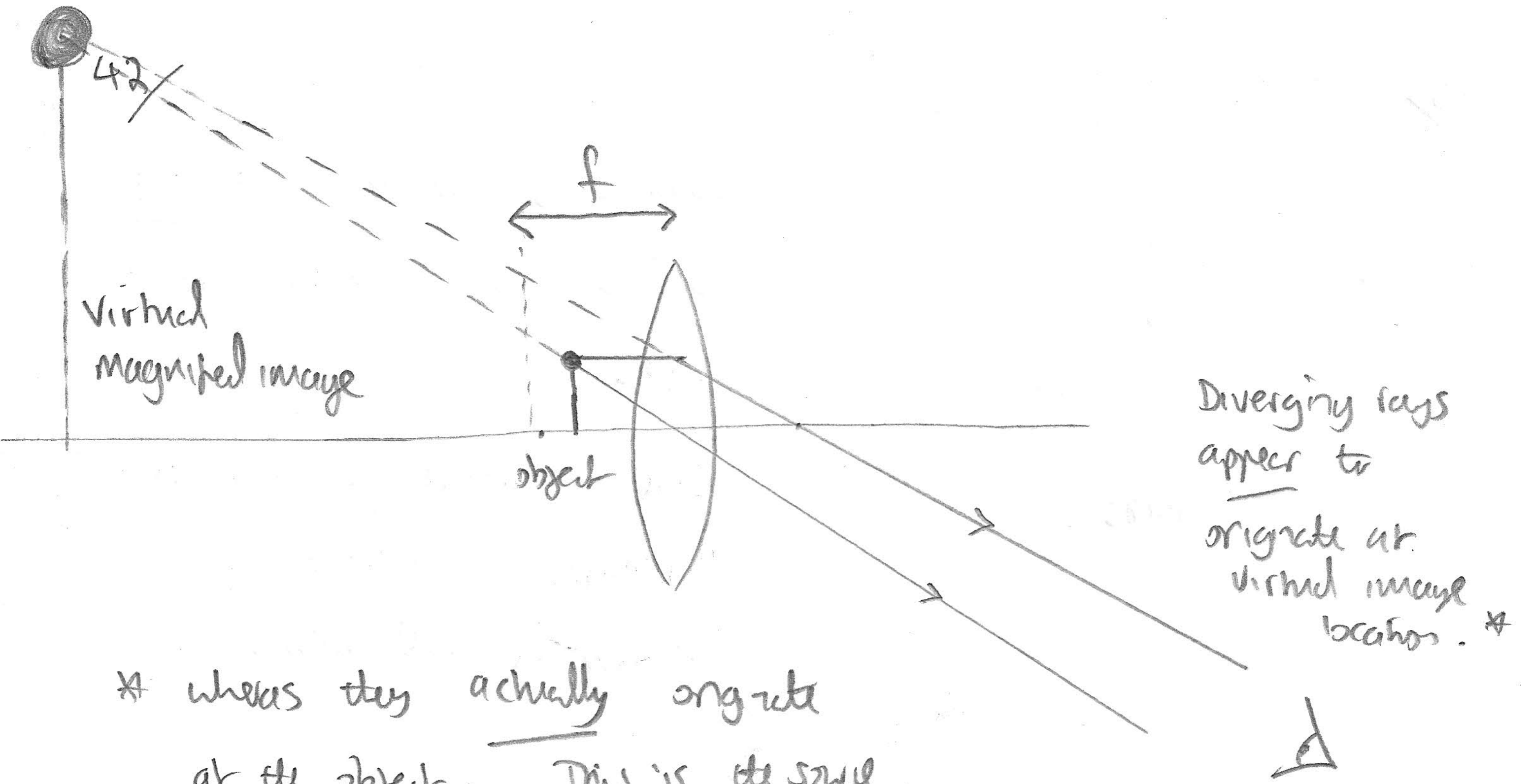
$$\boxed{v = \left(\frac{1}{f} - \frac{1}{u}\right)^{-1}}$$

$$\therefore v = \left(\frac{1}{5} - \frac{1}{30}\right)^{-1}$$

$$v = \boxed{6cm}$$

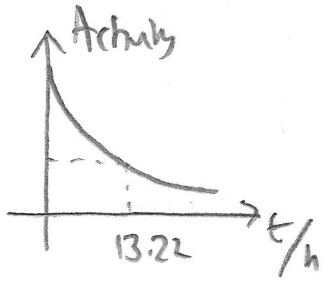
$$\therefore H = \frac{6}{30} \times 10 = \boxed{2cm}$$

42/



* whereas they actually originate at the object. This is the source of light.

43/ $T_{\frac{1}{2}}$ for Iodine-123 is 13.22 hours.



$$\frac{52.88 \text{ hours}}{13.22 \text{ hours}} = 4 \text{ half lives.}$$

$$\therefore \text{ Dosage is } \frac{25 \times 10^6 \text{ Bq}}{2^4} = \boxed{1.56 \times 10^6 \text{ Bq}}$$

$[2^4 = 16]$

ie $\frac{1}{16}$ of dose at $t = 0$.

44/ $${}^{60}_{27}Co \longrightarrow {}^{60}_{28}Ni + {}^{0}_{-1}e^- + \bar{\nu}_e$$

β particle

electron antineutrino.

