Which is used in rocket fuel?

17TH GROUP ELEMENTS

Continued from 5th November..

- Aqua regia is prepared by mixing three parts of Conc. HCl and one part of Conc. HNO_3 which is used for dissolving noble metals like Gold and Platinum

$Au + 4H^+ + NO_3^- + 4Cl^- \rightarrow AuCl_4^- + NO + 2H_2O$

$Au + 3HNO_3 + 4HCl \rightarrow$
$AuCl_4^- + 3NO_2 + H_3O + 2H_2O$

$3Pt + 16H^+ + 4NO_3^- + 18Cl^- \rightarrow$
$3PtCl_6^{-2} + 4NO + 8H_2O$

- HCl decomposes salts of weaker acids
  e.g : Carbonates ; Hydrogen carbonates; Sulphites

$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$

$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$

$Na_2SO_3 + 2HCl \rightarrow 2NaCl + H_2O + SO_2$

- HCl is used in the preparation of chlorine, NH_4Cl and glucose from corn starch
- HCl is used for extracting glue from bones and purifying bone black
- HCl is used in medicine and as a laboratory reagent

Oxoacids of Halogens: Flourine forms only one oxoacid HOF known as fluoric (I) acid or hypofluorous acid.
All other forms oxy acids of the type HOX, HXO_2, HXO_3 and HXO_4 as shown below.

Halous(I) acid (Hypo halous acid)	HOF (Hypo florous acid)	HOCl (Hypo chlorous acid)	HOBr (Hypo bromous acid)	HOI (Hypo iodous acid)
Halous(III) acid (Halous acid)	- -	HOClO (chlorous acid)	- -	- -
Halic (V) acid (Halic acid)	- -	$HOClO_2$ (chloric acid)	$HOBrO_2$ (bromic acid)	$HOIO_2$ (iodic acid)
Halic (VII) acid (Perhalic acid)	- -	$HOClO_3$ (Perchloric acid)	$HOBrO_3$ (Perbromic acid)	$HOIO_3$ (periodic acid)

- **Oxo acids of Chlorine:**

Acid	Formulae	O.S
Hypochlorous acid	HClO (or) HOCl	+1
Chlorous acid	$HClO_2$	+3
Chloric acid	$HClO_3$	+5
Perchloric acid	$HClO_4$	+7

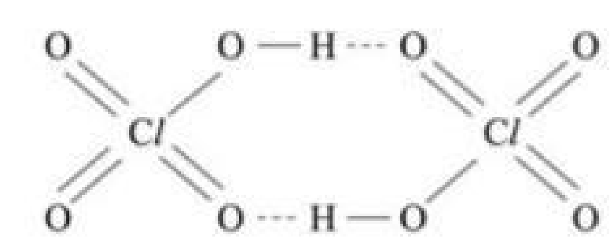
- Cl - O bond length decreases from OCl^- to ClO_4^-
- Cl - O bond energy increases from OCl^- to ClO_4^- except for ClO_3^-
- The order of acidic strength is $HClO < HClO_2 < HClO_3 < HClO_4$

Hypochlorous acid: Chlorine atom in ClO^- ion is sp^3 hybridised with three lone pairs electrons.
- ClO^- ion is stable due to strong tendency to form $p\pi$-$d\pi$ bonding between filled p-orbitals of oxygen and vacant d-orbitals of chlorine.
- Between one oxygen atom and chlorine atom there is σ bond
- It is unstable, dissociates to give nascent oxygen
- It is a strong oxidising agent
- Its salt is called hypochlorite
  e.g. Sodium hypo chlorite NaOCl

Chlorous acid: Chlorine atom in ClO_2^- ion is sp^3 hybridised with two lone pairs of electrons.
- The shape of ClO_2^- ion is angular
- ClO_2^- ion contains 2σ and one π bonds.
- The bond angle is $111°$
- its salt is called chlorite

Chloric acid: Chlorine atom in ClO_3^- ion is sp^3 hybridised with one lone electron pair.
- The shape of ClO_3^- ion is pyramidal.
- ClO_3^- ion contains 3σ and 2π bonds.
- In ClO_3^- ion O-Cl-O bond angle is 106^0

Perchloric acid: Chlorine atom in ClO_4^- ion is sp^3 hybridised with no lone pair of electrons.
- The shape of ClO_4^- ion is tetrahedral.
- ClO_4^- ion contains 4σ and 3π bonds.
- The O-Cl-O bond angle is $109^0 28'$ its salt is called perchlorate.
- Perchloric acid is dimerized due to hydrogen bond.



