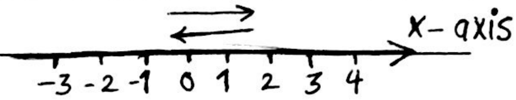
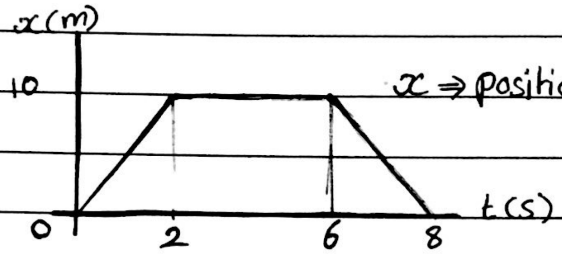
* Motion in one dimension :-

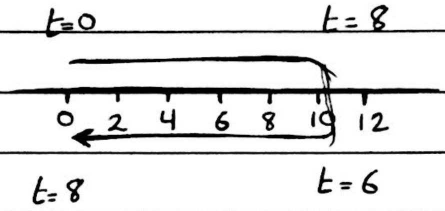
moving in a straight Line



⇒ a particle is moving in one dimension as follows :-



$x \Rightarrow$ position



$0 \rightarrow 2s$: motion along the +ve x-axis.

$2 \rightarrow 6s$: No motion (particle at rest).

$6 \rightarrow 8s$: motion along the -ve x-axis.

* Average velocity :-

- velocity : change ~~in~~ of position with time

$$\bar{v} = \frac{x_f - x_i}{t_f - t_i} = \frac{\Delta x}{\Delta t}$$

$\bar{v}$ is defined over a time interval.

$$\Rightarrow \text{Find } \bar{v}_{0-2} = \frac{x_{(2)} - x_{(0)}}{2-0} = \frac{10-0}{2} = \frac{10}{2} = 5\,m/s$$

$$\Rightarrow \text{Find } \bar{v}_{2-6} = \frac{x_{(6)} - x_{(2)}}{6-2} = \frac{10-10}{4} = \frac{0}{4} = 0\,m/s$$

$$\Rightarrow \text{Find } \bar{v}_{6-8} = \frac{x_{(8)} - x_{(6)}}{8-6} = \frac{0-10}{2} = \frac{-10}{2} = -5\,m/s$$

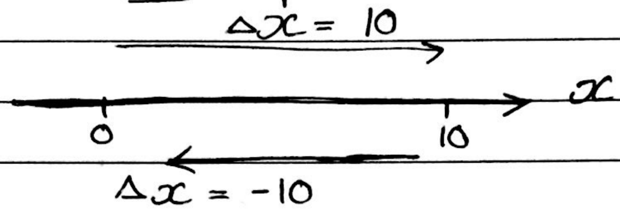
moving along -ve x-axis

$\bar{v}$ is a vector quantity.

i.e. it has magnitude and direction.

$\Delta x = x_f - x_i$ is a vector quantity.
↳ it's called displacement.

∗ Sign of $\bar{v}$ depends on the sign of Δx



$\bar{v}_{0-8} = \frac{0-0}{8-0} = 0\ m/s$ $\quad \Delta x = 0 \rightarrow$ Object returned to the starting point.

find $\bar{v}_{0-6} = \frac{x(6) - x(0)}{6-0} = \frac{10-0}{6} = \frac{10}{6} = \frac{5}{3}\ m/s$

∗ $\bar{v} = \frac{\Delta x}{\Delta t}$ is the slope (gradient) of the straight line connecting the initial and final points.

∗ Average speed : $\boxed{\bar{s}}$

Speed: scalar (has magnitude only).

i.e. mass / temperature / work / - - -

$\bar{s} = \frac{\text{total distance covered}}{\text{total time}}$ [defined over a time interval]

$\bar{s}_{0-2} = \frac{10}{2} = 5\ m/s$

$\bar{s}_{6-8} = \frac{10}{8-6} = \frac{10}{2} = 5\ m/s$

$\bar{s}_{0-8} = \frac{10+10}{8} = \frac{20}{8} = 2.5\ m/s$

[⇒ remember $\bar{v}_{0-8} = 0$]

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* If object doesn't change direction, then

$$\bar{S} = |\bar{v}|$$

i.e. speed equals magnitude of average velocity.

* Instantaneous Velocity :-

velocity at a particular time & position.

$$\bar{v} = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$$

E.g. a particle moves such that its position changes with time as follows :-

$x(t) = t^2 - 2t$, find $\bar{v}_{0-3}$

$$\bar{v}_{0-3} = \frac{x(3) - x(0)}{3-0} = \frac{((3)^2 - 2(3)) - (0)}{3} = \frac{9-6}{3} = \frac{3}{3} = \boxed{1 m/s}$$

* Average acceleration $\boxed{\text{vector}}$

$$a = \frac{\bar{v}_f - \bar{v}_i}{t_f - t_i} = \frac{\Delta \bar{v}}{\Delta t}$$

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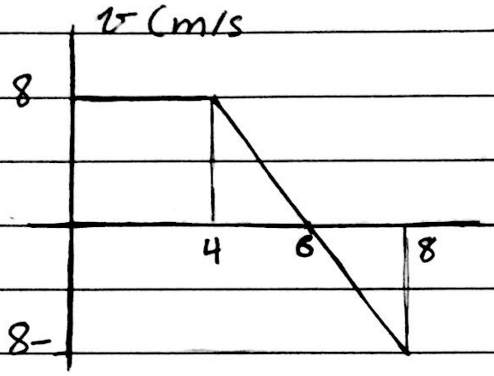
* Average acceleration :- ((vector))

$$\bar{a} = \frac{\bar{v}_f - \bar{v}_i}{t_f - t_i} = \frac{\Delta v}{\Delta t}$$



$$\bar{a}_{0-4} = \frac{8-8}{4-0} = 0\ m/s^2$$

$$\bar{a}_{4-6} = \frac{0-8}{2} = -4\ m/s^2$$

$$\bar{a}_{6-8} = \frac{-8-0}{2} = -4\ m/s^2$$

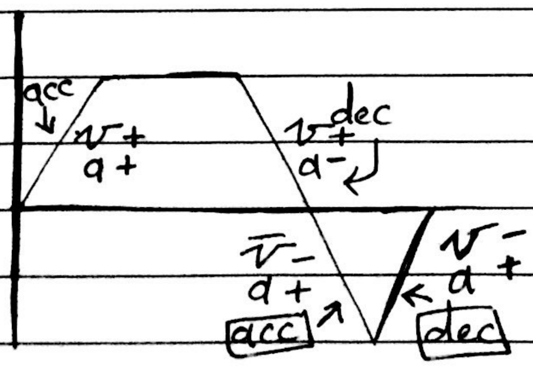
$\bar{a}$ slope of line connecting initial and final points in $v-t$ graph.

(according to the previous graph)

	v	a	
4 – 6	+	–	deceleration
6 – 8	–	–	acceleration

(In General)

v	a	
+	+	acceleration in +ve
–	–	acceleration in –ve
+	–	} → deceleration
–	+	



1/2/2016

* Constant acceleration :-
[constant in magnitude and direction].

⟹ Five equations of motion :-

① $v_f = v_i + at$

② $\underbrace{\Delta x}_{\boxed{x_f - x_i}} = v_i t + \frac{1}{2} a t^2$

③ $v_f^2 - v_i^2 = 2a\,\overbrace{(x_f - x_i)}^{\boxed{\Delta x}}$

④ $x_f - x_i = v_f t - \frac{1}{2} a t^2$

⑤ $x_f - x_i = \frac{1}{2}(v_i + v_f)\,t$

* Example :-
a car starts from rest at the origin, and has a constant acceleration of $4\ m/s^2$

(i) find its velocity after 3 seconds

$v_i = 0$, $x_i = 0$, $a = 4\ m/s^2$

$v_f = 0 + 4 * 3 = \boxed{12\ m/s}$

(ii) find its position at $t = 2$ seconds

$\cancel{x_f - 0 = \frac{1}{2}(4)}$ $x_f - 0 = 0 + \frac{1}{2}(4)(2)^2$

$\boxed{x_f = 8m}$

Example (2) :-

a car moving at 10 m/s. The driver suddenly applies the breaks and the car decelerates at $2 m/s^2$

(i) find the time needed for the car to stop.

$0 = 10 + (-2)t \Rightarrow \boxed{t = 5 \text{ seconds}}$

(ii) The displacement of the car when it stops.

$\Delta x = 10(5) + \frac{1}{2}(-2)(5)^2$

$50 + -25 = 25 m$

(iii) The $\bar{v}_{0-5} \Rightarrow \frac{25}{5} = \boxed{5 m/s}$

When $\boxed{a}$ is constant

$\bar{v} = \frac{1}{2}(v_i + v_f)$

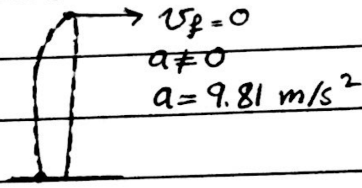
$\Rightarrow x_f - x_i = \bar{v} t$

* Free Fall *

⇒ moving under the effect of the gravitational force only. [ignore air resistance].

⇒ It has an acceleration of $g = 9.81\ m/s^2$ towards the centre of the earth.

⇒ In vacuum all objects have the same gravitational acceleration.



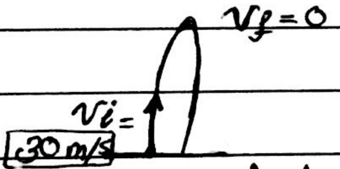
$+\uparrow$ $a = -g = -9.81\ m/s^2$

① $v_f = v_i - gt$
② $y_f - y_i = v_i t - \frac{1}{2} g t^2$
③ $v_f^2 - v_i^2 = -2g(y_f - y_i)$
④ $y_f - y_i = v t + \frac{1}{2} g t^2$
⑤ $y_f - y_i = \frac{1}{2}(v_f + v_i) t$

$+\downarrow$ $a = g$

① $v_f = v_i + gt$
② $y_f - y_i = v_i t + \frac{1}{2} g t^2$
③ $v_f^2 - v_i^2 = 2g(y_f - y_i)$
④ $y_f - y_i = v_f t - \frac{1}{2} g t^2$
⑤ $y_f - y_i = \frac{1}{2}(v_f + v_i) t$

* Example:-



(i) find its maximum hieght.

① $+\uparrow$ $a = -g$

$v_f^2 - v_i^2 = -2g(y_f - y_i)$

$0 - (30)^2 = -2(10)(y_f - 0)$

$-900 = -20 y_f$

$\boxed{45\ m = y_{max}}$

ii find the time it takes to go back.

$0 - 0 = 30t - \frac{1}{2} 10 (t)^2$

$0 = 30t - 5t^2$ / $t = 0$ or 6 // $\boxed{t = 6}$

iii find its velocity after 2 s.

②

$v_f = v_i + gt$

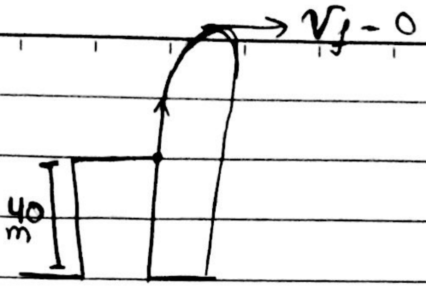
$0 = 30 - 20 = \boxed{10\ m/s}$

iv find it velocity after 4 s.

③ $v_f = 30 - 40 = \boxed{-10\ m/s}$

moving down ↵

* Example



a stone is projected vertically upwards from the top of a building that is 40 m height ($v_i = 20$ m/s)

(i) find its height (from the ground) after 3s

① $\uparrow +$ $a = -g = -9.81$

$$y_f - y_i = v_i t - \tfrac{1}{2} g t^2$$

$$y_f - 0 = 20(3) - \tfrac{1}{2}(10)(3)^2$$

$$60 - 45 = \boxed{15\,m}$$

height from ground level $= 40 + 15 = \boxed{55\,m}$

② $y_f - y_i = v_i t - \tfrac{1}{2} g t^2$

$$y_f - 40 = 20(3) - 5(3)^2$$

$$y_f - 40 = 60 - 45$$

$$\boxed{y_f = 55\,m}$$

(ii) find the ~~position~~ ~~of~~ time needed for the stone to hit the ground

$$0 - 40 = 20(t) - 5(t)^2$$

$$-40 = 20t - 5t^2$$

$$+8 = -4t + t^2$$

$$t^2 - 4t - 8 = 0 \qquad x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

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* Problems:-

[4] $x_1 = 8.4\ cm \longrightarrow x_2 = -4.2\,cm$

$t_1 = 3\ s \longrightarrow t_2 = 6.1\ s$

$\bar{v}_{3-6.1} = \frac{\Delta x}{\Delta t} = \frac{-4.2 - 8.4}{6.1 - 3} = -4.06\ cm/s$

$= -0.0406\ m/s$

[20] $a = 1.8\ m/s^2$

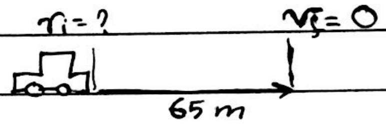
$\bar{v}_i = 65\ km/hour \longrightarrow \bar{v}_f = 120\ km/h$

$v_f = v_i + at$

$33.3\ v_f = 18.1 + 1.8 * t$

$t = 8.4$ seconds

[28] $a = -4.0\ m/s^2$



$v_f^2 - v_i^2 = 2a(x_f - x_i)$

$0 - v_i^2 = (2)(-4)(65)$

$\boxed{v_i = 22.8\ m/s}$ (moving in +ve x direction).

[39]

$t = 3.4\ s$

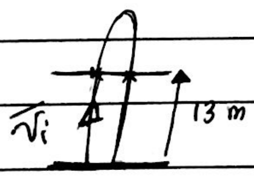
$\bar{v}_f = 0$

$y_f - y_i = v_i t - \frac{1}{2} g t^2$

$0 - 0 = v_i * 3.4 - 5 * (3.4)^2$

$\boxed{v_i = 17\ m/s}$

[43]



$v_f^2 - v_i^2 = -2g(y_f - y_i)$

$v_f^2 - (24)^2 = -20(13-0)$

(a) $v_f^2 = (24)^2 - 260$

$v_f = \pm 17.8\ m/s$

$v_f = 17.8\ m/s$

(b) $y_f - y_i = v_i t - \frac{1}{2} g t^2$

$13 - 0 = 24t - 5t^2$

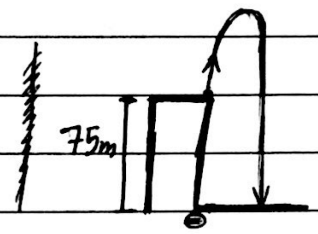
$5t^2 - 24t = 13$

$t = \dfrac{-(-24) \pm \sqrt{(-24)^2 - 4(5)(13)}}{2 * 5}$

$t = 0.62\ s$ or $t = 4.18\ s$

on the way up ↑ ↑ on the way down

[65]



$\bar{v}_i = 15.5$

+ ↑ $a = -g$

$y_f - y_i = v_i * t - \frac{1}{2} g t^2$

[a] $0 - 75 = 15.5t - 5 * t^2$

$t = 5.7$ seconds to reach the ground.

[b] $v_f = 15.5 - 10(5.7)$ $v_f = -41.66\ m/s$

↑ moving downwards

$S = |v_f| = |-41.66| = 41.66\ m/s$

[c] (Total distance traveled)

$y_{max} \Rightarrow$ $\overset{0}{v_f^2} - \cancel{15.5}\ v_i^2 = -2g(y_f - y_i)$

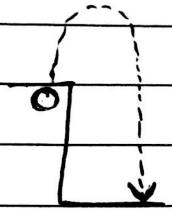
$0 - (15.5)^2 = -20\,(y_{max} - 75)$

$y_{max} = 87\ m$

total distance traveled $= (87) * 2 - 75$

$174 - 75 = \boxed{99\ m}$

(another way)



total distance = $2 * y_{max} + 75$

$= 99\ m$

<u>Extra</u> :

$$\bar{v} = \frac{\Delta y}{\Delta t} = \frac{y_f - y_i}{t_f - t_i} = \frac{0 - 75}{5.7}\ m/s$$

$$\bar{\delta} = \frac{\text{total distance}}{\text{total time}} = \frac{99}{5.7}\ m/s$$

* $\boxed{\bar{\delta} \geq |\bar{v}|}$ since distance $\geq$ |displacement|

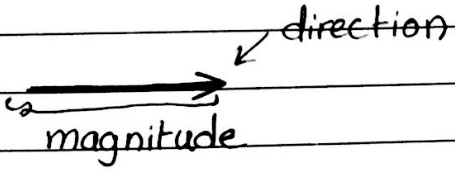
6/2/2017

Kinematics in two dimensions : Vectors

* Vectors :- (Magnitude and direction).
  velocity / acceleration / displacement / force / Weight.

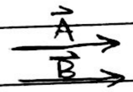
* Scalar :- Speed / mass / pressure / temperature / work.

⟹ How do we represent a vector?



* Properties of vectors

① equality of vectors.

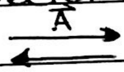


(i) $\vec{A} \parallel \vec{B}$

(ii) $|\vec{A}| = |\vec{B}|$

$\Rightarrow \vec{A} = \vec{B}$

② negative of a vector

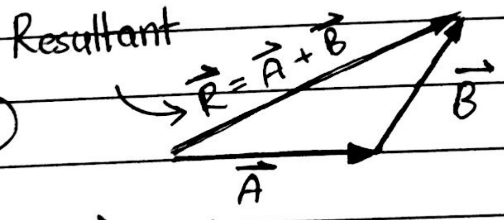


$\vec{A} = -\vec{B}$ — $\vec{A}$ and $\vec{B}$ are antiparallel.

(i) $|\vec{A}| = |\vec{B}|$

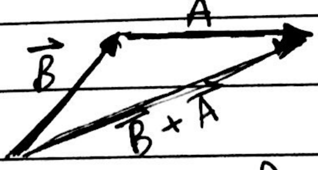
(ii) $\vec{A}$ in opposite direction to $\vec{B}$

* Addition of vectors

① 

$\vec{R} = \vec{A} + \vec{B}$

② $\vec{B} + \vec{A}$

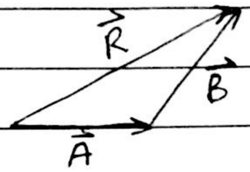


$\vec{A} + \vec{B} = \vec{B} + \vec{A}$

⟹ commutative law of addition.

8/2/2017

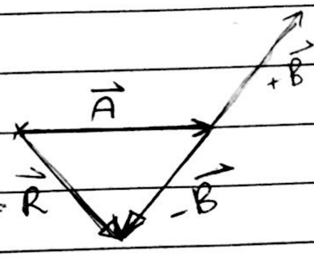
$\vec{R} = \vec{A} + \vec{B}$



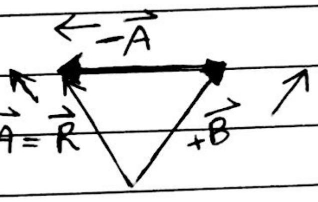
$\vec{A} + \vec{B} = \vec{B} + \vec{A}$

* Subtraction of vectors :-

$\vec{A} - \vec{B} = \vec{A} + (-\vec{B})$



$\Rightarrow$ Find $\vec{B} - \vec{A} = \vec{B} + (-\vec{A})$

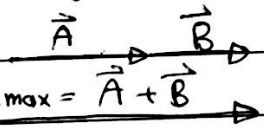


$\vec{A} - \vec{B} \neq \vec{B} - \vec{A}$ * Subtraction process is not commutative.

$\vec{A} - \vec{B} = -(\vec{B} - \vec{A})$

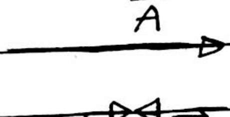
$\vec{R} = \vec{A} + \vec{B}$

$\vec{R}_{max} = \vec{A} + \vec{B}$ when they are parallel.



$|\vec{R}_{max}| = |\vec{A}| + |\vec{B}|$

$\vec{R}_{max} = A + B$ when $\vec{A} \parallel \vec{B}$



$R_{min} = |A - B|$ when $\vec{A}$ is antiparallel to $\vec{B}$

Example $|\vec{A}| = 10$ $|\vec{B}| = 3$

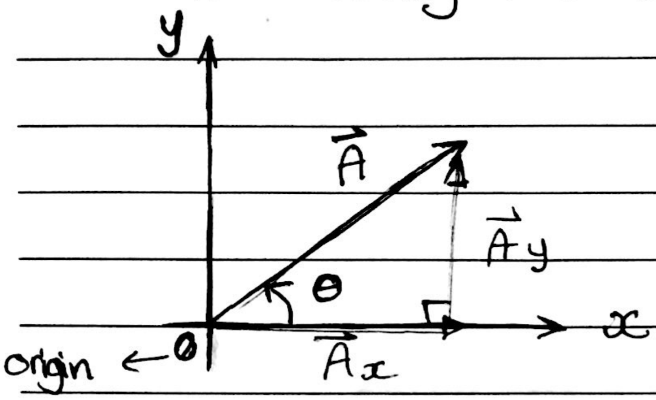
which of the following can never ~~be~~ represent the magnitude of the resultant $\vec{R} = \vec{A} + \vec{B}$

A. 6 B. 8 C. 10 D. 13

$7 \leq R \leq 13$

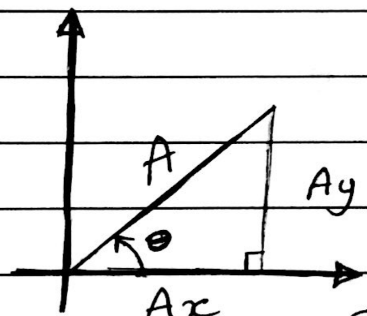
$R \neq 6$

* Resolving vectors into components.