45/ $${}^{240}_{94}Pu \longrightarrow {}^{236}_{92}U + {}^{4}_{2}He$$

α particle.

[Z for U-236 is 236 - 144 = 92]

46/ Practical applications

α $\boxed{\text{Smoke alarms.}}$

Highly ionizing, not very penetrating. (unlike β, γ).
Smoke molecules absorb α, become ionized, but move more slowly than air. ∴ Ionization current ↓.
Don't need much shielding as a few cm of air will stop α.

β Thickness monitoring of paper mills

Attenuation of β varies significantly with paper thickness (unlike α, γ).
[α is too much!]
∴ can use β count to control position of rollers in a paper mill (feedback loop).

γ

* Therapeutic cancer treatment
* Imaging of cracks in aero engine blades ...

EM wave so can be focussed

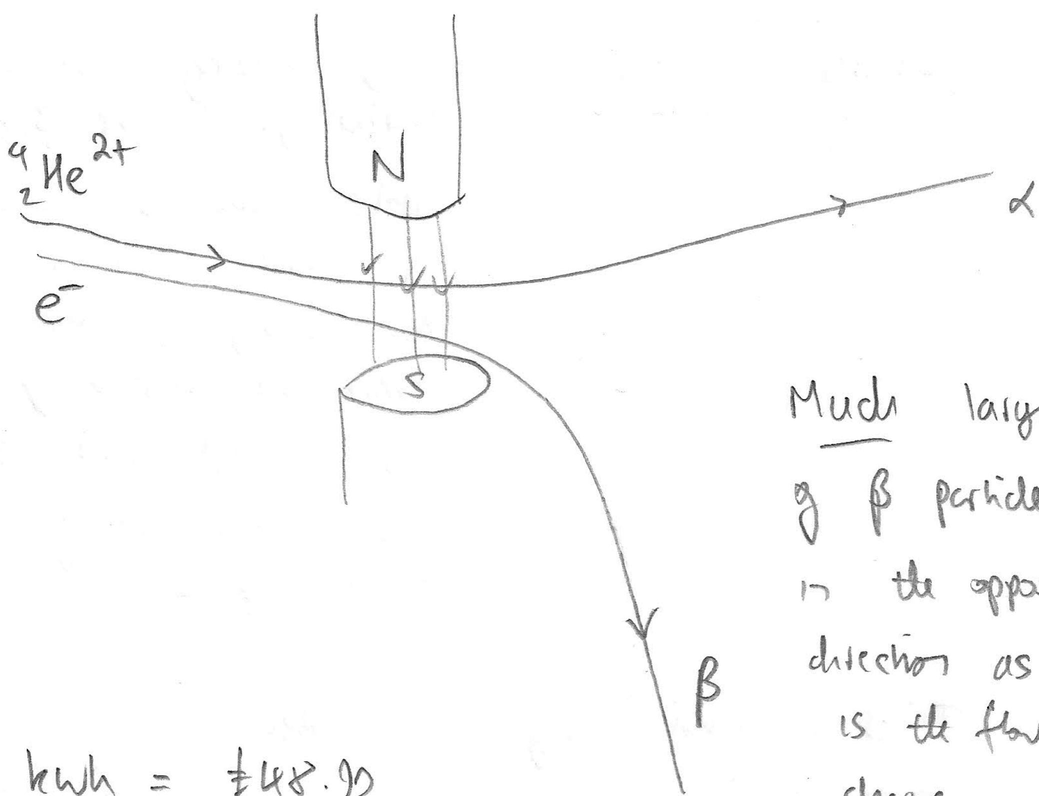
* Highly penetrating
* Not very ionizing.
* Very small λ (so can see v. small features) (α)

47/ $5\,MeV \simeq 100{,}000\; E_{ionization}$

∴ $E_{ionization} \simeq \boxed{50\,eV}$

(Hydrogen is 13.6eV so could be less than this).

48/



Much larger deflection of β particle, and in the opposite direction as current is the flow of +ve charge.

Note $M_\beta \simeq 9.1 \times 10^{-31}$ kg

$M_\alpha \simeq 4 \times 1.7 \times 10^{-27}$ kg

$\therefore \frac{M_\alpha}{M_\beta} \simeq \boxed{7500}$

so β has >> acceleration, (β does have $\frac{1}{2}$ the charge of α though).

49/ $\#\text{ kwh} = \frac{\$48.90}{\$0.1}$

$= \boxed{489 \text{ kwh}}$

$E = 489 \times 3.6 \times 10^6 \text{ J}$

$= \boxed{1.76 \times 10^9 \text{ J}}$

$P = E/t = \frac{1.76 \times 10^9}{28 \times 24 \times 3600}$

$= \boxed{728 \text{ W}}$

Misleading as my power usage will vary quite a lot during the day. (High in evenings, low during the night etc).

50/ UK power: $\frac{125 \times 3.6 \times 10^6 \text{ J} \times 70 \times 10^6}{24 \times 3600}$ W

$= \boxed{3.65 \times 10^{11} \text{ W}}$ (365 GW). $\Rightarrow \frac{3.65 \times 10^{11}}{2{,}500{,}000} = \boxed{1.46 \times 10^5}$ turbines (!)

SO ANOTHER SOURCE IS NEEDED TOO!