Structural Parameters of Oxoacids of chlorine

Acid	Cl – O distance (Å)	∠OClO in the anion	Cl – O bond energy in kg mol⁻¹
HClO	1.70	–	209
$HClO_2$	1.64	111°	245
$HClO_3$	1.57	106°	244
$HClO_4$	1.45	109.5°	364

Interhalogen compounds: Halogens react with each other to produce a number of interhalogen compounds of general formulae XX'_n (X'=more electro negative halogen) where n = 1, 3, 5 or 7
The stability of the interhalogen compounds increases as the size of the central atom increases.
ClF_3 and BrF_3 are used for the production of UF_6 in the enrichment of uranium (U^{235}).

- $U_{(s)} + 3ClF_{3(l)} \rightarrow UF_{6(g)} + 3ClF_{(g)}$

Interhalogen compounds can be prepared by direct combination or by the action of halogen on lower interhalogen compounds.

$Cl_2 + F_2 \xrightarrow{437K} 2ClF$
(equal volume)

$Cl_2 + 3F_2 \xrightarrow{573K} 2ClF_3$
(excess)

$Br_2 + 5F_2 \rightarrow 2BrF_5$
(excess)

Inter halogen compounds	Hybridisation	O.N	σ Bonds	Shapes
XA	No hybridisation	+1	1	Linear
XA_3	SP^3d	+3	3	T-shape
XA_5	SP^3d^2	+5	5	Square Pyramidal
XA_7	SP^3d^3	+7	7	Pentagonal bipyramidal

- Interghalogen compounds are covalent and diamagnetic ClF is gas and the rest are solids or liquids at 298K

ADDITIONAL INFORMATION

Fluorine: Scheele discovered this element.
- **Occurence :** Fluorine occur as
  Fluorspar - CaF_2
  Cryolite - Na_3AlF_6
  Fluorapatite - $3Ca_3(PO_4)_2 \cdot CaF_2$
- Fluorine was first prepared by Moissan.
- The preparation of Fluorine was delayed because of its high reactivity and non conducting nature of HF.
- Fluorine is prepared by Whytlaw Gray's method
- The products of electrolysis of fused KHF_2 are hydrogen at cathode and flourine at anode. solids or liquids at 298 K.
- Being polar interhalogen compounds are more reactive than halogens except fluorine.
- All interhalogen compounds undergo hydrolysis giving halide ion.

Type	Formula	Physical state and colour	Structure
MX	ClF BrF IF[a]	Colourless gas Pale brown gas Detected spectroscopically gas	– – –
	$BrCl_s$	Ruby red solid (α-form)	–
	ICl	Brown red solid (β-form)	–
	IBr	Black solid	–
MX_3	ClF_3 BrF_3 IF_3 ICl_3[c] IF_5	Colorless gas Yellow green liquid Yellow powder Orange solid Colourless gas but solid below 77K	Bent T-shaped Bent T-shaped Bent T-shaped Bent T-shaped Bent T-shaped Square Pyramidal
MX_5	BrF_5 ClF_5	Colourless liquid Colourless liquid	Square Pyramidal
MX_7	IF_7	Colourless gas	Pentagonal bipyramidal

[a]Very unstable : [b]Pure solid known at room temperature; [c]Dimerises as Cl-bridged dimer (I_2Cl_6)

- Fluorine prepared in the electrolytic cell is passed through U-tubes containing sodium fluoride to remove HF vapours present in Fluorine as $NaHF_2$

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- In Whytlaw Gray's method rectangular copper vessel acts as cathode and a graphite rod acts as anode.
- In Whytlaw Gray's method graphite anode is surrounded by a perforated copper diaphragm to avoid mixing up of H_2 and F_2.
- Fluorine is most reactive element. It combines directly with all non metals except Nitrogen and Oxygen at room temperature.