$\vec{A} = \vec{A}y + \vec{A}x$

θ ⇒ measured w.r.t. positive x-axis, and in an anticlock direction.



$\sin\theta = \frac{Ay}{A}$

~~cos θ = 1/θ~~

~~cos~~

$\cos\theta = \frac{Ax}{A}$

① ∴ $Ay = A\sin\theta$

② ∴ $Ax = A\cos\theta$

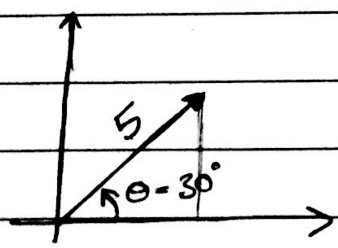
$Ay^2 = A^2\sin^2\theta$

$+ \quad Ax^2 = A^2\cos^2\theta$ =

$Ay^2 + Ax^2 = A^2 \quad \Rightarrow \quad A = \sqrt{Ay^2 + Ax^2}$

$\tan\theta = \frac{Ay}{Ax}$

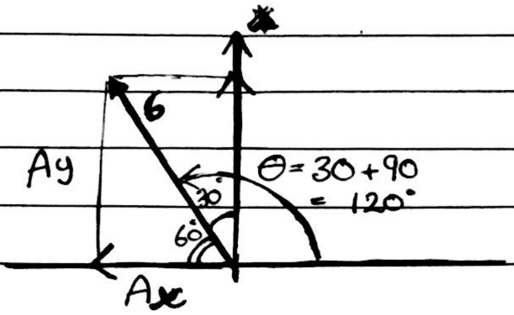
$\therefore \theta = \tan^{-1}\left(\frac{Ay}{Ax}\right)$



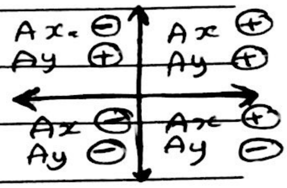
$Ay = 5\sin 30° = 2.5$

$Ax = 5\cos 30° = 2.5\sqrt{3}$

* Example



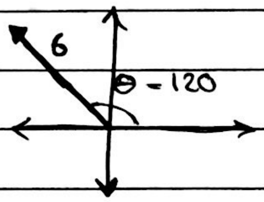
Remember :-



$Ay = 6 \sin 60° = 3\sqrt{3}$

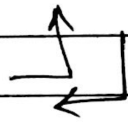
$Ax = -6 \cos 60° = -3$

* Example:



$Ay = ?$

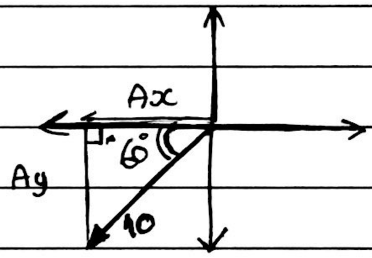
$Ax = ?$



$Ay = 3\sqrt{3}$

$Ax = -3$

* Example :-

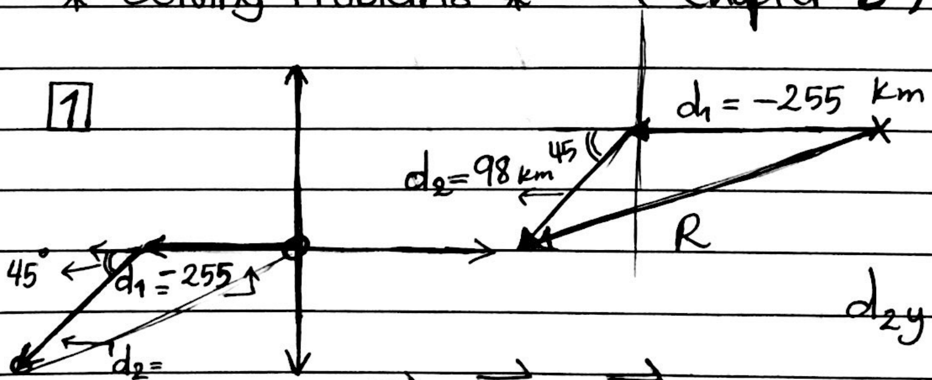


$Ay = -10 \sin 60° = -5\sqrt{3}$

$Ax = -10 \cos 60° = -5$

* Solving Problems * (Chapter 3)

$\boxed{1}$



$d_1 = -255$

$d_{2x} = 98 \cos 225° = \frac{-98}{\sqrt{2}}$

$d_{2y} = 98 \sin 225° = \frac{-98}{\sqrt{2}}$

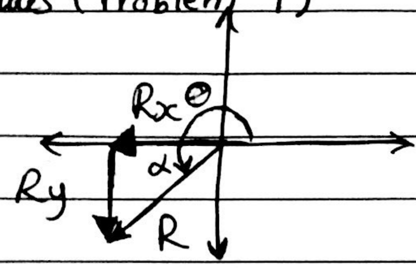
$\vec{R} = \vec{d_1} + \vec{d_2}$

- $Rx = d_{1x} + d_{2x}$

$= -225 - \frac{98}{\sqrt{2}} = -294.3$ km

- $Ry = d_1y + d_2y = 0 - \frac{98}{\sqrt{2}} = -69.3$ Km.

continues (Problem 1)



$R = \sqrt{R_x^2 + R_y^2} \simeq 302.3$ Km

$\tan\alpha = \left|\frac{R_y}{R_x}\right|$

$\alpha \simeq 13.25°$

$\theta = 13.25° + 180 = \boxed{193.25°}$.

(3) $V_x = 9.8$ units

$V_y = -6.4$ units

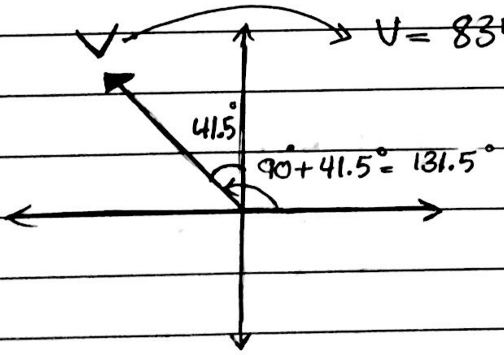
$V = \sqrt{V_x^2 + V_y^2} \sim 11.7$ units

$\tan\alpha = \left|\frac{V_y}{V_x}\right| = \frac{6.4}{9.8}$

$\alpha \simeq 33.1°$

$\theta = 360 - \alpha$.

$\boxed{8}$



$V_x = V\cos 131.5 = 553.3$ km/h

$V_y = V\sin 131.5 = 625.4$ km/h

$t = 1.75$ hours.

$R_x = V_x * 1.75$

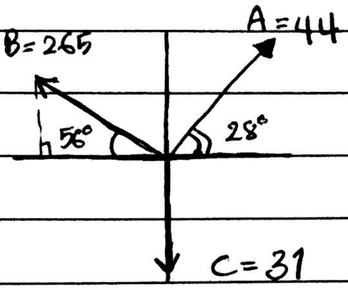
$= -968.3$ km

$R_y = V_y * 1.75$

$= 1094.5$ km

$R = \sqrt{R_x^2 + R_y^2}$

$\boxed{12}$



$\boxed{a}$ $\vec{R} = \vec{B} - 3\vec{A}$

$A_x = 44 \cos 28 = 38.8$ units

$\rightarrow$ $A_y = 44 \sin 28 = 20.7$ units

$-26.5 \cos 56$

$B_x = +26.5 \cos (180-56) = -14.8$ units

$\rightarrow$ $B_y = 26.5 \sin 56 = \cancel{-14.8 \text{ units}}$ 22.0 units

$C_x = 0$

$\rightarrow$ $C_y = -31$

$\rightarrow$ $R_x = B_x - 3A_x$ (تعويض)

$R_y = B_y - 3A_y$

$\boxed{B}$ $\vec{D} = 2\vec{A} - 3\vec{B} + 2\vec{C}$ (تعويض)

$D_x = 2A_x - 3B_x + 2C_x$

$D_y = 2A_y - 3B_y + 2C_y$

* Newton's Laws *

→ Force is a vector

* Newton's First Law (Law of inertia)

An object at rest and an object moving at constant velocity both remain so, unless acted upon by an external force. → [External force]

* 2nd Law

$$\underbrace{\sum \vec{F}}_{\text{resultant force}} = \overset{\text{mass}}{m}\,\vec{a} \leftarrow \text{acceleration}$$

$$\left(\vec{a} = \frac{1}{m}\sum \vec{F}\right)$$

∴ always: $\vec{a} \parallel \sum \vec{F}$

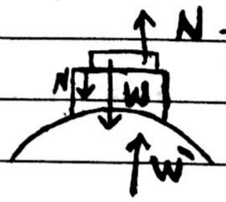
$$\sum \vec{F} = m\vec{a} \longrightarrow \sum F_x = m a_x$$
$$\longrightarrow \sum F_y = m a_y$$
$$\longrightarrow \sum F_z = m a_z$$

note $a \propto \frac{1}{m}$

* 3rd Law

Action and reaction forces are equal and opposite.

N → Normal force



W: Force of earth on book
can call it action

W`: Force of book on earth

$W = -W`$ (W and W` are action, reaction pair).

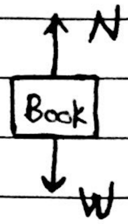
N: force of table on book (can call it action).

N`: force of book on table (reaction)

$N` = -N$ (N and N` are action reaction pair).

* Free body diagram :-

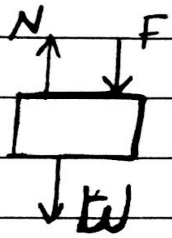
It shows all external forces acting on an object.



⇒ book is at rest (static equilibrium).

$$\sum F_y = m a_y^{0} = m \times 0 = 0 \quad // \therefore \sum F_y = 0$$

$+\uparrow$ $N - W = 0 \qquad N = W$

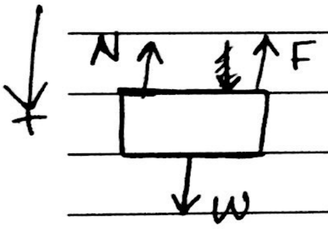


((at rest)) $F_y = m \times 0 = 0$

$\uparrow +$ $N - F - W = 0$

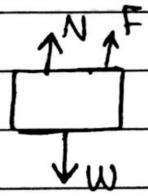
$N = F + W$

$N > W$



$F + W - N = 0$

$N = F + W$



$\overset{+}{\uparrow}$

$F + W - N = 0$

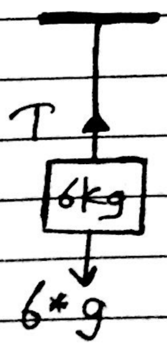
$N = W - F$

$N < W$

* action-reaction pair of forces never act on the same object

* Examples :-

Find the tension in the rope.



Static equilibrium object at rest and $\sum \vec{F} = 0$

$\sum \vec{F} = 0$ $\qquad \overset{+}{\uparrow}$ $T - 6 * g = 0$

$T = 6 * g$

$T = 60$ ~~netw~~ ~~netw~~ newton.

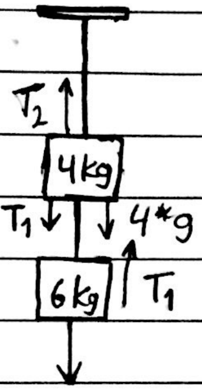
((Newton unit))

$$F = m * a$$

$$1\,kg * m/s^2 \Rightarrow 1\ \text{Newton} = 1\,kg * m/s^2$$

* Example :-

Find the tensions ~~of~~ in the ropes :-



* For 6 kg mass :-

$\overset{+}{\uparrow}\ T_1 - 6g = 0 \quad T_1 = 60$ Newtons

* For 4 kg mass :-

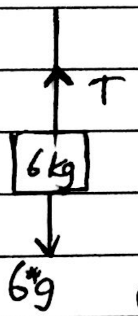
$\overset{+}{\uparrow}\ T_2 - T_1 - 4g = 0$

$T_2 = T_1 + 4*g = T_2 = 60 + 40 = 100$ Newtons

* Example :-

moving up at constant velocity.

$\therefore a_y = 0$

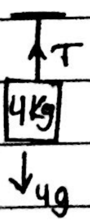


$\Sigma F_y = 0$ (But object is moving :- "dynamic equilibrium.
moving

When an object is moving take direction of motion as positive.

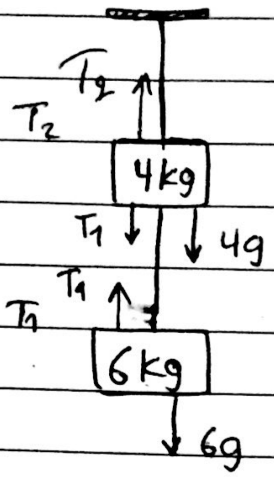
$\overset{+}{\uparrow}\ T - 6g = m * 0 \Rightarrow T = 6g = 60$ Newtons

Example :



$\overset{+}{\uparrow}\ T - 4g = (4)(2) \Rightarrow T - 4g = 8 \Rightarrow T = 40 + 8 = \boxed{48\ \text{new}}$

*Homework:- depending on the following figure:- if $a = 2 m/s^2$, find T_1 and T_2



$$T_1 - 6g = m * a$$

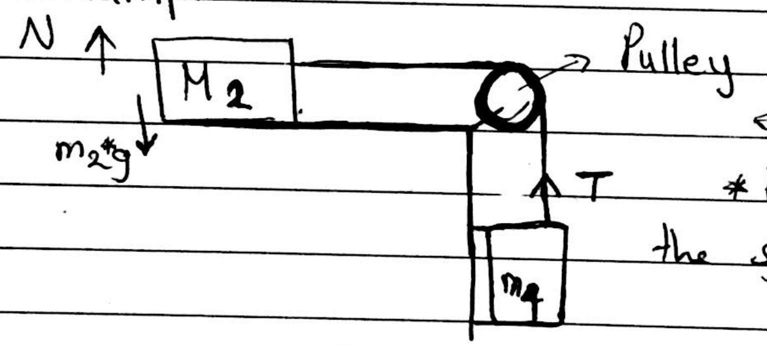
$$T_1 - 60 = 6 * 2 \Rightarrow T_1 = 12 + 60 \Rightarrow \boxed{T_1 = 72 \text{ newton}}$$

$$T_2 - 4g - T_1 = 4 * 2 \Rightarrow$$

$$T_2 - 40 - 72 = 8$$

$$T_2 - 112 = 8 \qquad \boxed{T_2 = 120 \text{ Newton}}$$

* Example:-



(smooth surfaces).

* Find the acceleration of the system

⇒ We assume the following:-

① massless ropes ② ignore mass of the pulley.

* for m_1

$+\downarrow$ $\quad m_1 * g - T = m_1 * a \Rightarrow ①$

$\rightarrow +$ $\quad T = m_2 * a \Rightarrow ②$

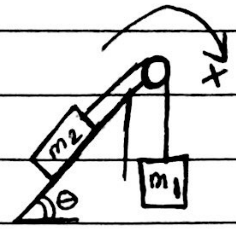
$+\uparrow$ $\quad N - m_2 * g = 0 \quad \therefore N = M_2 * g$

$① + ② \Rightarrow m_1 g = (m_1 + m_2) * a$

from 2 $\Rightarrow T = \dfrac{m_2 * m_1}{m_1 + m_2} * g$

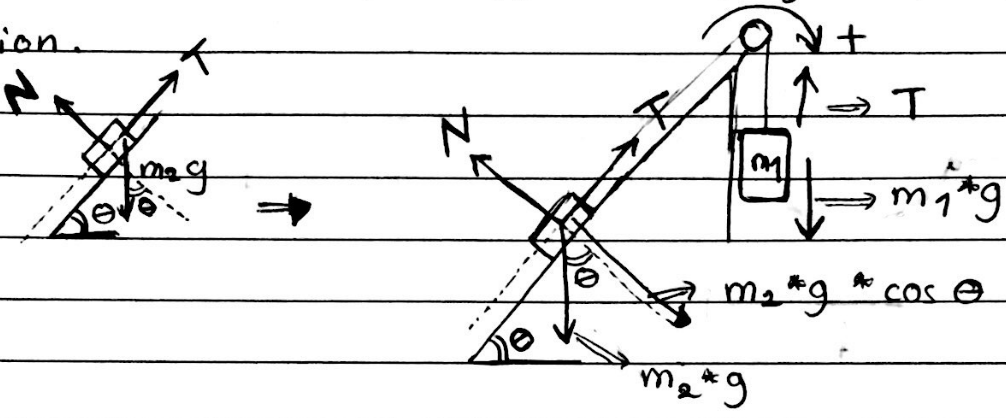
Scanned by CamScanner

* Example :- Inclined plane



Find $\boxed{a}$ and $\boxed{T}$

⇒ when there's no friction, guess the direction of motion.



For mass M_1 :-

$$m_1*g - T = m_1*a \quad ①$$

From$_2$:- $T - m_2*g*\sin\theta = m_2*a$ ②

$$N - m_2*g*\cos\theta = 0 \quad ③$$

① + ② ⇒ $m_1*g - m_2*g*\sin\theta = (m_1+m_2)*a$

$$a = \frac{m_1*g - m_2*g*\sin\theta}{m_1+m_2}$$

For m_1 to move down (and m_2 move up the plane).

$m_1*g > m_2*g*\sin\theta$

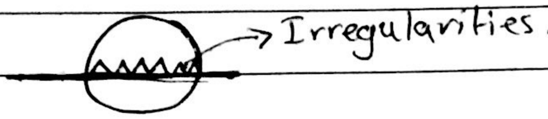
If $a>0$ ⇒ guess direction is correct.

If $a<0$ ⇒ correct direction is opposite to the direction we suggested and $|a|$ is correct.

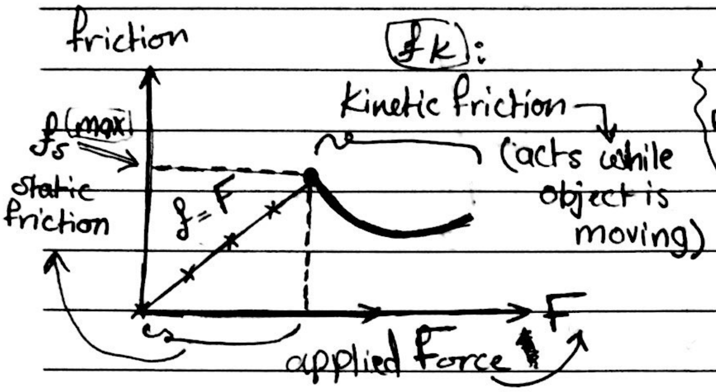
$m_1 = 4$ kg / $m_2 = 2$ kg / $\theta = 30°$

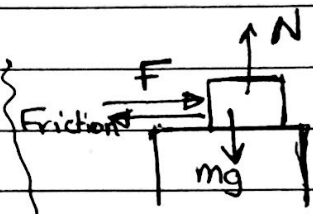
$$a = \frac{4*10 - 2*10*1/2}{6} = \frac{40-10}{6} = \boxed{5\ m/s^2}$$

** Friction **



* Interference between Irregularities causes friction.





$f_{s,max}$ = maximum static friction.

$$f_{s,max} = \mu_s * N$$

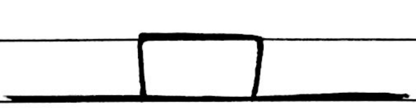
coeffecient of static friction.

$$f_k = \mu_k * N$$

coeffecient of kinetic friction

$\mu_s > \mu_k$
and both are dimensionless

Ex



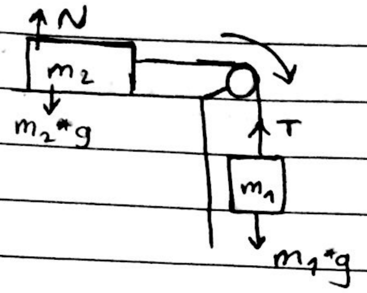
$f_s = 0$ (since no force is trying to move the object)

object at rest

f_s = 5 newton

20/2/2017

Ex



Find a and T.

$\downarrow +$ For m_1

$m_1 g - T = m_1 * a$ equation ①

$\rightarrow +$ For m_2

$T - f_R = m_2 * a$

$T - \mu_R * N = m_2 * a$ equation ②

$\uparrow +$

$N - m_2 * g = 0$

$N = m_2 * g$

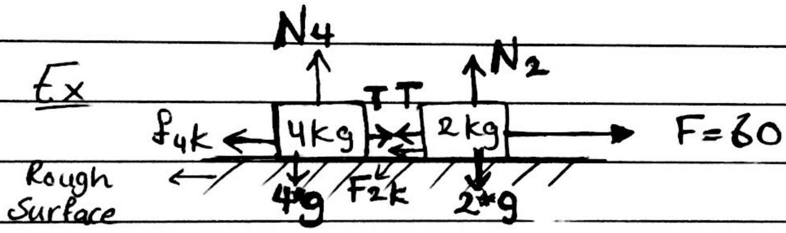
1 + 2 ⇒

$m_1 * g - \mu_R (m_2 g) = (m_1 + m_2) * a$

$a = \dfrac{m_1 * g - \mu_R * m_2 * g}{m_1 + m_2}$

(To Find T, use ① & ②)

Ex



* Find the $\boxed{a}$ and $\boxed{T}$

$\rightarrow +$ For 2kg mass

$F - T - f_{2k} = 2*a$ equation --- ①

$\rightarrow +$ For 4kg mass

$T - f_{4k} = 4*a$ --- ②

① + ② =

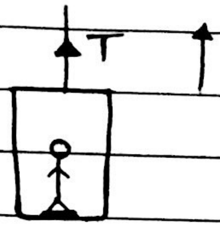
$F - f_{2k} - f_{4k} = 6*a$

$\therefore a = \dfrac{60 - \mu_k (\overbrace{2*g}^{N_2}) - \mu_k (\overbrace{4*g}^{N_4})}{6} \Rightarrow a = \dfrac{60 - 4 - 8}{6} = \dfrac{48}{6}$

$\boxed{8 \, m/s^2}$

⇒ Use ① or ② find T

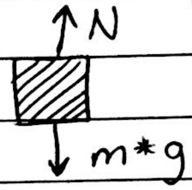
* Apparant Weight *



$a = 3 m/s^2$

$m = 50$ kg

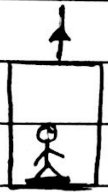
⇒ Lift is moving upwards and accelerating at $3 m/s^2$, Find the normal force on the person.



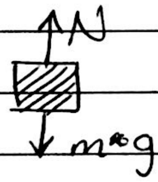
$+\uparrow$ $N - m*g = m*a$

$N = m(g+a)$

$= 50(10+3) = 750$ Newton



(moving up and decelerating at $3 m/s^2$.



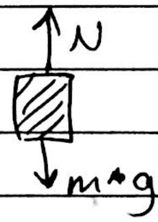
$+\uparrow$

$N - m*g = m*a$

$N = m(g+a)$

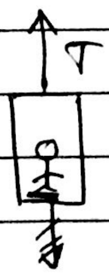
$N = 50(10-3) = \boxed{350 \text{ Newton}}$

moving up at constant velocity. $\boxed{a=0}$



$N - m*g = \cancel{m*a}^{\,0}$

$N = m*g = 500$ Newton



moving down and accelerating at $3 m/s^2$

$-(N) + m*g = m*a$

$-(N) + 50*10 = 50*3$

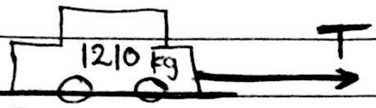
$\cancel{500} - N = 150$

$\cancel{-500} \qquad -500$

$N = 350$ neuton ← apparant weight.

(Solving Problems)

3

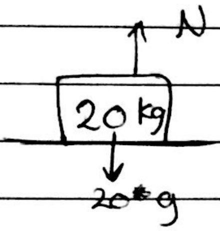


$a = 1.2\ m/s^2$

$T = m * a \Rightarrow T = 1210 * 1.2 = 1452$ newtons.

$T \geq 1452$ newton.

11



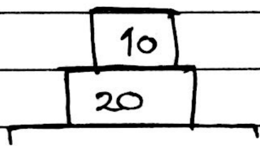
a

$W = 20 * g \approx 200$ newton

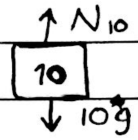
$+\uparrow\ N - 20g = 0$

$N = 20g \Rightarrow \boxed{N = 200 \text{ Newton}}$

b



1



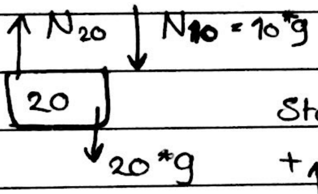
Static equilibrium $\Rightarrow$

$\Sigma \vec{F} = 0$

$+\uparrow\ N_{10} - 10 * g = 0$

$N_{10} = 10 * g = \boxed{100 \text{ newton}}$

2

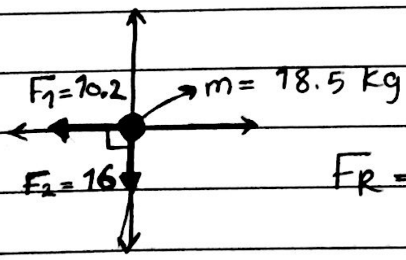


Static equilibrium

$+\uparrow\ N_{20} - 20 * g - 10 * g = 0$

$\boxed{N_{20} = 300 \text{ newton}}$

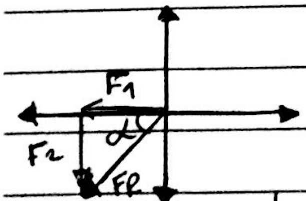
28



$F_R = \sqrt{(F_1)^2 + (F_2)^2} \approx 19$ Newtons.

a

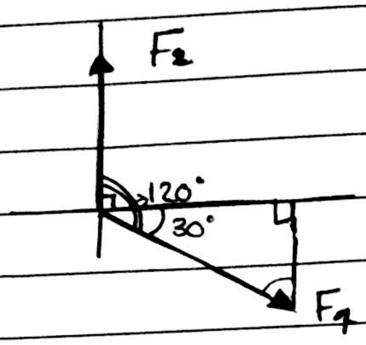
$F = m * a \Rightarrow a = \frac{19}{18.5} \sim 1\ m/s^2$



$\vec{a} \parallel \vec{F_R}$

$\tan\alpha = \left|\frac{F_2}{F_1}\right| \rightarrow \alpha \sim 57.5°$

(b)



$F_2 x = 0$

$F_2 y = 16$

$\Rightarrow$ $F_1 x = F_1 \cos 30 = 5.1\sqrt{3}$ Newtons.

or $F_1 x = F_1 \cos 330 = 5.1\sqrt{3}$ Newtons.

$\Rightarrow$ ~~$F_1 x$~~ $F_1 y = -F_1 \sin 30 = -5.1$ Newtons.

or $F_1 y = F_1 \sin 330 = -5.1$ Newtons.

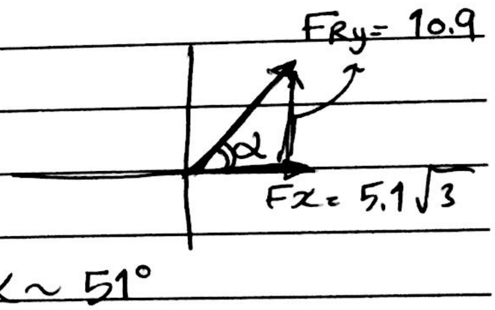
$F_{Rx} = F_1 x + F_2 x$

$= +5.1\sqrt{3} + 0 = +5.1\sqrt{3}$ Newton.

$F_{Ry} = F_2 y + F_1 y$

$16 + -5.1 = F_{Ry} = 10.9$

$F_R = \sqrt{F_1 x^2 + F_1 y^2} \sim 14$ Newton



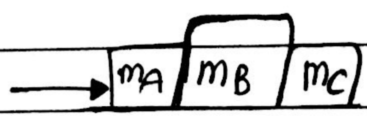
$a = \dfrac{14}{18.5} \sim 0.76\ m/s^2$

$\tan\alpha = \left|\dfrac{F_{Ry}}{F_{Rx}}\right|$

$\alpha \sim 51°$

(33)

(3 Free body diagrams).



(Solving Problems)

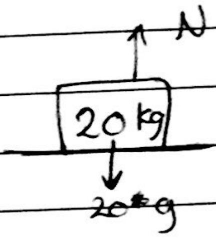
[3]

$a = 1.2\ m/s^2$

$T = m * a \Rightarrow T = 1210 * 1.2 = 1452$ newtons.

$T \geq 1452$ newton.

[11]



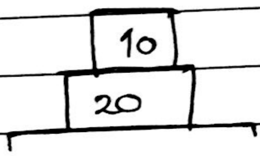
(a)

$W = 20 * g = 200$ newton

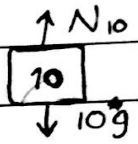
$+\uparrow\ N - 20g = 0$

$N = 20g \Rightarrow \boxed{N = 200 \text{ Newton}}$

[b]



(1)



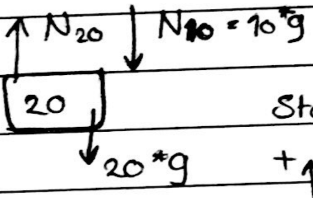
Static equilibrium $\Rightarrow$

$\Sigma \vec{F} = 0$

$+\uparrow\ N_{10} - 10 * g = 0$

$N_{10} = 10 * g = \boxed{100 \text{ newton}}$

(2)

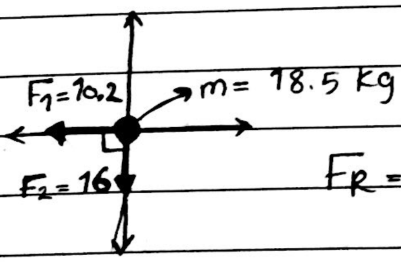


Static equilibrium

$+\uparrow\ N_{20} - 20*g - 10*g = 0$

$\boxed{N_{20} = 300 \text{ newton}}$

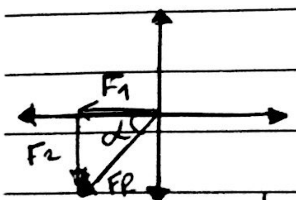
[28]



$F_R = \sqrt{(F_1)^2 + (F_2)^2} \approx 19$ Newtons.

(a)

$F = m * a \Rightarrow a = \frac{19}{18.5} \sim 1\ m/s^2$

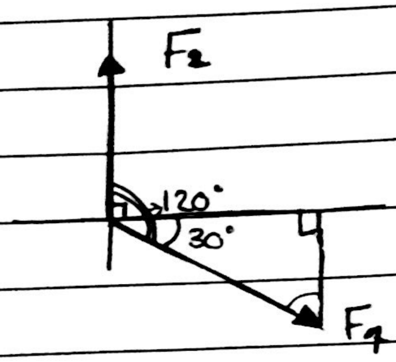


$\vec{a} \parallel \vec{F_R}$

$\alpha \sim 57.5°$

$\tan\alpha = \left|\frac{F_2}{F_1}\right|$

(b)



$F_2 x = 0$

$F_2 y = 16$

$\Rightarrow \quad F_1 x = F_1 \cos 30 = 5.1\sqrt{3}$ Newtons.

or $\quad F_1 x = F_1 \cos 330 = 5.1\sqrt{3}$ Newtons.

$\Rightarrow \quad F_1 y = -F_1 \sin 30 = -5.1$ Newtons.

or $\quad F_1 y = F_1 \sin 330 = -5.1$ Newtons.

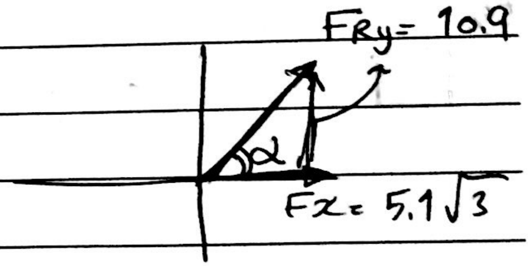
$F_{Rx} = F_1 x + F_2 x$

$= +5.1\sqrt{3} + 0 = +5.1\sqrt{3}$ Newton.

$F_{Ry} = F_2 y + F_1 y$

$16 + -5.1 = \quad F_{Ry} = 10.9$

$F_R = \sqrt{F_1 x^2 + F_1 y^2} \sim 14$ Newton



$a = \dfrac{14}{18.5} \sim 0.76 \ m/s^2$

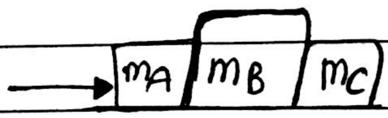
&

$\tan\alpha = \left|\dfrac{F_{Ry}}{F_{Rx}}\right|$

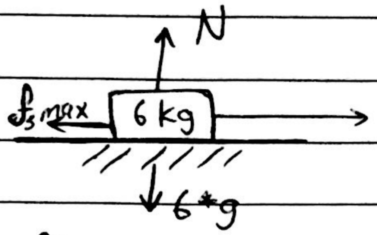
$\alpha \sim 51°$

(33)

(3 free body diagrams).



(36)



35 netwton required to start moving

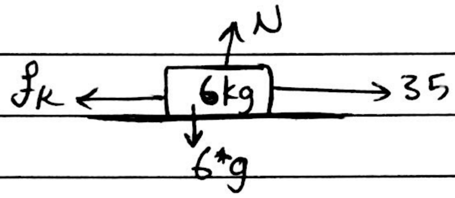
(a) μ_s ?

Just to start moving $F = 35 = f_{s\,max}$

$$35 = \mu_s * N = \mu_s * (6*g)$$

$$\frac{35}{60} = \mu_s = 0.6$$

(b)

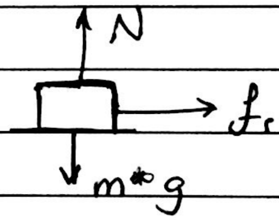


$$35 - f_K = 6*(0.6)$$

$$35 - \mu_K * 6g = 3.6$$

$$\mu_K = 0.52$$

$\boxed{37}$ $a = 0.2g = 2\,m/s^2$



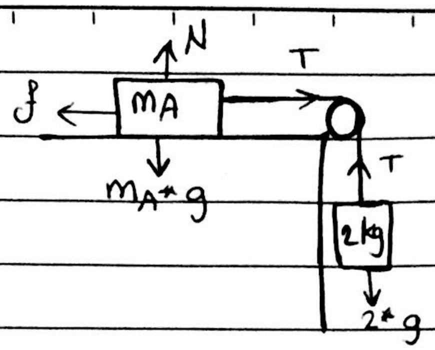
$$6 * \overset{a}{2} \leq f_{s,\,max}$$

$$12 \leq \mu_s (6*g)$$

$$\frac{12}{60} \leq \mu_s$$

$$\boxed{0.2 \leq \mu} \leftarrow$$

45



$\mu_s = 0.4 \quad \mu_k = 0.2$

(a)

at rest $\Rightarrow \quad 2g - T = 0 \qquad \boxed{2g = T}$

$\xrightarrow{} + \quad T - \text{friction} = 0$

$T - f_{s_1 max} \leq 0 \qquad T \leq f_{s max}$

$2g \leq f_{s_1 max}$

$2\cancel{g} \leq \mu_s * (m_A * \cancel{g})$

$2 \leq \mu_s * m_A \quad \Rightarrow \quad m_A \geq \frac{2}{\mu_s}$

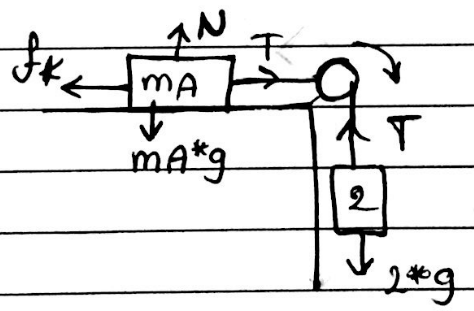
$m_A \geq \frac{2}{0.4} \quad \Rightarrow \quad \boxed{m_A \geq 5 \text{ kg}}$

$\rightarrow m_A > 5$ kg remains at rest

$\rightarrow m_A = 5$ kg on verge of motion

$\rightarrow m_A < 5$ kg it moves.

(b)



$\boxed{m_A = \frac{2}{\mu_k} = 10 \text{ kg}}$

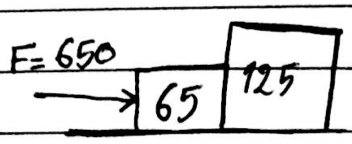
$\downarrow + \quad 2g - T = 0$

$2g = T$

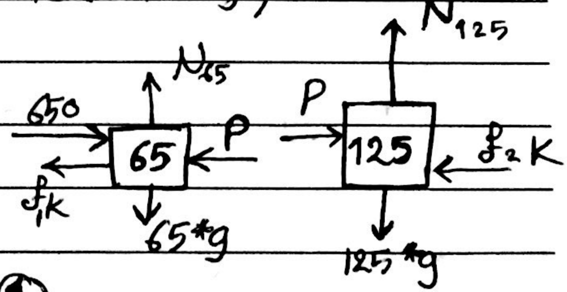
$\rightarrow + \quad T - f_K = 0$

$2g - f_K = 0 \qquad 2\cancel{g} = \mu_k (m_A * \cancel{g})$

47



$\mu_K = 0.18$



for 65 kg

$\rightarrow + \quad 650 - P - f_{1K} = 65 * a \quad \rightarrow (1)$

for 125 kg

$\rightarrow + \quad P - f_2 k = 125 * a$

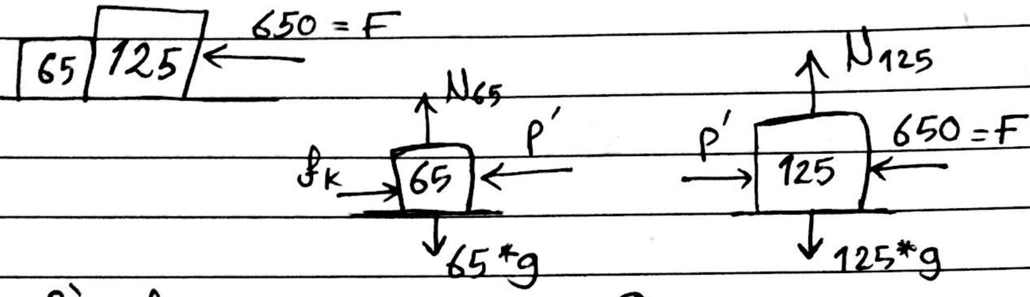
$650 - f_{1k} - f_{2k} = 190 * a$

$650 - \mu_k(65*g) - \mu_k(125*g) = 190*a$

$a \sim 1.66 \ m/s^2$

from ① $P = 428$ newtons.

ⓑ



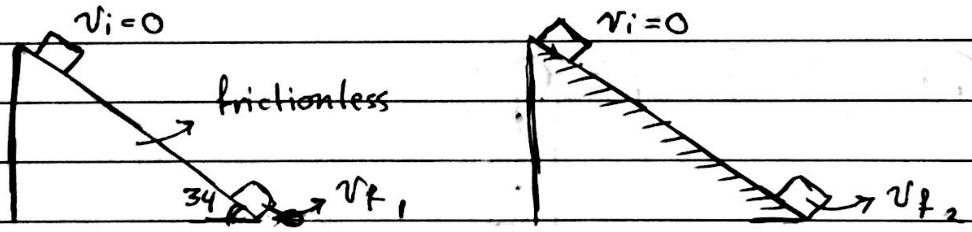
$\overset{+}{\leftarrow} \quad P' - f_{1k} = 65 * a \qquad ①$

$\overset{+}{\leftarrow} \quad 650 - P' - f_{2}k = 125 * a \qquad ②$

$650 - f_1k - f_2k = 190\, a$

$a = 1.66\ m/s^2 \qquad P' = 222.6$ newton.

$\boxed{54}$



$\searrow + \quad \cancel{m}*g * \sin 34 = \cancel{m}*a$

$a = g \sin 34 \qquad v_{f_1}^2 - v_i^2 = 2(g * \sin 34) * \Delta x$

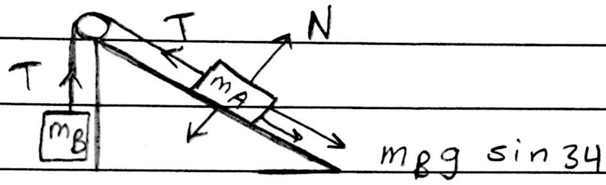
$v_{f_1} = \sqrt{2*g*\sin 34 * \Delta x}$

$\searrow + \quad a = g \sin 34 - \mu_k g \cos 34$

$\sqrt{(v_{f_2})^2 - 0} = \sqrt{2(g \sin 34 - \mu_k g \cos 34)\Delta x}$

$\frac{v_{f_1}}{v_{f_2}} = \frac{1}{2} = \sqrt{\quad} \qquad \therefore \mu_k = 0.51$

$\boxed{61}$



$\downarrow +$ for M_B $\quad m_B * g - T = m_B * a \quad (1)$

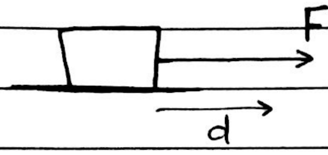
$+ \nwarrow$ for m_A

$$T - m_B * g * \sin 34 - \mu_k (\overset{N}{m_B * g \cos 34}) = m_B * a \quad (2)$$

$\boxed{a}$ $\quad (1) + (2) \Rightarrow a = 1.6 \ m/s^2$

$\boxed{b}$ $\quad \mu_k = \dfrac{1 - \sin 34}{\cos 34} \sim 0.53$

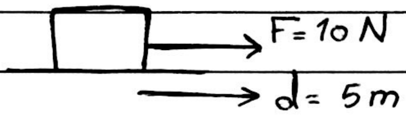
Work and Energy :- work done by a constant force.



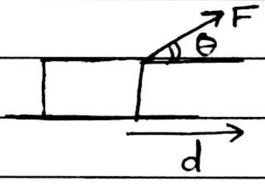
$W = F * d$ work done which is a scalar quantity.

unit ⇒ Joule

$1\,J = 1\,N.m = 1\,kg.m^2/s^2$

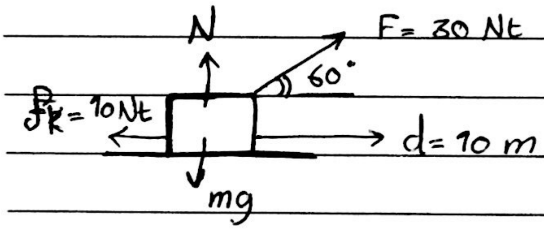


$W = 10 * 5 = 50\,J$



$\vec{F}$ and $\vec{d}$ must originate from the same point to define θ.

$$W = Fd\cos\theta$$



Find the work done by each force:-

$W_{mg} = mg * d * \cos 90° = \boxed{0}$

$W_N = N * d * \cos 90° = \boxed{0}$

$W_F = 30 * 10 * \cos 60° = 150\,J$

$W_{fk} = (10) * (10) * \cos 180° = -100\,J$

$W_{total} = 150 - 100 = 50$ Joule

$\xrightarrow{} +$ F_R resultant force in the x direction.