$S + 3F_2 \rightarrow SF_6$; $C + 2F_2 \rightarrow CF_4$

Fluorine forms inter halogen compounds.

$Cl_2 + F_2 \xrightarrow{473K} 2ClF$

$Cl_2 + 3F_2 \xrightarrow{573K} 2ClF_3$
(excess)

$I_2 + 7F_2 \xrightarrow{523-573K} 2IF_7$

- Fluorine forms XeF_2, XeF_4 and XeF_6 with xenon.
- Abnormal behaviour of fluorine is due to
  a) small size
  b) highest electronegativity
  c) low dissociation energy for F-F bond and
  d) 2 electrons only in the penultimate shell while other halogens have 8 electrons.
- The abnormal characteristics of flourine are
  a) F_2 exhibits only -1 oxidation state
  b) In its hydride it forms hydrogen bonding and forms HF_2^- ion but of other halogens hydrides do not show hydrogen bonding .
  c) It combines directly with carbon while others do not, even under drastic conditions.
  d) F_2 has a lower E.A compared to Cl_2 even though F_2 is the most electronegative element.
  e) Fluorides have maximum ionic character.
- Fluorine is oxidising agent.
- $2KHSO_4 + F_2 \rightarrow K_2S_2O_8$
  $H_2S + 4F_2 \rightarrow 2HF + SF_6$

Glass dissolves in HF only due to the formation of Hydro fluoro silicic acid (H_2SiF_6).
$SiO_2 + 4HF \rightarrow 2H_2O + SiF_4$
$SiF_4 + 2HF \rightarrow H_2SiF_6$

- HF is used for etching or marking glass.
- Fluoro Chloro Carbon is called Freon. It is used as a refrigerant. (CCl_2F_2)
- Polymeric tetra fluoro ethylene is called Teflon. It is used as an anti corrosive plastic.
- Fluorine is used in the seperation of U^{235} and U^{238} in the form of UF_6 gases based on their rates of diffusion.

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- NaF and Na_3AlF_6 are used as insecticides.
- DDFT is used as fungicide.
- F_2 is used in rocket fuels.
- In Whytlaw Gray method copper metal is used as electrolytic cell
- Because it forms CuF_2 with flourine. CuF_2 layer protects the metal from further attack of flourine
- SF_6 is used as gas faced insulater in high voltage electricity.

Bleaching Powder: Formula of Bleaching Powder is $CaOCl_2$.
- Bleaching Powder is also called chloride of lime.
- The chemical name of Bleaching Powder is calcium chloro hypo chlorite.
- The oxidation states of chlorine in Bleaching Powder are -1 and + 1.
- Bleaching Powder is prepared by the action of dry chlorine and dry slaked lime. This process is called Bachmann process.

$Ca(OH)_2 + Cl_2 \rightarrow CaOCl_2 + H_2O$.

- Principle of counter currents is used in Bachmann process for high yield of Bleaching Powder.
- Bleaching Powder is unstable. On long standing it decomposes to form $CaCl_2$ and $Ca(ClO_3)_2$
  $6CaOCl_2 \rightarrow 5CaCl_2 + Ca(ClO_3)_2$
- The cold aqueous solution of Bleaching Powder contains Ca^{2+}, Cl^- and OCl^- ions.
- The hot aqueous solution of Bleaching Powder contains Ca^{2+}, Cl^- and ClO_3^- ions.
- Bleaching Powder decomposes in the presence of any Cobalt salt liberating Oxygen.
  $2CaOCl_2 \xrightarrow{CoCl_2} 2CaCl_2 + O_2$
- Bleaching Powder reacts with insufficient dil. acids liberates oxygen gas
  $2CaOCl_2 + H_2SO_4 \rightarrow CaCl_2 + CaSO_4 + 2HCl + O_2$
- Bleaching Powder reacts with excess dil. acids to liberate chlorine gas. The amount of chlorine liberated is called "Available Chlorine".
  $CaOCl_2 + H_2SO_4 \rightarrow CaSO_4 + H_2O + Cl_2$
  Similar reaction takes place when CO_2 is passed over bleaching powder paste prepared with H_2O
  $CaOCl_2 + CO_2 \rightarrow CaCO_3 + Cl_2 \uparrow$
- A good sample of Bleaching Powder contains 35 - 38% of available chlorine.
- Bleaching Powder reacts with ethyl alcohol or acetone to form chloroform.
- Bleaching Powder is used as Bleaching agent in textile and paper industry.
- Bleaching Powder is used for the sterilization of drinking water.
- Percentage of Chlorine in bleaching powder is 56%
- Bleaching Powder is used for the manufacture of chloroform.
- It is oxidising agent and chlorinating agent..