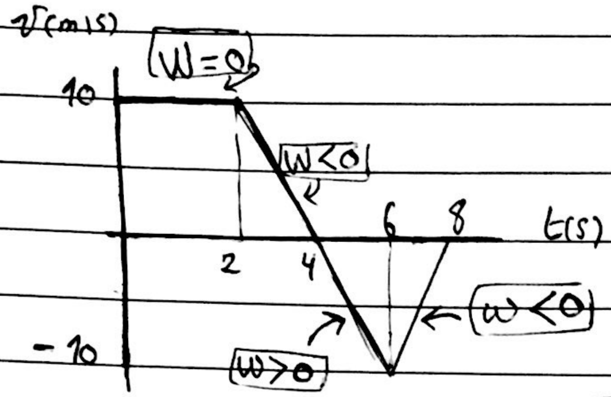
$F_R = F\cos 30° - f_k = 30 * 1/2 - 10 = 5$ Newton

$W_{total} = F_{(R)} * d * \cos 0° = 5 * 10 * 1 = \boxed{50\,J}$

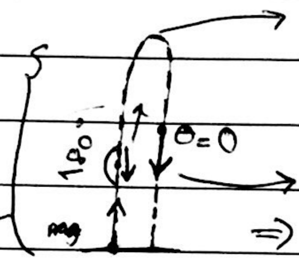
$W = 0 \Rightarrow$ either at rest or moving at constant speed.

$W > 0 \Rightarrow$ Object accelerating

$W < 0 \Rightarrow$ object decelerating



* Example :



Free fall

$\rightarrow W > 0$

$\Rightarrow$ object accelerates.

$W < 0$

$\Rightarrow$ Stone decelerates

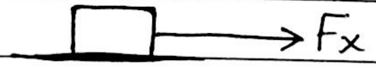
$$W = F * d * \cos\theta$$

Cases in which $W = 0$:-

① $\theta = 90°$ ② $F = 0$ ③ $d = 0$ (no motion).

Work done by a variable force

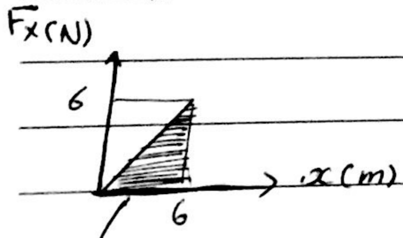
$F_x = x$



$$W = \int_0^6 F_x \, dx$$

$$= \int_0^6 x \, dx = \left[\frac{x^2}{2}\right]_0^6$$

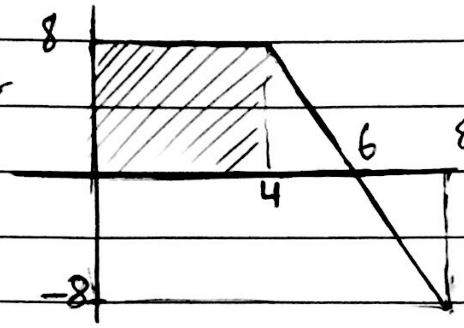
$$= 18 \text{ J}$$



$W = \frac{1}{2}(6m)(6N) = 18 \text{ m.N} = \boxed{18 \text{ J}}$

$\Rightarrow$ the area under the graph (curve) in f-d graph represents the work done.

~~The or~~



Find $W_{0-4} = 8 * 4 = 32\,J$

Find $W_{4-6} = \frac{1}{2} * 2 * 8 = \boxed{8\,J}$

Find $W_{6-8} = \frac{1}{2} * 2 * -8 = \boxed{-8\,J}$

$W_{total} = 32 + 8 - 8 = \boxed{32\,J}$

* Kinetic Energy :

$K = \frac{1}{2} m * v^2 \qquad K \geq 0$

* measured in Joules *

$v_f^2 - v_i^2 = 2a\,\Delta x$

$(v_f^2 - v_i^2 = 2a\,\Delta x)\ \frac{1}{2} * m$

$\frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 = \cancel{*}\, a * \Delta x * m$

$K_f - K_i = F * \Delta x$

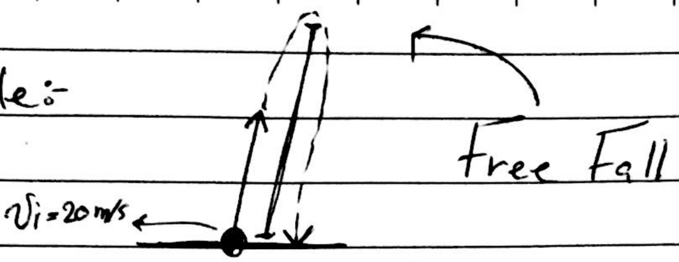
$K_f - K_i = W \implies \boxed{W = \Delta K}$

$W > 0 \therefore v_f^2 > v_i^2\ (K_f - K_i)$.

$W < 0 \Rightarrow K_f < K_i \Rightarrow v_f^2 < v_i^2$

$W = 0 \Rightarrow K_f = K_i \rightarrow v_f^2 = v_i^2$ no acceleration.

Example:-



Find the maximum height.

$$W_{Total} = \Delta K$$

only (mg) does work $\rightarrow$ $W_{Total} = W_{mg}$

$$W_{mg} = (mg)(y_{max})\cos 180^\circ = \frac{1}{2} m (0)^2 - \frac{1}{2} m (20)^2$$

$$-g\, y_{max} = 0 - \frac{400}{2}$$

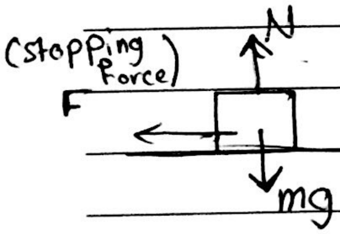
$$-10\, y_{max} = -200$$

$$\boxed{y_{max} = 20 \ m}$$

Example:-

A car moving on a level road at 30 m/s. The driver suddenly applies the brake. Assuming a constant retarding force. Find the distance it moves before stopping.

(assume $m = 2000\,kg$ / $F = 10000\,N$)



$$W_{total} = W_{mg} + W_N + W_F$$

$$W_{total} = W_F$$

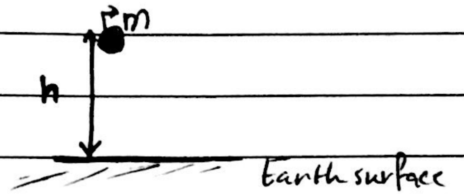
$$W_F = \Delta K = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$$

$$Fd \cos 180^\circ = 0 - \frac{1}{2} m v_i^2$$

$$d = m v_i^2 / 2F = \frac{2000 * (30)^2}{2 * 10000} = \boxed{90 \ m}$$

* Potential Energy :-

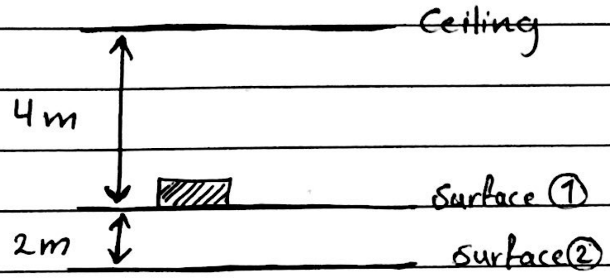
Gravitational potential energy



We define gravitational potential energy for mass (m) as :-

$$U = m*g*h$$

measured in Joules.



$U_{ceiling} = mg(-4)$ (P.E w.r.t ceiling).

$U_1 = mg(0) = 0$ (P.E. w.r.t. surface 1).

P.E w.r.t surface 2 $\Rightarrow U_2 = mg * \overset{\boxed{h}}{(2)}$

$\Rightarrow$ Same mass (object) can have different potential energy depending on the reference surface.

2 1/3/2017

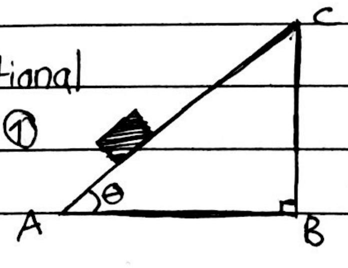
Conservative Forces :

Work done by a conservative force

① Does not depend on the path.

② Work done round a closed path equals zero.

$\Rightarrow$ Find the work done by the gravitational force in moving the object along path ① and then path ②



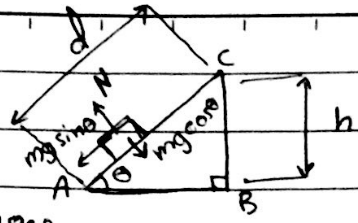
path ① A → C directly

path② A → B → C

follows →

Five Apple

Path ① $A \to C$



$W_{mg} = (mg\sin\theta)(d)\cos 180°$

$W_{mg} = -mgd\sin\theta = -mgh$

Path ② $A \to B \to C$

$W_{mg}(A \to B \to C) = W_{mg}(A \to B) + W_{mg}(B \to C)$

$= 0 + (mg)h\cos 180°$

$= -mgh$

W_{mg} ~~only~~ depends on the vertical displacement not the horizontal one.

$\ast$ $W_{A \to B \to C \to A} = W_{A \to B \to C} + W_{C \to A} = -mgh + mgh = \boxed{0}$

$W_c \longrightarrow$ work done by a conservative force.

$W_c = -\Delta U = -(U_f - U_i)$

Work + kinetic energy theorem

$W_{total} = \Delta k \Rightarrow W_{nc} + W_c = \Delta k$

↳ work done by a non conservative force.

$\boxed{\Delta k + \Delta U = W_{nc}}$

If we dont have non-conservative forces :-

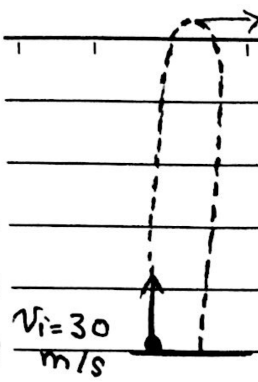
$W_{nc} = 0 \Rightarrow \Delta k + \Delta U = 0$

conservation of total mechanical energy

$(k_f - k_i) + (U_f - U_i) = 0 \Rightarrow k_f + U_f = k_i + U_i$

final total mechanical energy → $E_f = E_i$ ← initial total mechanical energy

$k_f + U_f = E_f$



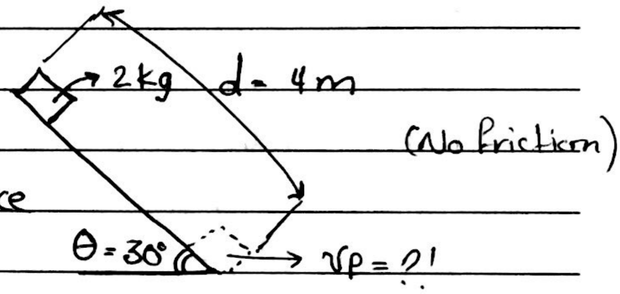
Free fall $\Rightarrow \therefore W_{nc} = 0$

Remember
$\Delta U = +$
same level $\Delta U = \boxed{0}$
$\Delta U = -$

$\Rightarrow$ find the maximum height.

$$\Delta K + \Delta U = 0$$
$$\left(\tfrac{1}{2} m v_f^2 - \tfrac{1}{2} m v_i^2\right) + mg\, y_{max} = 0$$
$$0 - \tfrac{1}{2}(30^2) = -g\, y_{max}$$
$$y_{max} = \frac{900}{2 * 10} = \boxed{45\,m}$$

* Example :-

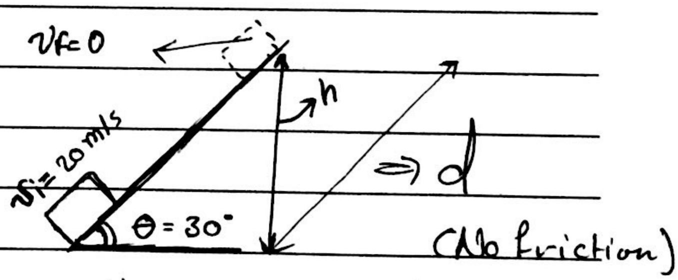


An object slides from rest, a distance of 4m down the inclined plane find its speed at the bottom of the incline.

$$\Delta K + \Delta U = 0$$
$$\left(\tfrac{1}{2} m v_f^2 - \tfrac{1}{2} m v_i^2\right) - mg\,(4 \sin 30°) = 0$$
$$\tfrac{1}{2} \cancel{m} v_f^2 \quad 0) \quad - 2\cancel{m} g = 0$$
$$v_f^2 = 4g \Rightarrow v_f = 2\sqrt{10}\ m/s$$

((alternatively $a = g \sin\theta$ / $v_f^2 - v_i^2 = 2a\Delta x$))

* Example :-



an object was given an initial speed of 20 m/s up the 30° inclined plane. find the maximum distance it covers up the incline.

$$\Delta K + \Delta U = 0$$
$$\left(\tfrac{1}{2} m v_f^2 - \tfrac{1}{2} m v_i^2\right) + mg\,(\underbrace{d \sin\theta}_{h}) = 0$$
$$-\tfrac{1}{2}\cancel{m}(400) + \cancel{m} g\, d * \tfrac{1}{2} = 0$$
$$\boxed{d = 40\,m}$$

$$h = 40 * \sin 30 = \boxed{20\,m}$$

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* Non-conservative Forces *

Work done by non-conservative forces :-

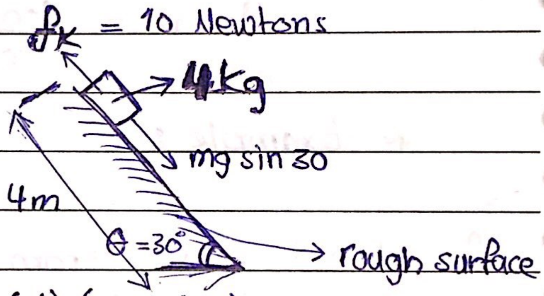
① depends on the path

② its work round a closed path $\neq 0$.

$$\Delta K + \Delta U = W_{nc}$$

$$E_f - E_i = W_{nc}$$

* Example :-



Find $v_f = ?$

$$\Delta K + \Delta U = W_{nc}$$

$$(\tfrac{1}{2} m v_f^2 - \tfrac{1}{2} m v_i^2) - mg*(4 \sin 30) = (f_K)(4)(\cos 180)$$

$$\tfrac{1}{2} * 4 * v_f^2 - 0 - 4*10*2 = 10*4*-1$$

$$2 v_f^2 - 80 = -40$$

$$2 v_f^2 = 40 \Rightarrow v_f = \sqrt{20} = 2\sqrt{5} \text{ m/s}$$

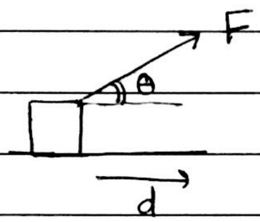
Scanned by CamScanner

Average Power $\overline{P}$

$\overline{P} = \frac{\text{work done}}{\text{time taken}}$ $J/s = \text{Watt}$

$\overline{P} = \frac{F * d}{t} \Rightarrow (F // d)$

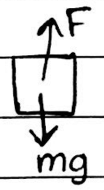
$= F v$ (both F and v are constants and in the same direction)



$P = \frac{Fd}{t} \cos\theta$ $P = F v \cos\theta$

Example :- A firefighter climbs a rope 10 m high in 5 seconds, at constant speed. find his average power output.

→ assume mass = 60 kg



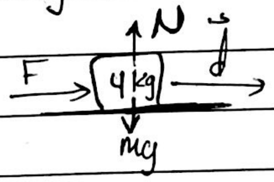
constant speed $\Rightarrow F = mg$

$\overline{P} = \frac{Fd}{t} \cos\theta = \frac{\overbrace{(60 * 10)}^{mg} * 10}{5} = 1200$ watt

* **horse power** = 746 watt

hp = 746 watt

* Solving Problems *

9 

$v_i = 0$ $a = 2\,m/s^2$ for 7 seconds

$W_{total} = Fd\cos(0)$

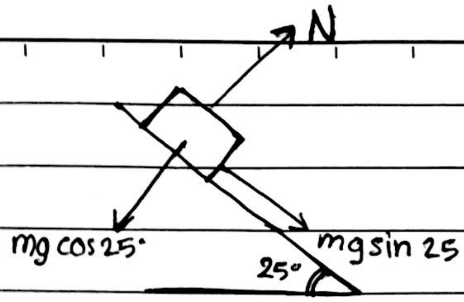
↳[since $W_n = W_{mg} = 0$]

$W_{total} = \Delta K = \frac{1}{2} m[v_f^2 - 0]$

$v_f = v_i + at = 0 + (2)(7) = \boxed{14\,m/s}$

$W_{total} = 392\,J$

10



(Slides down at constant velocity).

$a = 0$

$m = 380\,kg$ / $d = 2.9\,m$

ⓐ ⊕ $mg \sin 25 - F = 0$ $\therefore F = mg \sin 25$

~~1570~~ 1574 Newton.

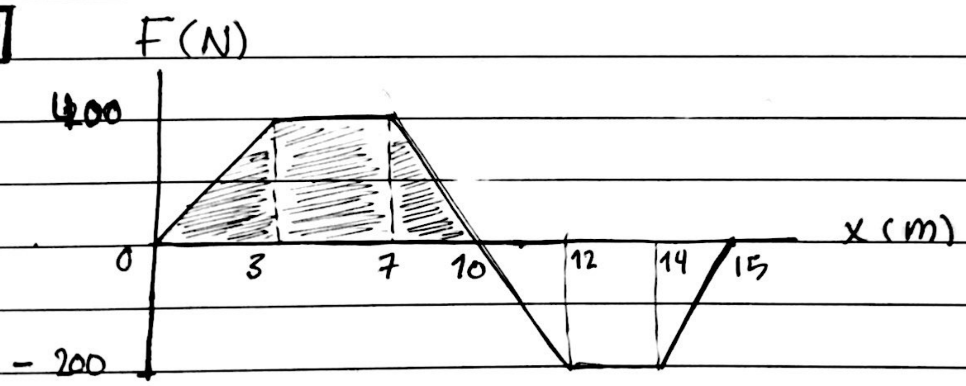
ⓑ $W_F = F d \cos 180°$

$= (1574)(2.9)(-1) = -4565\,J$

ⓒ $W_{mg} = (mg)(2.9)(\cos 0) = +4565\,J$ (mg → cos 25)

ⓓ $W_{total} = 0$ [since $\boxed{a = 0}$]

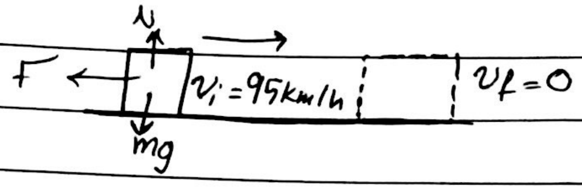
13



$W_{Fx}(x=0 \rightarrow x=10) = \frac{1}{2}(10+4)(400) = 2800\,J$

$W_{Fx}(x=0 \rightarrow x=15) = 2800 + \frac{1}{2}(5+2)(-200) = 2100\,J$

18 $v_i = 95\ km/h$



$v_i = 95\ km/h = \frac{95000\ m}{3600\ s}$

$= 26.4\ m/s$

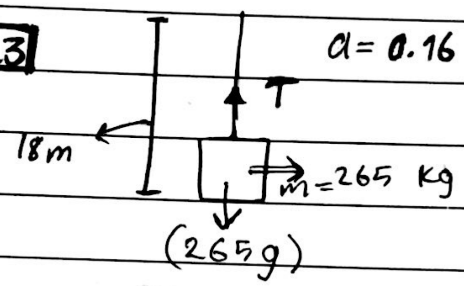
$m = 925\ kg$ $\quad W_{total} = \Delta k = \frac{1}{2} m (0 - (26.4)^2)$

$= -322344\ J$

Work required = $\boxed{322344\ J}$

23

$a = 0.16\ g$



ⓐ $\uparrow \oplus$ $T - 265g = 265(0.16g)$

$T = 265g + (265 * 1.6)$

$T = 3015.6$ Newtons

ⓑ $W_{total} = T(18 * \cos 0) + 265g * (18) * \cos 180°$

$54280.8 - 46794 = \boxed{7487\ J}$.

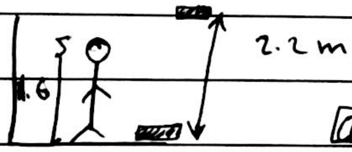
ⓒ $v_i = 0 \Rightarrow v_f^2 - v_i^2 = 2a\Delta y$

$W_{total} = \Delta K = \frac{1}{2} m (v_f^2 - 0) = 7487$

$\therefore v_f = 7.52\ m/s$

28

$m = 1.6$



ⓐ $U_{ground} = mgh = 1.6 * g * 2.2 =$

ⓑ $U_{top\ of\ head} = mg(0.6)\ J$

c

$W_c = -\Delta U$

work done by a conservative force.

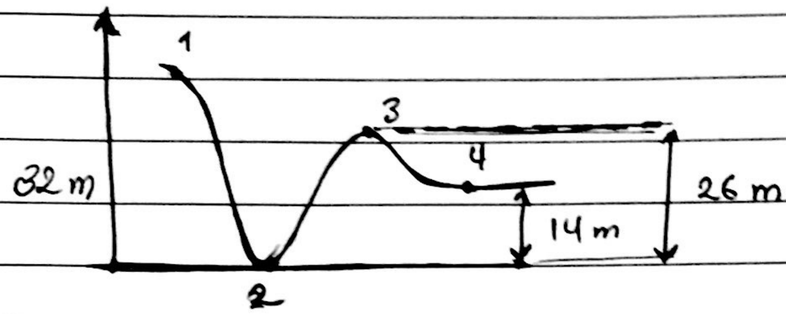
$W_{external} = -W_c = \Delta U$ [Provided $\Delta K = 0$]

Work done by the external force.

$\Delta K + \Delta U = W_{nc}$ $\quad W_{total} = \Delta K$

$W = Fd \cos\theta$

36



$v_1 = 0$ $\quad \Delta K + \Delta U = 0$ since there is no friction

$\frac{1}{2} m (v_2^2 - v_1^2) - mg(32) = 0$

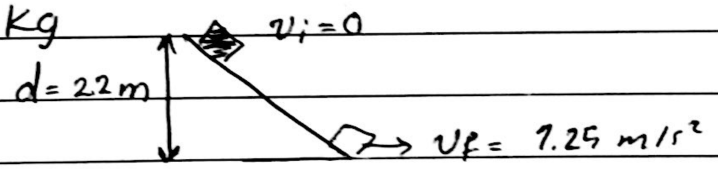
$\Rightarrow \boxed{v_2 = 25 \text{ m/s}}$

$\Delta K + \Delta U = 0 \Rightarrow \frac{1}{2} m (v_3^2 - 0) - mg(6) = 0$

$\boxed{v_3 = 10.8 \text{ m/s}}$

$\frac{1}{2} m (v_4^2 - 0) - mg(18) = 0 \Rightarrow \boxed{v_f = 18.8 \text{ m/s}}$

41 $\quad m = 16$ Kg



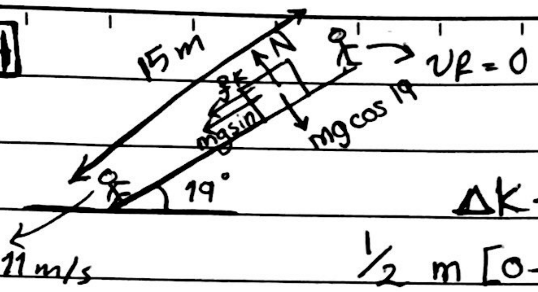
$\Delta K + \Delta U = W_{nc}$ energy lost due to friction.

$\frac{1}{2}(16)((1.25)^2 - 0) - (16)(10)(2.2) = W_{nc}$

$W_{nc} = 12.5 - 344.26 = -332.5$ J

energy lost as heat due to friction 332.5 J.

44



$\mu_k (mg\cos 19)$

$\downarrow$

$$\Delta K + \Delta U = W_{nc}$$

$$\frac{1}{2} m[0-(11)^2] + mg(15\sin 19°) = f_k(15)\cos 180$$

$\mu_k \sim 0.1$

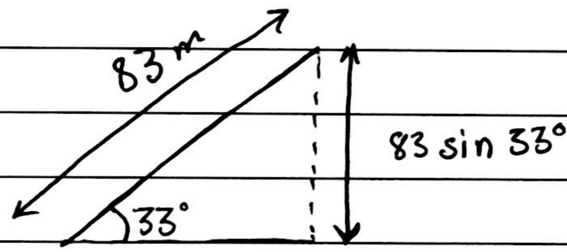
55 $\bar{P} = 2\ hp$

$hp = 746\ W$

$$\bar{P} = \frac{W}{t} \Rightarrow \underset{\text{work}}{W} = \bar{P} * t$$

$= 2(\overset{\text{watt}}{746})(1 * 3600)$ s

57



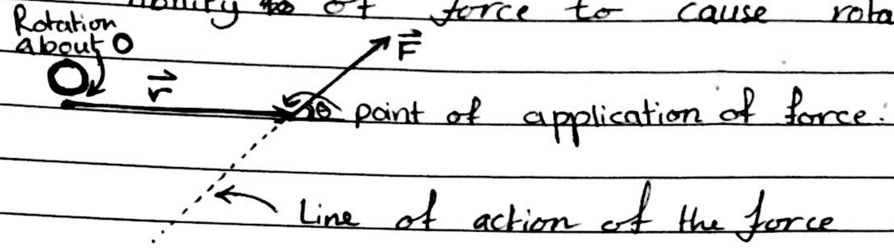
$t = 75$ s $m = 82$ kg

$$\bar{P} = \frac{(mg)(83\sin 33)}{75} = 484.4 \text{ watt}$$

13/3/2017

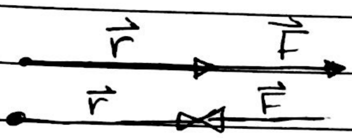
Torque

Ability ~~to~~ of force to cause rotation.



$\theta \Rightarrow \vec{F}$ and $\vec{r}$ must originate from the same point.

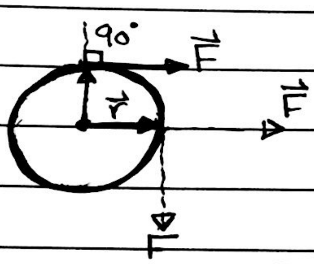
$\tau = rF\sin\theta$



$\theta = 0 \quad \tau = 0$

$\tau = 0 \quad \sin\theta = 0 \quad \theta = 180$

For a given r and F τ_{max} occurs at $\theta = 90°$

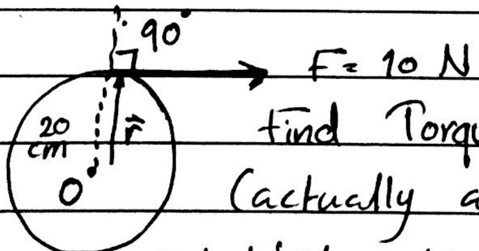


Note: If the line action of the force passes through the rotation point $\tau = 0$.

$\tau = rF\sin\theta \Rightarrow$ unit: $\boxed{N.m}$

Clockwise rotation $\Rightarrow \tau$ is negative
Counterclockwise rotation $\Rightarrow \tau$ is positive
by convention.

<u>Ex</u>



find Torque due to F about point O (actually about an axis that passes through point 'O' which is perpindicular to the surface)

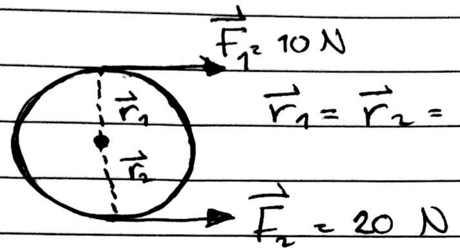
+

$\tau = rF\sin\theta$

$\tau = -(0.2)(10)\sin 90°$

$= -2$ N.m → clockwise rotation.

Example



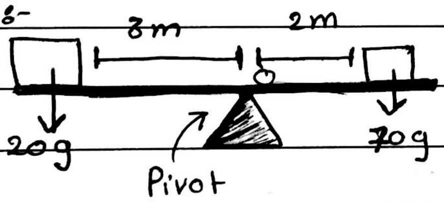
$\vec{r_1} = \vec{r_2} = 20$ cm

Find the net torque.

$\oplus$ ⇒ $\tau = 20(0.2)\sin 90^\circ - (10)(0.2)\sin 90^\circ$

$= 4 - 2 = +2$ N.m (Anticlockwise) Rotation.

* Example:-



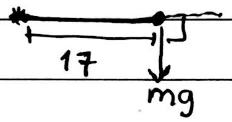
Find the torque.

$\tau = (20\,g)(3)\sin 90 - (70\,g)(2)$

$= 60\,g - \cancel{40g}\ 140\,g = -80\,g = -800$ N.m

Solving Problems

(24)



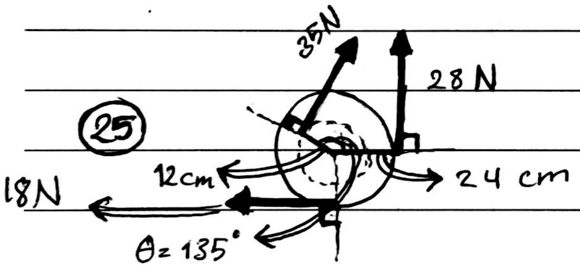
$m = 52\ kg$

$\tau_{max} = -mg * (0.17) * \sin 90^\circ$

$\tau_{max} = -86.6\ N.m$

clockwise direction

(25)



$\oplus$ ⟲

$\tau = (0.24)(28) - (0.24)(18) - (0.12)(35)$

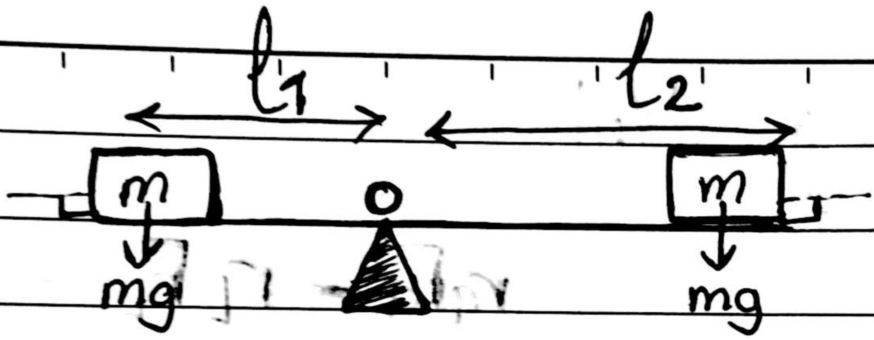
$= -1.8\ N.m$ (clockwise

$\tau_{net} = -1.8 + \tau_{friction}$

$= -1.8 + 0.6$

$= -1.2\ N.m$

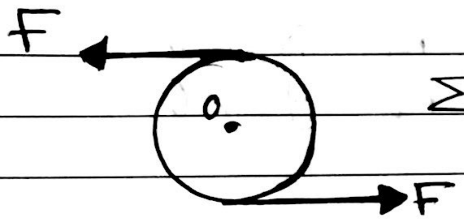
$\boxed{27}$



$$+\circlearrowleft O \quad \tau = l_1\, mg - l_2\, mg$$
$$= mg\,(l_1 - l_2).$$

* Conditions for Static Equilibrium *

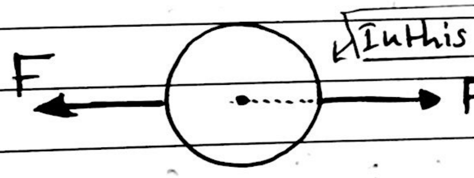
15/3/2017



$\sum \vec{F} = 0$ but wheel rotates about point O.

$\oplus \circlearrowleft \quad \tau = rF + rF = 2rF$

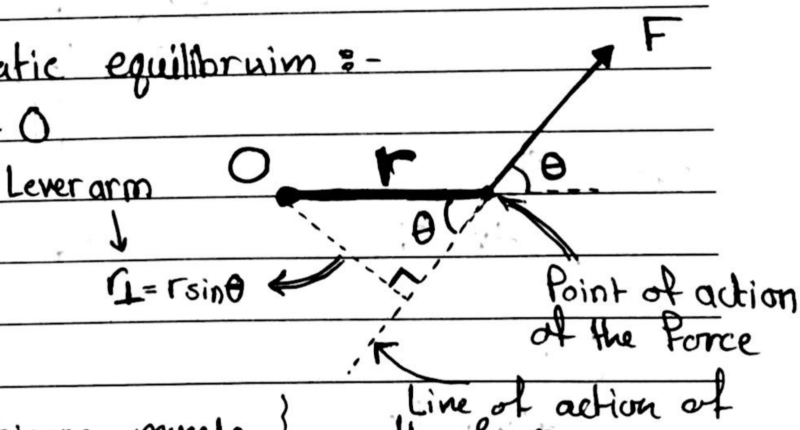
we have net torque that causes the wheel to rotate.



In this case: $\sum \vec{F} = 0 \quad \sum \tau = 0$

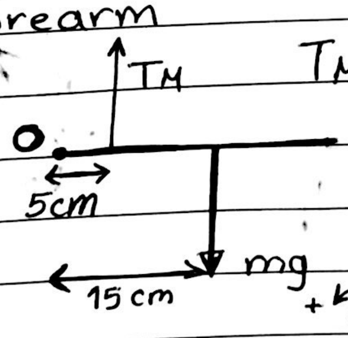
Two conditions for static equilbruim :-

① $\sum \vec{F} = 0$ ② $\sum \tau = 0$



Example :-

Forearm



T_M = tension due to the biceps muscle.

for the arm to be in static equilibrium.

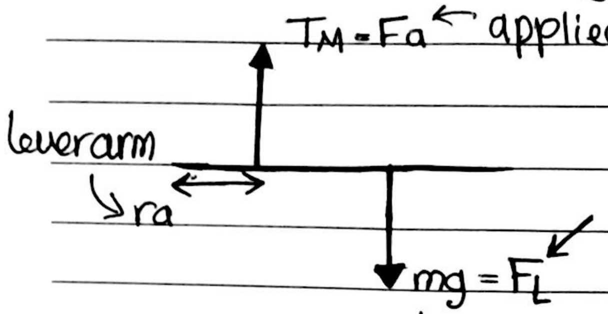
$\sum \vec{F} = 0 \ // \ \sum \tau = 0$

$+\circlearrowleft \quad \tau = (0.05) T_M - (0.15) mg = 0$

$T_M = \frac{0.15}{0.05} mg = \boxed{3\, mg}$ $T_M = 3mg$

Five Apple

* Mechanical Advantage * $\boxed{MA}$

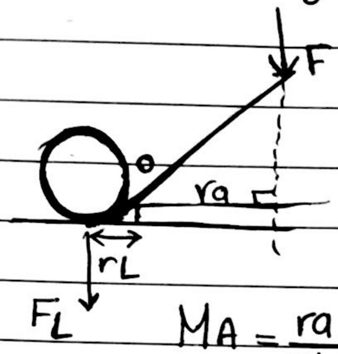


$$r_a F_a - r_L F_L = 0$$ for static equilibrium

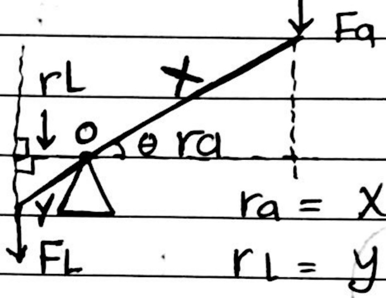
$$r_a F_a = r_L F_L$$

$$MA = \frac{F_L}{F_a} = \frac{r_a}{r_L}$$

i.e we like to carry a heavy object using a small force.



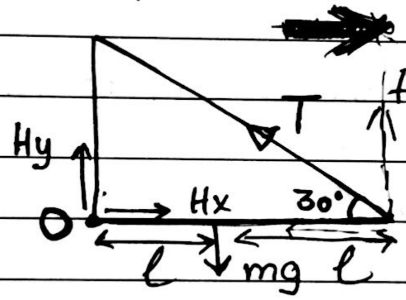
$$MA = \frac{r_a}{r_L} \gg 1$$



$$r_a = x\cos\theta$$

$$r_L = y\sin\theta$$

Example:-



Static Equilibrium:- $\left(\Sigma \vec{F} = 0 \,/\, \Sigma \tau = 0\right)$

Find T.

$\xrightarrow{+}$ $H_x - T\cos 30 = 0 \longrightarrow ①$

$\overset{+}{\uparrow}$ $H_y + T\sin 30 - mg = 0 \longrightarrow ②$

$$+\circlearrowleft o \quad (T\sin 30)(2\cancel{l}) - (mg)(\cancel{l}) = 0$$

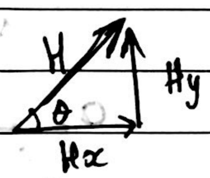
$$T(1/2)(2) - mg = 0$$

$$\boxed{T = mg}$$

From ①

$$H_x - T\cos 30^\circ = mg * \frac{\sqrt{3}}{2} \Rightarrow \boxed{\sqrt{3}/2 \; mg = H_x}$$

From ②

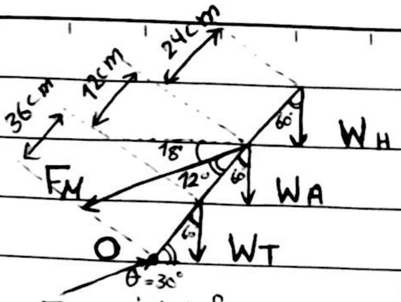


$$H_y + T\sin 30 - mg = 0$$

$$H_y = mg - mg * 1/2 \Rightarrow \boxed{H_y = 1/2 \, mg}$$

$$H = \sqrt{H_x^2 + H_y^2} \quad / \quad \tan\theta = \left|\frac{H_y}{H_x}\right|$$

20/3/2017



head → $W_H = 0.07\,W$

arms → $W_A = 0.12\,W$ (Static Equilibrium)

trunk → $W_T = 0.46\,W$

F_j = joint force

* Find F_M and F_j in terms of W.

$$\sum \vec{F} = 0$$

$\xrightarrow{+}$ $F_{jx} - F_M \cos 18° = 0$ $\quad \overset{+}{\uparrow}$ $F_{jy} - F_M \sin 18° - W_T - W_A - W_H = 0$

$$\sum \tau = 0$$

$$+\circlearrowleft (F_M \sin 12)(0.48) - (W_T \cos 30°)(0.36) - (W_A \cos 30°)(0.48) - (W_H \cos 30°)(0.72) = 0$$

$\therefore F_M \simeq 2.4\,W$

From ① $F_{jx} = 2.3\,W$ $\quad F_{jy} = 1.4\,W$

Since both F_{jx} and F_{jy} are positive ⇒ Our directions are correct

$F_j = \sqrt{F_{jx}^2 + F_{jy}^2} = 2.6\,W$ $\quad \tan\theta = \frac{F_{jy}}{F_{jx}} \Rightarrow \theta \sim 32°$

* Types of Equilibrium *

Stable Equilibrium

* → a ball in a bowe

If the ball is slightly displaced from equilibruim position it eventually returns to the equilibium.

Unstable Equilibrium

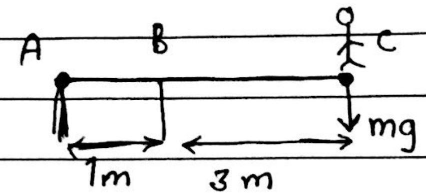
If ball is displaced from equilibrium position it doesn't retain

* Natural Equilibrium. — ~~But don't~~ doesn't return to the original equilibrium point.

Static Equilibrium $\qquad$ Static Equilibruim.

* Solving Problems *

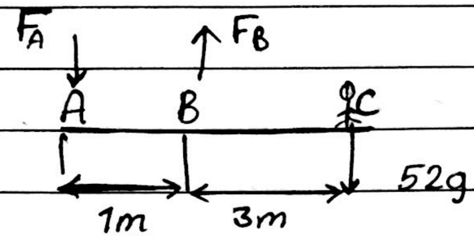
4



$\tau_A = -1800$ N.m torque of weight of the diver about point A.

$+\circlearrowleft A$ $\quad -1800 = -(mg)(4) \Rightarrow \frac{1800}{4g} = 46$ Kg

5



ⓐ Static Equilibrium $\therefore \sum \vec{F} = 0$

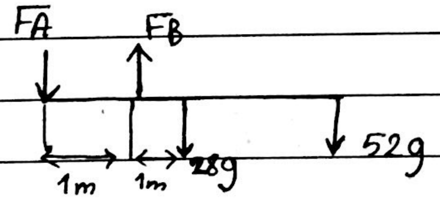
$+\uparrow$ $\quad F_B - F_A - 52g = 0 \longrightarrow$ ①

$\therefore \sum \tau = 0$

$+\circlearrowleft A$ $\quad F_B * 1 - (52g) * 4 = 0 \qquad F_B = 52g*4 \simeq 2038$ N.

$\therefore F_A = 156g \simeq 1529$ N

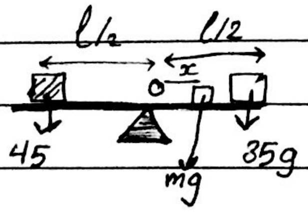
ⓑ (don't ignore mass of the board)



$F_A = 1803$ N $\quad F_B = 2587$ N

16 $\quad F_A = 6300$ N $\qquad F_B = 6100$ N (same as 5).

17

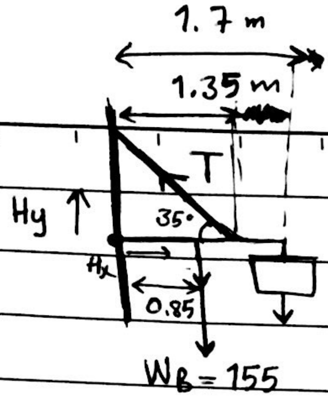


$m = 25$ kg ((Static Equilibrium))

$+\circlearrowleft o$ $\quad 45g(l/2) - mg(x) - 35g(l/2) = 0$

$x = 2/5\, l = \frac{2}{5}(3.2)$ m.

18



Find T

Static Equilibrium :-

$\sum \vec{F} = 0$

$\xrightarrow{+}$ $H_x - T\cos 35 = 0$

$+\uparrow$ $H_y + T\sin 35 - 155 - 215 = 0$

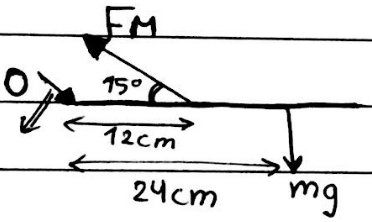
$+\circlearrowleft O)$ $T\sin 35\,(1.35) - 155(0.85) - 215(1.7) = 0$

$T \sim 642\ N$

$H_y = -1.76\ N$ (act downwards but magnitude is correct).

$H_x = 525.9\ N$

32



Find Fj and FM

$\sum \vec{F} = 0$ (Static Equilibrium)

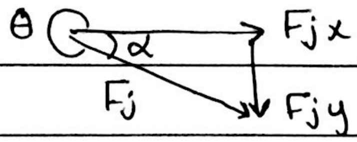
$+\uparrow$ $F_M \sin 15° - F_{jy} - mg = 0$ ①

$\xrightarrow{+}$ $F_{jx} - F_M \cos 15° = 0$ ②

$+\circlearrowleft O)$ $F_M \sin 15 * (0.12) - mg\,(0.24) = 0$

$F_M = 250\ N$

$F_{jx} = 242\ N$



$F_{jy} = 32.4\ N$

$F_j = 244\ N$ $\alpha = 76°$ $\theta = 360 - \theta$

* Fluids *

Four phases of matter :-

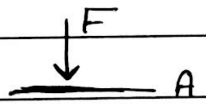
- Solid : Fixed in shape and size
- Liquid : Fixed in size but variable shape.
- Gas : Variable in shape and size.
- Plasma : a mixture of positive ions and negative electrons.
  ↳ (occurs at high temperatures).

* Density *

Density = Mass / Volume

$\rho = M/V$ unit kg/m^3

Pure water $\rho = 1000\ kg/m^3$

Pressure = Force / Area 

$P = F/A$

unit = N/m^2 = Pascal

(Pressure is a scalar quantity because it acts on all directions).

* Example :- The two feet of a 60 kg person cover an area of 500 cm^3

$500\ cm^3 \equiv 500 * 10^{-4}\ m^3$

ⓐ Find the pressure on the ground when he stands at rest.

$P = F/A = mg/A = 60g/500*10^{-4} = 6/5*10^{-4} = 12000\ N/m^2$

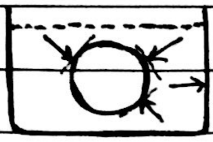
$\equiv$ 12000 Pascal

ⓑ Find P if he stands on one foot

$P = F/(A/2) = 2F/A = 2mg/A = 24000$ Pascal.

* Example :-

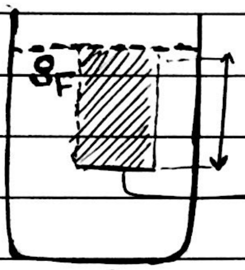
(For a static fluid)



Pressure of fluid on immersed object is always perpendicular to the surface of the object.

P is also perpendicular to the surface of the beaker.

Calculating the pressure due to the fluid under the fluid surface.



h: height of fluid

→ A: area

$P = F/A = (mg)/A$ → weight of fluid column on top of Area $\boxed{A}$

ρ_F = density of the Fluid

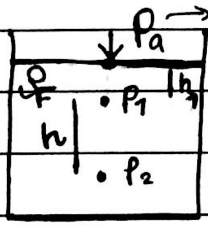
$= \rho_F V g / A = \dfrac{\rho_F (\cancel{A} h) g}{\cancel{A}}$

$\Rightarrow \boxed{P = \rho_F h g}$. $\quad P \propto h$

* as we go deeper below the surface the pressure increases.

P_a → atmospheric pressure.

* Example :-



$P_2 = P_1 + \rho_F g h$

$P_1 = P_a + \rho_F g h_1$

* Atmospheric Pressure :- P_a = atmospheric pressure measured at sea level.

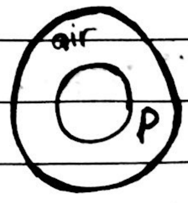
$P_a = 1.013 * 10^5$ Pa

Gauge Pressure $\boxed{P_g}$

$P_g = P - P_a$

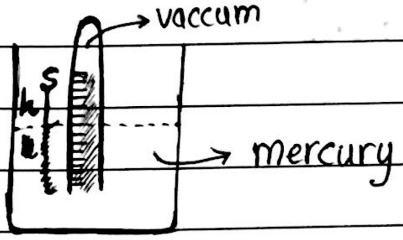
absolute value (P) ; atmospheric Pressure (P_a)

* tire of a car



we don't measure P
we in fact measure
$P_g = P - P_a$

* Barometer :- Instrument to measure atmospheric pressure.



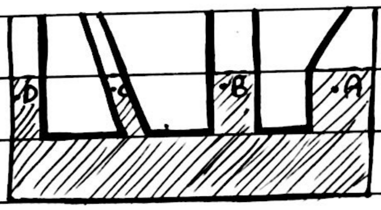
$h = 760$ mmHg

a long enough evacuated tube contains mercury of height = 760 mm.

this height of mercury causes pressure that is equal to the atmospheric pressure.

$$P_a = \rho_{mercury} * g * h \rightarrow 0.76 \text{ meters}$$
$$= 1.013 * 10^5 \text{ Pascal.}$$

Example

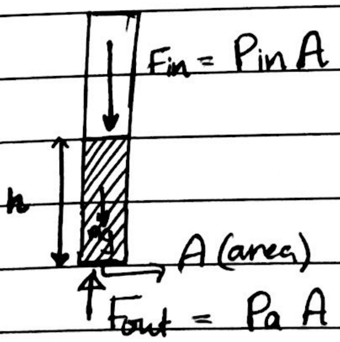


Points $A \rightarrow D$ are at the same height.

$\therefore P_A = P_B = P_C = P_D$

all points at the same depth below the fluid surface have the same pressure.

Ex Does the fluid flow out of the tube?!



((For static Equilibrium)).

$\sum \vec{F} = 0$ $\therefore (P_a - P_{in}) A = mg$

$+\uparrow$ $F_{out} = F_{in} + mg$

$P_a * A = P_{in} * A + m * g$

$P_a - P_{in} = \dfrac{\rho_F (h \cancel{A}) g}{\cancel{A}}$

$P_a - P_{in} = \rho_F * h * g$ $\longrightarrow$

Five Apple

*Summary :

$P_a - P_{in} = \rho_F g h$ ((Static Equilibrium)).

$P_a - P_{in} > \rho_F g h$ ((moves up))

$P_a - P_{in} < \rho_F g h$ ((moves down))

Units for Pressure

$1\ atm = P_a = 1.013 * 10^5\ Pa$

$1\ atm = 1.013 * 10^5\ Pa$ (in science)

$\equiv 760\ mmHg$ (in medicine).

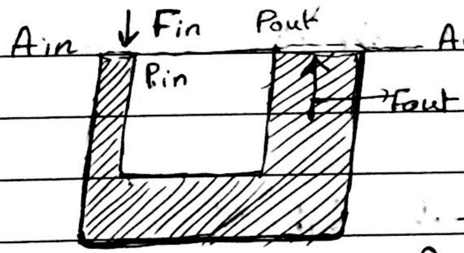
$\equiv 1.013\ bar$

* Pascal's Principle *

(External P Pressure) confined fluid

When external pressure is applied to a confined fluid, the pressure at each point ~~on~~ the fluid increases by that amount.

* application :-



- A_{in} and A_{out} are at the same level.
- confined fluid.

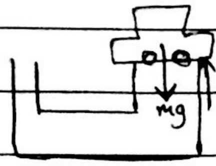
$$P_{in} = P_{out}$$

$$F_{in}/A_{in} = F_{out}/A_{out}$$

$$F_{out} = \frac{A_{out}}{A_{in}} F_{in}$$

$A_{out} = 20\, A_{in}$ (suppose) we want to lift a car whose mass is 1000 kg (in equilibrium).
Calculate F_{in}

$\equiv M \quad F_{out} = Mg$



((to lift a car whose weight = 1000 N we apply a force $F_{in} = 500N$))

$F_{in} = \frac{1}{20} F_{out}$

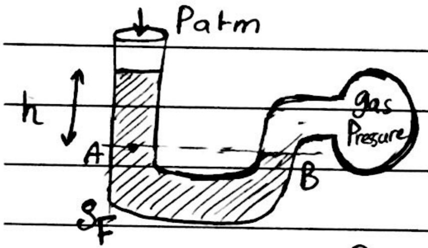
$F_{in} = \frac{1}{20} mg$

$F_{in} = \frac{1}{20} * 1000 * 10 = 500\ N$

$MA = F_L / F_a = F_{out} / F_{in} = 10000 / 500 = \boxed{20}$

* Open - tube Manometer

a device that can be used to measure gas pressure.

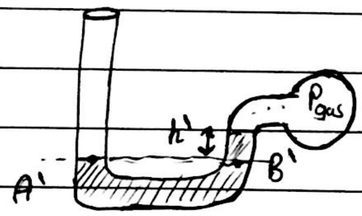


$P_A = P_B$

$P_A = P_{atm} + \rho_F g h$

$P_B = P_{gas}$

$P_{gas} = P_{atm} + \rho_F g h$



$P_{A'} = P_{B'}$

$P_{atm} = P_{gas} + \rho_{gas} + \rho_F g h'$

$P_{gas} = P_{atm} - \rho_F g h$

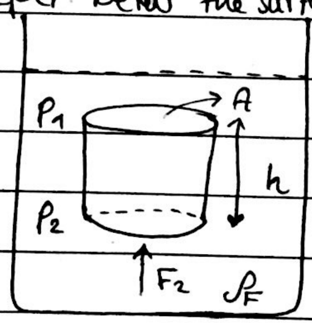
* ~~Buoy~~

$\therefore$ FB is due to an increase in pressure of the fluid as we go deeper below the surface.

* Buoyant Force *

cylinder immersed inside fluid

Area A / Height h



$F_B = \rho_F g V$ → the force exerted by the fluid upwards

$P_2 = P_1 + \rho_F g h$

$F_2 = P_2 * A$

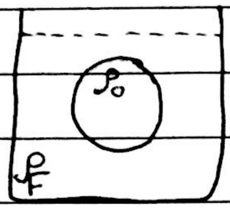
$F_1 = P_1 * A$

Resultant force of F_2 and F_1 $\quad F_B = F_2 - F_1$

$= P_2 A - P_1 A = (P_2 - P_1) A = \rho_F g (hA)$ → volume of immeresed object.

Five Apple

*Example :- when do objects float or sink?



ρ_o = density of object
ρ_F = density of fluid.

object of volume V and density ρ_o fully under fluid at a given instance. What happens next? moves up? moves down? or hangs in equilibrium?

$$\overset{+}{\uparrow} F_R = F_B - mg$$
$$= \rho_F V g - \rho_o V g$$
$$F_R = (\rho_F - \rho_o) V g$$

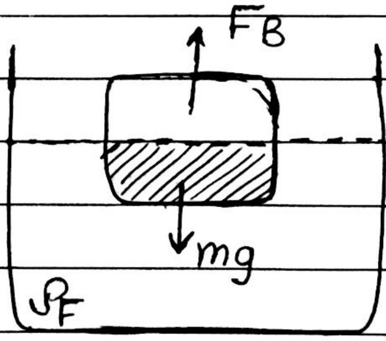
$\rho_F = \rho_o$ floats in equilibrium
If $\rho_F > \rho_o$ object floats ↑
$\rho_F < \rho_o$ object sinks ↓

* Why does a ship float, even though it is mostly made of Iron?!
⇒ Because it has an evacuated volume $\boxed{\rho = M/V \ll \rho_{iron}}$

* Partial Submersion *

$\therefore F_B = mg$
$\rho_F \, V_s \, \cancel{g} = \rho_o \, V \, \cancel{g}$ ← volume of object
↳ submerged volume

$\therefore \dfrac{V_s}{V} = \dfrac{\rho_o}{\rho_F}$

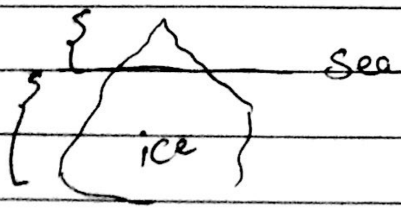


$\therefore F_B = mg$

Static Equilibrium.

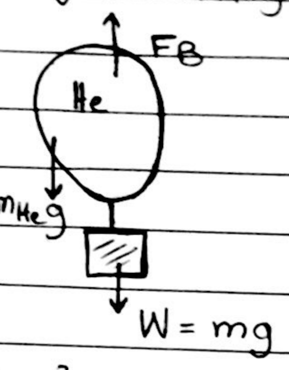
$\underline{V_s < V}$

Example :- $\dfrac{\rho_{ice}}{\rho_{water}} = \dfrac{V_s}{V}$



$\sim 0.9 = \dfrac{V_s}{V}$ ⇒ 90% of volume of the ice it below the water surface.

*Example :- what volume of a helium balloon is needed if it is to lift a load of 180 kg ((Including the weight of the empty balloon)).



* For equilibrium :-

$F_B - M_{He}\,g - mg = 0$

$\rho_{air} * V * g - \rho_{He} * V * g = m * g$

$(\rho_{air} - \rho_{He})(V) = m$

$V = m / (1.29\ kg/m^3 - 0.179\ kg/m^3) \approx 160\ m^3$

* Fluid in motion *

two types of Fluid motion:-

⇒ Streamline flow  (Layers don't cross)

⇒ Turbulant  Whirle-pools

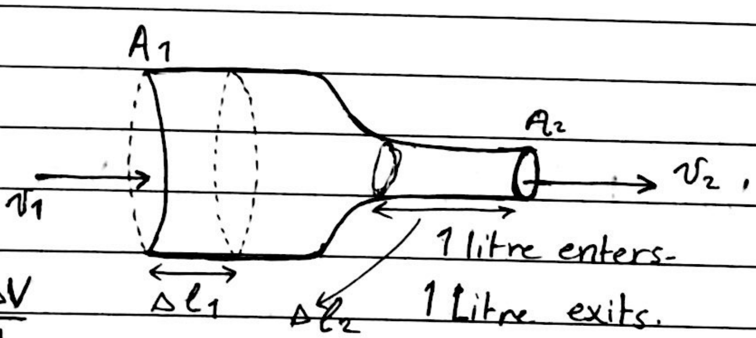
Layers cross each other.

Will consider streamline flow and assume:-

① non-viscous flow (no-viscosity). ⇒ No Friction ⇒ no loss of energy.

② Incompressible fluid.

Continuity Equation



Volume rate flow :- $\frac{\Delta V}{\Delta t}$

mass rate flow $\frac{\Delta M}{\Delta t} = \frac{\rho \Delta V}{\Delta t}$

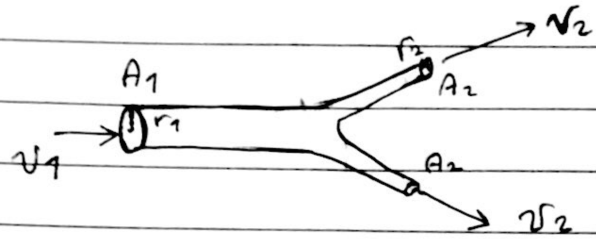
$\frac{A_1 * \Delta l_1}{\Delta t} = \frac{A_2 * \Delta l_2}{\Delta t}$

$\boxed{A_1 v_1 = A_2 v_2}$ → Continuity equation

((number of litres entering the tube on L.H.S = numbers of litres Leaving the tube on the R.H.S)

→ (Since fluid is incompressible).

* Example :- An artery splits into two smaller ~~arteries~~ artries of equal radius. If the speed of blood in the main artery is v_1. determine the speed in the other two small arteries.

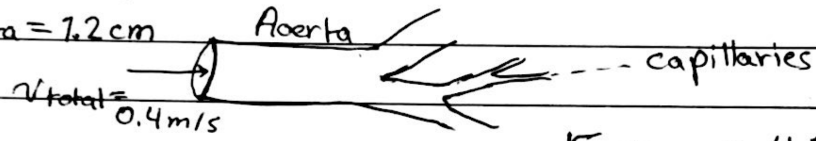


Suppose $r_1 = 2r_2$

$$A_1 v_1 = 2 A_2 v_2$$
$$\pi r_1^2 v_1 = 2 \pi r_2^2 v_2$$
$$4 r_2^2 v_1 = 2 r_2^2 v_2$$
$$v_2 = 2 v_1$$

* Example :- Estimate the number of capillaries in the human body.

$r_{aorta} = 1.2\,cm$



$r_{capillary} = 4 * 10^{-4}\,cm$

$v_{capillary} = 5 * 10^{-4}\,cm/s$

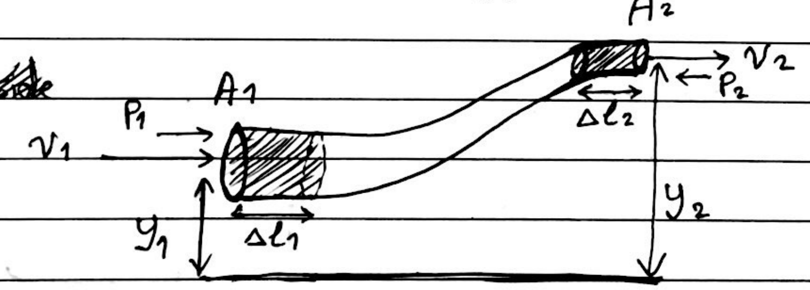
$$A_{aortal} * v_{aortal} = N * A_{cap} * v_{cap}$$
$$\therefore N \simeq 7 * 10^{9}$$

* Bernoulli's Equation :-

It's a statement of conservation of energy.

- Work done on shaded ~~side~~ volume of L.H.S

$$W_1 = P_1 * A_1 * \Delta l_1$$



- Work done on shaded volume on R.H.S

$$W_2 = -P_2 * A_2 * \Delta l_2$$

work done by gravity is

$W_g = -mg(y_2 - y_1)$ $\{W_g = -\Delta U\}$

$W_{total} = \Delta K \rightarrow W_1 + W_2 + W_g = \Delta K$

$P_1 * A_1 * \Delta l_1 - P_2 * A_2 * \Delta l_2 - mg(y_2 - y_1) = \frac{1}{2} m v_2^2 - \frac{1}{2} m v_1^2$

(note) $A_1 * \Delta l_1 = A_2 * \Delta l_2 = V$

$P_1 V - P_2 V - mgy_2 + mgy_1 = \frac{1}{2} m v_2^2 - \frac{1}{2} m v_1^2$

$$V \Rightarrow \boxed{P_1 + \underbrace{\rho g y_1}_{\text{P.E per unit volume}} + \underbrace{\tfrac{1}{2}\rho v_1^2}_{\text{K.e per unit volume}} = P_2 + \rho g y_2 + \tfrac{1}{2}\rho v_2^2}$$

Constant

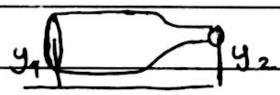
* Cases :-

① Fluid at rest $v_1 = v_2 = 0$

$P_1 + \rho g y_1 = P_2 + \rho g y_2$

$P_1 + \rho g (y_1 - y_2) = P_2 \Rightarrow P_1 = P_2 + \rho g (y_2 - y_1)$

$P_1 = P_2 + \rho g h$

② $y_1 = y_2 \Longrightarrow$ 

$(y_1 = y_2)$

$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$ ((we know $v_2 > v_1$))

$\therefore P_1 > P_2$

low $v \longrightarrow$ Large P

large $v \longrightarrow$ low P

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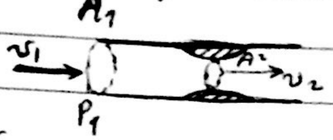
* Applications on Bernoulli's equation:-

⟹ Artery with plague



Plague leads to smaller cross sectional area $v_2 > v_1$ since $A_2 < A_1$

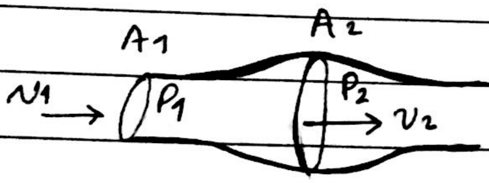
the pressure P_2 drops compared to P_1

tissues surrounding the artery exert pressure larger than P_2 ⟹ artery collapses.

the blood that builds behind the closure reopens the artery.

When it reopens the pressure inside the artery falls again and so the artery closes and so on.

⟹ Flatting (dilation) of the artery.

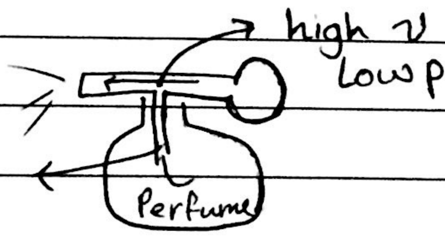


$A_2 > A_1 \Rightarrow v_1 > v_2$

$\therefore P_2 > P_1$

P_2 is larger than the outside pressure. This could lead to rupturing the artery.

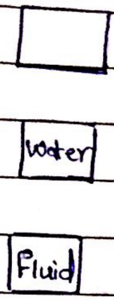
* Perfume atomizer



⟹ as water falls out of the tap the cross sectional area decreases.

* Solving Problems :-

5



$m = 35$ grams (when empty).

$m = 98.44$ grams

$m = 89.22$ grams

Specific Gravity $= \frac{\rho}{\rho_{water}}$

$S_g = \rho_{Fluid} / \rho_{Water} = \frac{m_{Fluid}/V}{m_{water}/V} = \frac{m_{fluid}}{m_{water}}$

$\frac{m_{fluid}}{m_{water}} = \frac{89.22-35}{98.44-35} \sim 0.855$

$\rho_{Fluid} = 0.855\, \rho_{water} = \boxed{855\ kg/m^3}$

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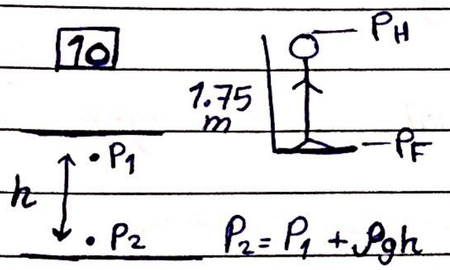

$P_2 = P_1 + \rho g h$

$P_F = P_H + \rho g h_{(blood)}$

$P_F - P_H = \rho_{blood} * g * h$

$= 1059.5 * 9.8 * 1.75$

$= 18170$ Pascal

$= 18170 * \frac{760}{1.013*10^5} \simeq \boxed{136\ mmHg}$

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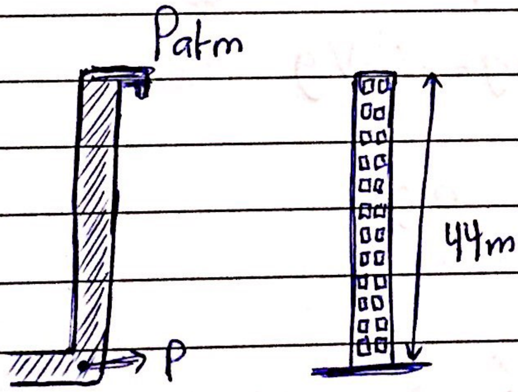

$P = P_{atm} + \rho_w g h$

$P - P_{atm} = \rho_w g h$

$P_{gauge} = \rho_w g h = 1000 * 9.8 * 44$

$= 431200$ Pa

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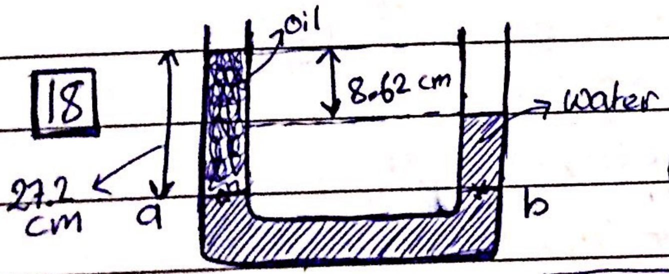

$P_a = P_b$

$P_{atm} + \rho_{oil}\, g\, (27.2 * 10^{-2})$

$= P_{atm} + \rho_w\, g\, (27.2 - 8.62) * 10^{-2}$

$\boxed{\rho_{oil} = 683\ Kg/m^3}$

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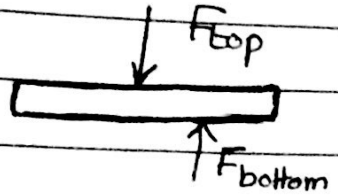
11



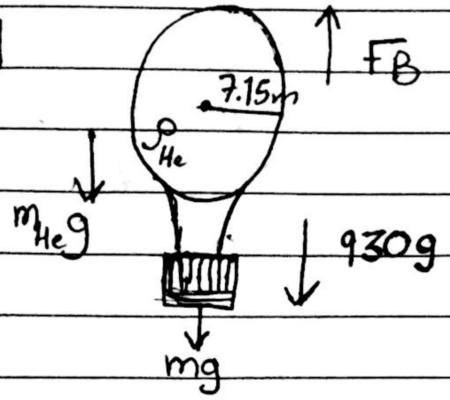
$F_{top} = P_{atm} * Area$

$= 1.013 * 10^5 * 1.7 * 2.6 = \boxed{44776\ N}$

$F_{bottom} = F_{top}$

$\Rightarrow$ resultant $= 0$

26



Just to left the carge assume

$\sum \vec{F} = 0$

$+\uparrow \quad F_B - m_{He}g - 93g - mg = 0$

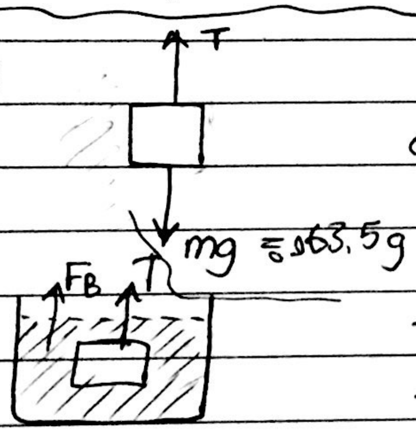
$\rho_{air} * \cancel{g} * V - m_{He}\cancel{g} - 930\cancel{g} - m\cancel{g} = 0$

$V = \frac{4}{3}\pi R^3$

$m = 771\ kg$

Archimedes Principle:- Bouyant force equals the weight of the displaced fluid

27



$0.0635g = T \quad \text{----} \ ①$

$0.0635g = \rho_m V g \quad ①$

$T' + F_B = mg$

$T' + F_B = 0.0635g$

~~$0.0635g = \rho_m V g$~~

$\rho_w * V * \cancel{g} + 0.0554\cancel{g} = 0.0635\cancel{g}$

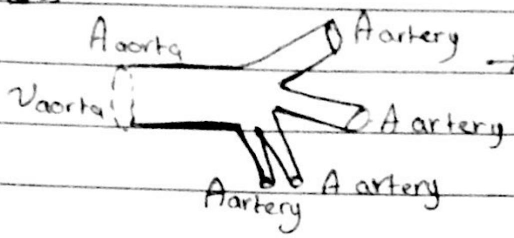
$\rho_w * V = 0.0635 - 0.0554 \quad ②$

~~$\rho_m / \rho_w = V/V$~~ $\quad \frac{\rho_m * V}{\rho_w * V} = \frac{0.0635}{0.0635 - 0.0554}$

$\rho_m = 7.84\ \rho_w = 7840\ kg/m^3$

Iron or Steel.

$\boxed{38}$



$A_{aorta} = \pi(1.2 * 10^{-2})^2$

$v_{aorta} = 40$ cm/s

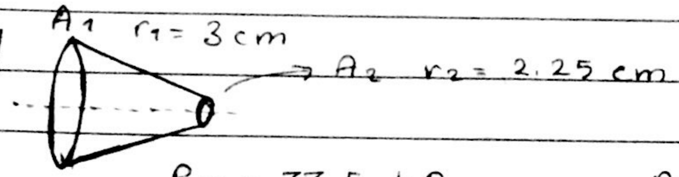
* Continuity equation :-

$\rightarrow A_{total} = 2 * 10^{-4}$ cm^2

$$A_{aorta} * V_{aorta} = \tilde{N}(A_{artery} * v_{artery})$$

$$\therefore v_{artery} = 0.9 \text{ m/s}$$

$\boxed{45}$



$P_{1g} = 33.5$ kPa $\qquad P_{2g} = 22.6$ kPa

volume flow rate $\dfrac{\Delta V}{\Delta t} = A_1 V_1 = A_2 v_2$

$$P_1 + \rho g y_1 + \tfrac{1}{2}\rho v_1^2 = P_2 + \rho g y_2 + \tfrac{1}{2}\rho v_2^2$$

$y_1 = y_2$ (horizontal tube).

$$P_1 - P_2 = \tfrac{1}{2}\rho(v_2^2 - v_1^2).$$

$\boxed{P_{1g} = P_1 - P_{atm} \quad P_{2g} = P_2 - P_{atm}}$

$$A_1 v_1 = A_2 v_2$$

$$v_1 = (A_2/A_1) * v_2$$

$$P_1 - P_2 = \tfrac{1}{2}\rho(v_2^2 - (A_2^2/A_1^2) * v_2^2)$$

$\boxed{P_1 = P_{1g} + P_{atm} \quad P_2 = P_{2g} + P_{atm} \quad P_1 - P_2 = P_{1g} - P_{2g}}$

or

$$P_1 - P_2 = \tfrac{1}{2}\rho(A_1^2/A_2^2 * v_1^2 - v_1^2)$$

$$\frac{2(P_1 - P_2)}{\rho} = (A_1^2/A_2^2 - 1) * v_1^2$$

$$\frac{2A_2^2 * (P_1 - P_2)}{\rho} = (A_1^2 - A_2^2) * v_1^2$$

$$v_1 = A_2\sqrt{\frac{2(P_1 - P_2)}{\rho(A_1^2 - A_2^2)}} \Rightarrow A_2 = \pi r_2^2 = \pi(2.25 * 10^{-2}).$$

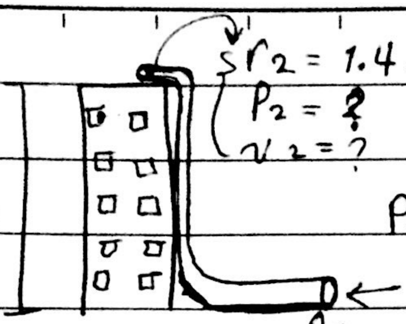
(Torcilles's law).

$\therefore v_1 = 0.21$ m/s $\qquad \dfrac{\Delta V}{\Delta t} = A_1 * v_1 = 6 * 10^{-4}$ m^3/s

$= 600$ cm^3/s

$\boxed{= 0.6 \text{ Litres/s}}$

[48]



$P_{1g} = 3.8\ atm \Longrightarrow P_1 = 4.8\ atm$

$y_1 = 0$
$y_2 = 16$

$A_1 v_1 = A_2 v_2$

$v_2 = (A_1/A_2) * v_1 = 2.5\ m/s$

$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$

$P_1 + \frac{1}{2}\rho(v_1^2 - v_2^2) + \rho g\underbrace{(y_1 - y_2)}_{-16} = P_2$

$P_2 = 3.23 * 10^5\ Pa$

$P_{2g} = P_2 - P_{atm} \Rightarrow 3.23 * 10^5 - 1.013 * 10^5$

Chapter 13:- Temperature and Kinetic theory.

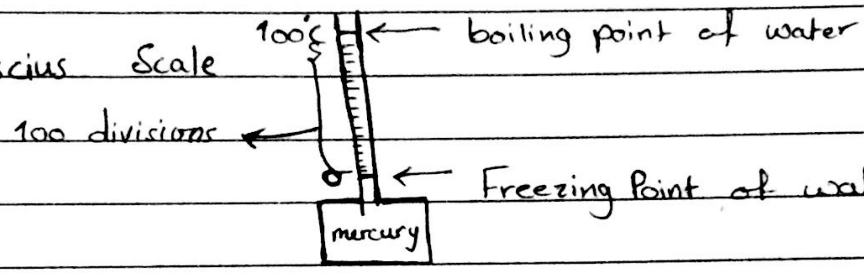
Temperature and thermometer

In measuring temperature we depend on some property of a given material that changes with temperature.

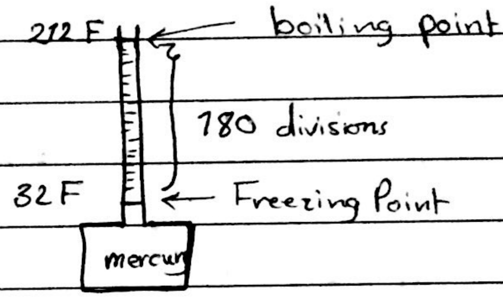
example : Volume of mercury increases as temperature increases.

Scales:-

[1] Celscius Scale



[2] ~~Falher~~ Fahrentheit Scale



for converting from C° to F :-

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

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

$\Rightarrow$ When $T_C = T_F$?

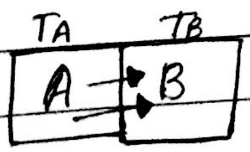
$T_C = T_F = T$

$T = \frac{5}{9}(T - 32)$

$\boxed{\therefore T = -40}$

* Thermal Equilibrium :-

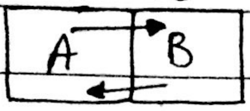
* Heat : energy being transferred from one system (object) to another. ((measured in Joules)).



$T_A > T_B$ net flow of energy from A (higher temp.) $\rightarrow$ B (lower temp)

* This process continues until $T_A = T_B$ (net heat flow).

$T_A = T_B$



when $T_A = T_B$

$\Rightarrow$ No net heat flow.

Thermal Equilibrium :- NO net heat flow between objects or systems.

* Zeroth law of thermodynamics :-

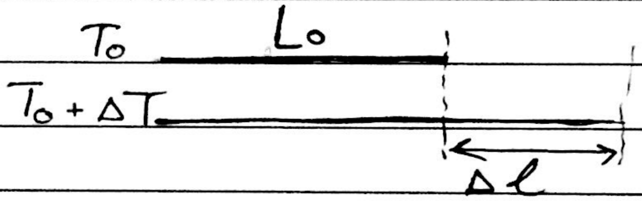
If A is in thermal equilibrium with B

B is in thermal equilibrium with C

$\therefore$ A and C are also in thermal ~~dynamics~~ equilibrium.

* Thermal Expansion :-

(i) Linear Expansion



Δl proportional to $L_0 \, \Delta T$

$\Delta l = \alpha * L_0 * \Delta T$

↑ linear expansion coefficient.

each material has it's own value of $\boxed{\alpha}$.

Units $\Rightarrow$ 1/temperature.

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5/4/2017

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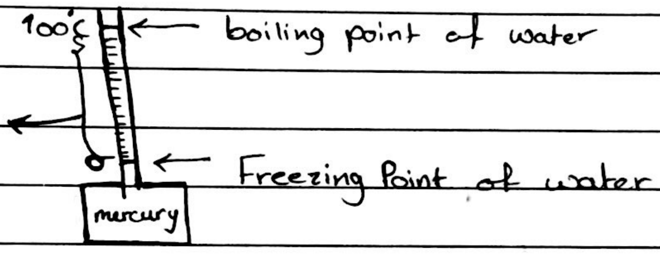
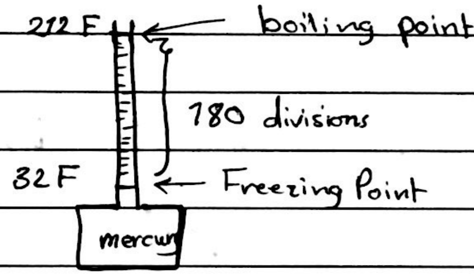


[2] ~~Water~~ Fahrentheit Scale



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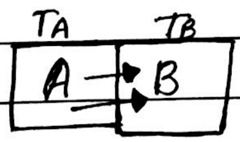

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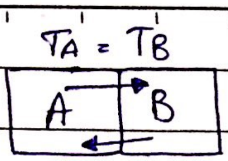

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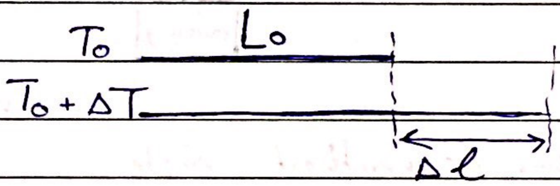

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$\uparrow$ linear expansion coefficient.

each material has its own value of $\boxed{\alpha}$.

Units $\Rightarrow$ 1/temperature.

$\boxed{\text{April 12, 2017}}$

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

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

$\Delta T_C = \frac{5}{9} \Delta T_F$

$\alpha = \frac{\Delta L}{L_0 \Delta T} \Rightarrow [\alpha] = \frac{1}{\text{Temp.}}$

* Volume Expansion :-

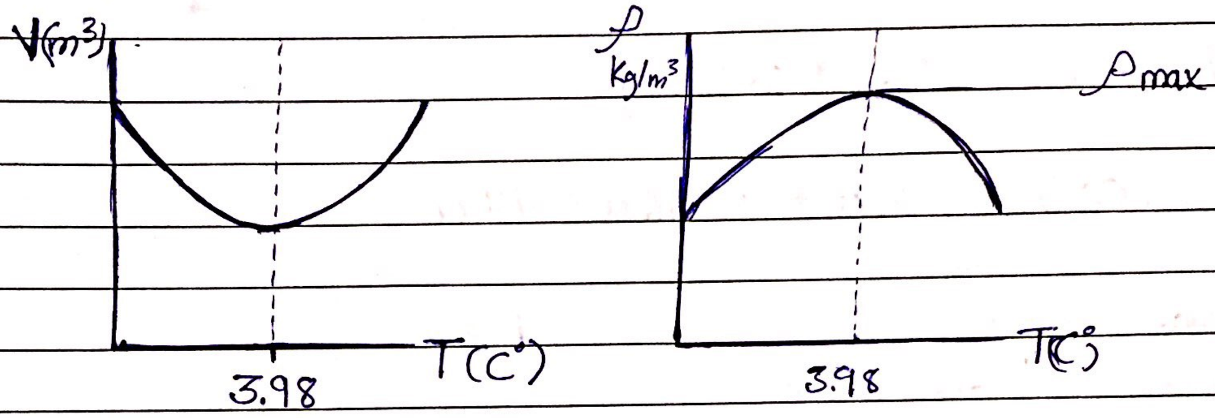
$\Delta V = \beta * V_0 * \Delta T$

coefficient of volume expansion.

for isotropic material $\Rightarrow \beta = 3\alpha$

Five Apple

materials usually expand in volume with increasing temperature, except water.



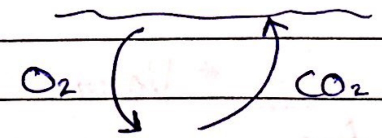
((Odd Behaviour of water)).

* applications:-

When air cools down, it cools the surface of water and reaches 3.98°C and thus has maximum density.

→ Warm water below the surface has lower density. surface water sinks taking O_2 downwards, while Warmer water floats taking CO_2 upwards.

⟹ This continues and eventually replinshes O_2 to aquatic life.



⟹ all water becomes at the same temperature. When air cools, further & water surface freezes. but water below does not freeze.

ice ⟵ insulating Layer.

Water

Molecular Mass

H_2

$M(H_2) = 2u$ 2 atomic mass unit (a.m.u)

$1 \text{ amu} = 1.67 * 10^{-27} \text{ kg}$

$M(CO_2) = 12u + 2 * 16u = 44u$

Molar mass

mass of one mole

Molar mass of H_2 = 2 grams

Molar mass of CO_2 = 44 grams

1 mole contains Avogadro's number of particles.

$N_A = 6.023 * 10^{23}$

Ideal Gas Law

$PV = nRT$

number of moles

temperature in kelvin scale.

absolute Pressure

Volume

Gas constant

$$PV = \frac{\text{Force}}{\text{Area}} * \text{Volume} = \frac{N}{m^2} * m^3 = N.m \Rightarrow \boxed{\text{Joule}}$$

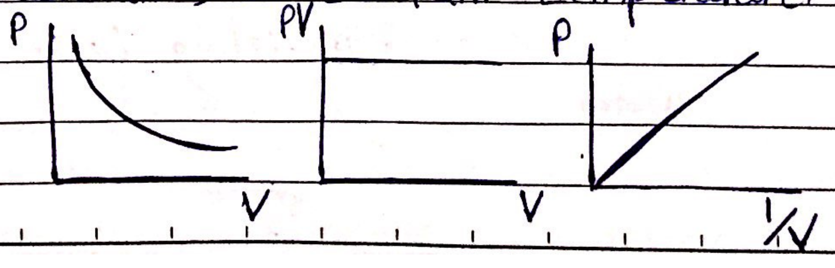
$$R = \frac{PV}{nT} \Rightarrow \frac{\text{Joule}}{(\text{mol. K})}$$

* Boyl's Law ((P & V are inversly proportional at constant temperature))

$PV = nRT$ = constant ; at constant temperature.

$PV =$ constant

$$P = \frac{\text{constant}}{V}$$



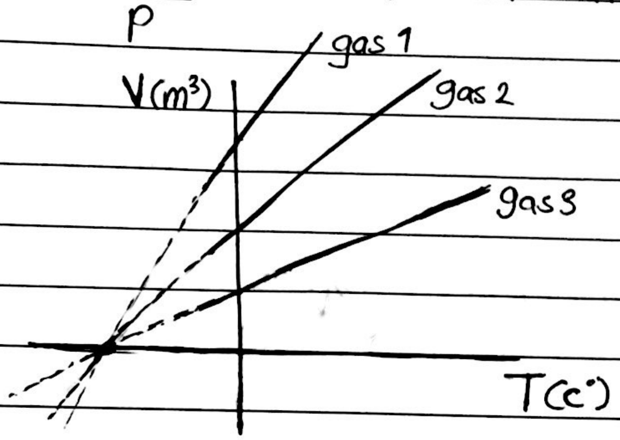
17 April 2017

$PV = nRT$

* Charls' Law

((When pressure is constant))

$V = \frac{nRT}{P}$ $V \propto T$ at constan P.



all curves, when extrapolated, cross the temperature axis at the same point.
$T = -273°C$
regardless of the gas used.

⇒ Define

$T\dot{c} = -273$ as absolute kelvin
'0' kelvin

$T_K = T_C + 273$ ⇒ $\Delta T_K = \Delta T_C$

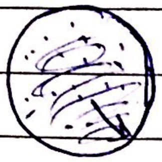
↑ kelvin scale ⇒ $\Delta T_C = 5/9\ \Delta T_F$

* Kinetic theory of gases

When dealing with gases we use properties like T, V and P.

⇒ Properties of an ideal gas :-

1. Low density
2. high temperature & Low pressure.
3. distance between particles >> than their dimensions (size).
4. collisions between the particles are assumed to be elastic.
5. collisions between particles and the walls are assumed to be elastic.

*  collisions of gas particles with the wall of the container leads to pressure.

* From Kinetic theory :-

$$PV = 2/3 * N * \overline{K}$$ average kinetic energy.

$$\overline{K} = 1/2 * m * \overline{v}^2 \Rightarrow v_{rms} = \sqrt{\overline{v}^2}$$

root mean square velocity

$$PV = nRT$$

$$PV = 2/3 N\overline{K}$$

$$2/3 N\overline{K} = nRT$$

$$\overline{K} = 3/2 \frac{nRT}{N} = 3/2 \left(\frac{N}{NA}\right) \frac{RT}{\cancel{N}}$$

$$\overline{K} = 3/2 * \left(\frac{R}{NA}\right) * T$$

$$\Rightarrow \overline{K} = 3/2 * K_B * T$$ constant

* $K_B = \frac{R}{NA}$ is called boltzman's constant

$$K_B = 1.38 * 10^{-23} \ J/K$$

∴ Temperature is a major of kinetic Energy.

Equipartition of energy → $\overline{K} = \frac{1}{2} K_B T + \frac{1}{2} K_B T + \frac{1}{2} K_B T$

((motion in 3D)) i.e :

due to motion along x-axis — due to motion along y-axis — z-axis

* Example :- a hydrogen molecule is moving in two dimensions. its value of $\bar{K}$ is :-

ⓐ 0 ⓑ $\frac{1}{2} K_B T$ ⓒ $K_B T$ ✓ ⓓ $\frac{3}{2} K_B T$

$$\bar{K} = \frac{1}{2} m \overline{v^2} = \frac{3}{2} K_B T$$

$$\overline{v^2} = 3 K_B T / m \qquad v_{rms} = \sqrt{\frac{3 K_B T}{m}}$$

$m \rightarrow$ measured in kg

* Example :- what is the v_{rms} value of an O_2 molecule at 20°C

$$v_{rms} = \sqrt{\frac{3(1.38*10^{-23})(293)}{2*16*1.67*10^{-27}}} \simeq 480 \text{ m/s}$$

$\Rightarrow$ For H_2 molecule $v_{rms} \simeq 1920$ m/s

$\simeq 6912$ Km/h

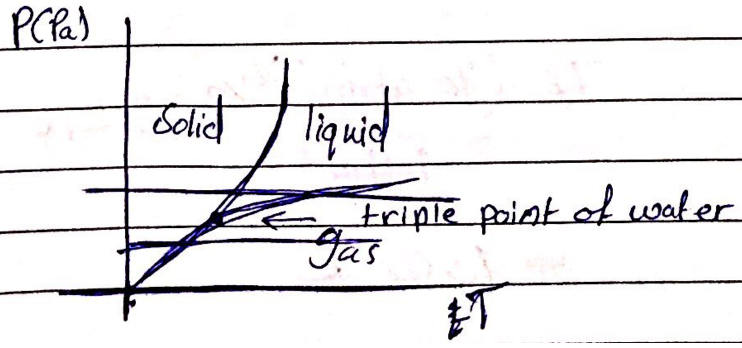
* Phase diagrams *

$\Rightarrow$ Phase change

ice $\longrightarrow$ water phase change

Liquid $\longrightarrow$ vapoure phase change $\leftarrow$ changes from one form to another.

* For Water :-



Solving Problems

③ 68° F

[a] $T_C = \frac{5}{9}(T_F - 32) = 20°C$

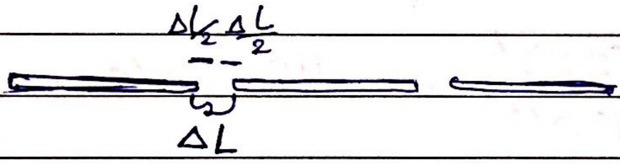
[b] $T_C = 1900°C$

$T_F = \frac{9}{5} T_C + 32 = 3452° F$

⑩ $L_0 = 12 m$

$T = 15°C$ ((buckling only occurs at high temperature. No problem with low temp.))

$-30°C \rightarrow 50°C$

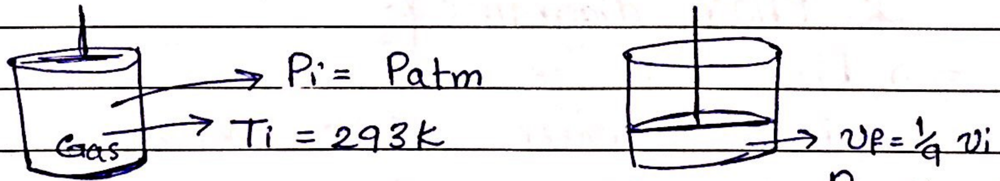


$\Delta l = \alpha l_0 \Delta T$

$(12 * 10^{-6})(12)(50-15) = 5.04 * 10^{-3} m$

Minimum separation between slabs ≈ 5mm.

㉓



[i]

$P_F = 40 atm$

$T_f = ??$

$P_i V_i = nRT_i$ ①

$P_f V_f = nRT_f$ ②

$\frac{②}{①} \Rightarrow \frac{P_f V_f}{P_i V_i} = \frac{T_f}{T_i}$

$T_f = \frac{(40 atm)(V_i/9)}{1 atm (V_i)} * 293$

$= 1302 K$

(24) $n = 16$, $T_i = 10°C \longrightarrow 283\,K$

$P_{ig} = 0.35$ atm $\longrightarrow P_i = 1.35$ atm

[a] $P_i V_i = nRT_i \Rightarrow V_i = \frac{nRT_i}{P_i}$ $T_i \longrightarrow K$, $P_i \longrightarrow Pa$ $= 0.323\ m^3$

[b] $v_f = \frac{1}{2} v_i$, $P_{fg} = 1atm \Rightarrow P_{final} = 2atm$

$\frac{P_i V_i}{P_f V_f} = \frac{T_i}{T_f}$ $T_f = 210\,K$

absolute pressure.

(36) 1 Litre of water has a mass of 1 Kg ((1000 g))

$M(H_2O) = (2 * 1.00794 + 15.9994)\ u$

$18.01528\ u$.

1 mole of water has a mass of $18.0152\ g$ grams.

$\cancel{n = \frac{mass}{M}}$ $n = \frac{1000 \text{ grams}}{18.01528 \frac{\text{grams}}{\text{mole}}} = 55.51$ moles

number of molecules in 1 mole $= 55.51 * N_A$

(40) $\overline{K} = \frac{1}{2} m \overline{v^2} = \frac{3}{2} K_B T$

$\overline{K} = \frac{3}{2}(1.38 * 10^{-23})(273) \simeq 5.65 * 10^{-21}\ J$

for one mole $\overline{K}_{total} = \overline{K} * N_A$

(44) $P_f = 3P_i$, $V_f = V_i$

$$v_{rms} = \sqrt{\frac{3K_B T}{m}}$$

$$v_{rms}^{i} = \sqrt{\frac{3K_B T_i}{m}}$$

$$v_{rms}^{f} = \sqrt{\frac{3K_B T_f}{m}}$$

$P_i V_i = nRT_i$

$P_f V_f = nRT_f$

$$\frac{P_f V_f}{P_i V_i} = \frac{T_f}{T_i}$$

$$\frac{3P_i V_i}{P_i V_i} = \frac{T_f}{T_i} \Rightarrow T_f = T_i$$

$$v_{rms}^{f} = \sqrt{\frac{3K_B\, 3T_i}{m}} \Rightarrow v_{rms}^{f} = v_{rms}^{i}\sqrt{3}$$

19 April 2017

* Nuclear Physics and Radioactivity *

Atom ≡ nucleus + orbiting e^-

Z : number of protons (atomic number).

N: number of neutrons

$A = N + Z$ ← mass number

$\binom{Z}{N}$ nucleus

* typical atomic diameter 10^{-10} m = 1 Å
* // nucleus radius 10^{-15} m

$$\frac{D_{atom}}{D_{nucleus}} = \frac{10^{-10}}{10^{-15}} = 10^5$$

* Isotopes :- have the same Z but different N.

$$\underset{Z \to}{{}^{A \to 12}_{6}C_{6}}{}_{\leftarrow N} \ , \ {}^{13}_{6}C_{7} \ , \ {}^{14}_{6}C_{8} \qquad \left(\left({}^{A}_{Z}X_{N}\right)\right)$$

^{14}C is radioactive, but ^{12}C is stable.

* Nuclear Radiation :-

types of nuclear radiation :-

① α- particle (made up of two protons and two neutrons.

$$\alpha \binom{pp}{nn} \equiv {}^{4}_{2}He_{2}^{++}$$

α particle is equivalent to a helium atom that is doubly ionized.

$${}^{A}_{Z}X_{N} \longrightarrow {}^{A-4}_{Z-2}Y_{N-2} + \alpha$$

② β^--decay $\quad n \longrightarrow p + e^- + \bar{\nu}_e$ ← antineutrino

$${}^{A}_{Z}X_{N} \longrightarrow {}^{A}_{Z+1}Y_{N-1} + e^- + \bar{\nu}_e$$

③ β^+ - decay $\quad p \longrightarrow n + e^+ + \nu_e$ ← neutrino

$${}^{A}_{Z}X_{N} \longrightarrow {}^{A}_{Z-1}Y_{N+1} + e^+ + \nu_e$$

④ Gamma decay

$${}^{A}_{Z}X^{*}_{N} \longrightarrow {}^{A}_{Z}X_{N} + \gamma$$ ← gamma

$*$:- excited nucleus.

originates from the nucleus.

⇒ γ-ray has higher energy than X-ray, due to e^- transitions between atomic orbitals.

$*$ Nuclear Radius

$R = 1.2 * A^{1/3}$ ← in fermi $\qquad$ 1 fermi $= 10^{-15}$ m.

For ${}^{12}C \qquad R = 1.2\,(12)^{1/3}$ fm

$*$ Radioactive decay law.

$$N = N_0\, e^{-\lambda t}$$

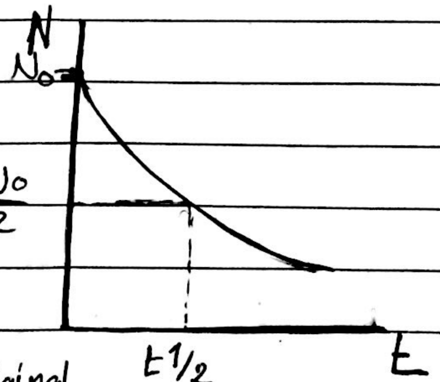
N: number of remaining radioactive nuclei at time t.

N_0: number of radioactive nuclei at $t=0$ (initially).

λ: decay constant related to the probability of decay.

λ has units of $1/\text{time}$.

$*$ Half-life



$t_{1/2}$ ⇒ time required for the number of radioactive nuclei to be half of the original value.

$$N = N_0 e^{-\lambda t}$$

$$N_0 \xrightarrow{t_{1/2}} N_0/2 \xrightarrow{t_{1/2}} N_0/4 \xrightarrow{t_{1/2}} N_0/8 \xrightarrow{t_{1/2}} N_0/16 \xrightarrow{t_{1/2}} N_0/32$$

$$N_0 \longrightarrow N_0/8 \Rightarrow t = 3\, t_{1/2}$$

consider $N_0 \longrightarrow N_0/64$ how many half lives do we need?

$$N/N_0 = 1/64 = (1/2)^n \qquad 1/64 = (1/2)^6 = (1/2)^n \Rightarrow n = 6$$

What is the relation between λ and $t_{1/2}$?

$$N = N_0 e^{-\lambda t} \qquad \cancel{N_0}/2 = \cancel{N_0} e^{-\lambda t_{1/2}}$$

$$1/2 = e^{-\lambda t_{1/2}}$$

$$\ln 1/2 = -\lambda t_{1/2}$$

$$-\ln 2 = -\lambda t_{1/2} \qquad \lambda = \frac{\ln 2}{t_{1/2}} = \frac{0.693}{t_{1/2}}$$

Large $t_{1/2} \Rightarrow$ Small λ

$\Rightarrow$ Small probability of decay.

Small $t_{1/2} \Rightarrow$ Large λ

$\Rightarrow$ Large probability of decay.

for ^{238}U $t_{1/2} \sim 4.5 * 10^9$ years

for ^{131}I $t_{1/2} \sim 8.1$ days.

for some other elements $t_{1/2} \sim \mu s$

* Activity

$$A = -\frac{dN}{dt} = \frac{-d}{dt}(N_0 e^{-\lambda t})$$

$$A = \lambda N_0 e^{-\lambda t} = A_0 e^{-\lambda t}$$

$A_0 \Rightarrow$ activity at $t = 0$

$A = A_0 e^{-\lambda t}$ Also $\boxed{A = \lambda N}$

A has units of decays per second

1 decay per second is called Becquerel.

Five Apple

1 decay per second is called the Becquerel.

$1\ Bq \equiv 1$ decay per second.

Bq is the SI unit.

Curie is more commonly used.

$$1\ \text{curie} = 3.7 * 10^{10}\ Bq.$$
$$1\ Ci = 3.7 * 10^{10}\ Bq.$$

*Example :- The isotope ${}^{14}_{6}C$ has $t_{1/2} = 5730$ years. if at sometime a sample contains 10^{22} ${}^{14}C$ nuclei, what is the activity of the sample?

$$A = \lambda(N_0 e^{-\lambda t})$$
$$= \lambda N \qquad \therefore A = \lambda(10^{22})$$
$$\lambda = \ln 2 / t_{1/2} = 0.693 / 5730$$
$$= 0.693/(5730 * 365 * 24 * 60 * 60)$$
$$\approx 3.83 * 10^{-12}\ s^{-1}$$
$$A \simeq 3.83 * 10^{-12} * 10^{22}$$
$$\sim 3.83 * 10^{10} \text{ decays per seconds} \equiv Bq$$
$$= \frac{3.83 * 10^{10}\ Bq}{3.7 * 10^{10}} \simeq 1\ Ci$$

* Problems :- Chapter 30

[2] radius of ^4_2He

radius $\rightarrow R = 1.2\, A^{1/3}$ ← in units of fermi

1 fermi $= 10^{-15}$ m

~~R=~~ For α: $R = 1.2(4)^{1/3} = (1.2 * 1.59)$ fm.

[37] $\lambda = ?$

$t_{1/2} = 4.5 * 10^{9}$ yrs.

$\lambda = \frac{\ln 2}{t_{1/2}} = \frac{0.693}{4.5 * 10^{9}}$ yrs^{-1} [a] $1.54 * 10^{-10}$ yr^{-1}

$= \frac{0.693}{4.5 * 10^{9} * 365 * 60 * 60 * 24}$

$\simeq 4.88 * 10^{-18}$ s^{-1}

[42] ^{131}I $m = 782\, \mu$gram

[a] $A = \lambda N$

$t_{1/2} = 8.02$ days

$\lambda = \ln 2 / (8.02 * 24 * 60 * 60)$

Molecular mass of $I^{131} = 131$ u

molar mass = 131 grams.

$n = \frac{782 * 10^{-6} \text{ grams}}{131 \text{ grams/mole}} = 5.969 * 10^{-6}$ mole

$N = n N_A \Rightarrow N = 3.59 * 10^{18}$

$A = \lambda N \sim 3.59 * 10^{12}$ $\underbrace{\text{decays / second}}_{Bq}$

$= \frac{3.59 * 10^{12}}{3.7 * 10^{10}} \sim 97$ Ci

$A = A_0 e^{-\lambda t} = 3.59 * 10^{12} * e$

in part (a)

$= 3.546 * 10^{12}$ Bq $= 95.83$ Ci

Five Apple

C after 3 months

$$A = A_0 e^{-\lambda(3*30*24*60*60)} \simeq 4.1 * 10^{-8}\ Ci$$

43 $A = 420$ Bq. , ^{238}U , $t_{1/2} = 4.9*10^9$

$A = \lambda N$

$N = A/\lambda = 8.61*10^{19}$

46 $A_0 = 2.4*10^5$ decay/s

$t_{1/2} = $ ~~1.28*~~ $1.248*10^9$ years.

$A_0 = \lambda N_0 \Rightarrow N_0 = 1.36*10^{22}$

$t_{1/2} = 4.9*10^9$

$n = \frac{N_0}{N_A} = 0.0226$

molar mass $= 40$ grams.

mass $= 0.0226 * 40 \simeq 0.91$ grams.

49 $A = A_0 e^{-\lambda t}$ $t = 9.4$

$\frac{A}{A_0} = e^{-\lambda t} = 1/6$

$1/6 = e^{-\frac{\ln 2}{t_{1/2}}(9.4*60)}$

$\ln\frac{1}{6} = \frac{-\ln 2}{t_{1/2}}(9.4*60)$ $t_{1/2} \simeq 278.2$ seconds.

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Chapter 31

Nuclear radiation is an ionizing radiation.
i.e when this radiation passes through matter, it Leads to Free e^- (radicals) and positive ions.

- Such ions can interfere with the chemical processes inside human bodies.

- ~~At~~ Excess nuclear radiation can cause damage to living cells, and also can cause structural damage to genetic material.

* two types of effects:-

① Somatic damage: affects any cell in human bodies except reproductive cells.
((Not transmitted to offspring))

② Genetic damage
affects reproductive cells, therefore it's transmitted to the off springs.

* Exposure

Unit: Roentgen

(radiation))

1 R ≡ amount of X-Ray or (Gamma-Ray) γ-Ray that deposites $0.878 * 10^{-2}$ Joules of energy per kg of air.

((radiation: X-Ray or γ-Ray
medium: air))

((medium))

* Absorbed Dose ((AD))
amount of energy deposited per kg in any medium by any radiation type.

Units ⟹
SI ⟹ Gray (Gy) = 1 J/kg
or Rad = 0.01 J/kg
((radiation absorbed dose))
Gy ⇒ 100 rad

* Which is more dangerous?
1 Gy of α
or 1 Gy of x-ray
((Note that 'AD' is the same in both ^ .))
∴ We need another measure to determine the effect of radiation on biological cells.

* Effective Dose :- $\boxed{ED}$
ED = AD * QF → quality factor (no unit).
((RBE))

Severt (Sv) ← Gy
rem ← rad
1 Severt = 100 rem

* type of radiation	* QF
X-ray, γ-ray	1
B^+	1
Fast Protons	1
Slow Neutrons	3
Fast Neutrons	up to 10
α	20

⟹ α radiation is the most dangerous to biological cells (check its QF).

Population type	Maximum allowed ED
* Normal People (don't deal with radiation sources)	5 mSv/yr ((0.5. rem/yr))
* People working in radiological units ((People at risk))	up to 50 mSV/yr

⇒ controlled amounts of radiation are used for:

① diagnosis.

② cancer treatment

P.S. Check more details about this Chapter in the Book, for further understanding.

Problems

$\boxed{38}$ 350 rad α

effective dose α = $ED_{x\text{-ray}}$

$AD_\alpha * QF_\alpha = AD_x \, QF_x$

$350 * 20 = AD_x * 1$

$AD_x = 7000$ rad

$\boxed{40}$ $AD = 2.5$ Gy , $m = 65$ kg

$= 2.5$ J/kg

Energy Absorbed $= 2.5 \, J/\cancel{kg} * 65 \, \cancel{kg} = 162.5$ Joules.

$\boxed{41}$ $E_p = 1.2$ MeV $\quad 1eV = 1.6 * 10^{-19}$ J

$E_p = 1.2 * 10^6 * 1.6 * 10^{-19}$ J

$m = 6.2$ kg

$ED = (AD) * (QF)$ — $1 rem = AD * 1$

ⓐ $AD = 1 rad = 0.01$ J/kg

ⓑ Energy absorbed by tumor $= 0.01 \, J/\cancel{kg} * 0.2 \, \cancel{kg} = 0.002$ J

∴ Number of absorbed protons $= 0.002 / 1.2 * 10^6 * 1.6 * 10^{-19} = 1.04 * 10^{10}$ protons.

$\boxed{44}$ $A = 1.6$ mCi , $1 mCi \Rightarrow AD = 10$ mGy/min

$AD = 32$ Gy

$1 mCi \Longrightarrow 10$ mGy/min $\Longrightarrow X = 16$ mGy/min

$16 mCi \longrightarrow x$

Time needed $= 32 Gy / (16 mGy/min) = 2 * 1000 = \boxed{2000 \text{ minute}}$

$\boxed{46}$

122 KeV γ-ray , m = 65 kg swallowed 1.55 mCi
find the dose rate ??
↳ divide by time (Gy/day)

$A = 1.55\ mCi = 1.55 * 10^{-6} * 3.7 * 10^{10}$ decay/seconds
$= 57350$ decays /s
Energy is radiated at a rate of $57350 * 122 * 10^{3} * 1.6 * 10^{-19}$ J/s
$\simeq 1.12 * 10^{-9}$ J/S
$\simeq 9.677 * 10^{-5}$ J/day
* Absorbed energy $= 1/2 * 9.677 * 10^{-5}$ J/day $= 4.8384 * 10^{-5}$ J/day
* To find AD → we divide Absorbed Energy by the mass

$$AD = \frac{4.8384 * 10^{-5}\ J/day}{65\ kg} = 7.44\ J/kg * \frac{1}{day} * 10^{-5}$$
$$= 7.44 * 10^{-5}\ Gy/day$$

THE END

Best of luck in your finals <3 <3