Reading of weighing machine is?

NEWTONS LAWS OF MOTION, FRICTION & UNIFORM CIRCULAR MOTION

Continued from November 9th..

Examples:

(i) Centrifugal force and deflection of pendulum relative to accelerating car

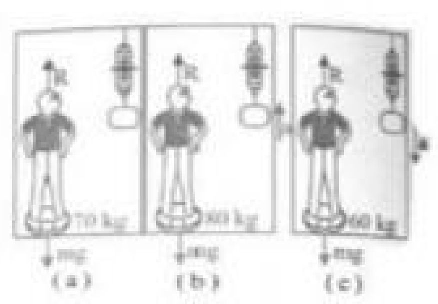
(ii) Gain or loss of weight experienced in an accelerating elevator

Apparent weight of a body in a moving elevator: Weight of a body on a surface comes due to the reaction of a supporting surface, i.e., Apparent weight of a body in a lift

W_{app} = Reaction of supporting surface. Consider a person standing on a spring balance, or in a lift. The following situations are possible

Case (i): If lift is at rest or moving with constant velocity then the person will be in translator equilibrium. So, R = mg

$\therefore W_{ap}$ = mg [as W_{app} = R]



Or $W_{app} = W_0$ [as W_o = mg = true weight]

i.e., apparent weight (reading or balance) will be equal to true weight

Case (ii): If lift is accelerated up or retarding down with acceleration a from Newton's II law we have R-mg=ma or R = m(g+a)

Or

$W_{app}=m(g+a)=mg\left[1+\frac{a}{g}\right]=W_o\left[1+\frac{a}{g}\right]$

Or $W_{ap} > W_o$

i.e., apparent weight (reading of balance) will be more than true weight

Case (iii): If lift is accelerated down or retarding up with acceleration 'a' mg- R = ma i.e., R = m(g - a)

Or

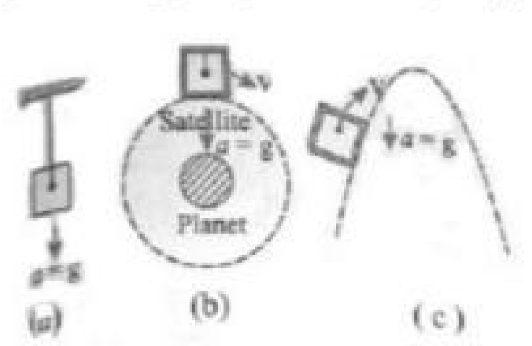
$W_{app}=m(g-a)$[as W_{app} = R]=mg[$1-\frac{a}{g}$]

i.e., $W_{app} = W_o\left[1-\frac{a}{g}\right] W_{ap} < W_o$

i.e., apparent weight (reading of balance) will be lesser than true weight

Note: If a > g, W_{app} will be negative; negative weight will mean that the body is pressed against the roof of the lift instead of floor (as lift falls more faster than the body) and so the reaction will be downwards, the direction of apparent weight will be upwards

Case(iv): If lift is in freely falling. Then a =g, So mg –R =mg i.e., R =0. So, W_{app} =0



a) Freely falling lift
b) Satellite motion
c) Projectile motion

i.e., apparent weight of a freely falling body is zero.

- This is why the apparent weight of a body is zero, or body is weightless if it is in a (i) lift whose cable has broken, (ii) orbiting satellite

W.E – 12: A mass of 1 kg attached to one end of a string is first lifted up with an acceleration 4.9 m/s^2 and then lowered with same acceleration. What is the ratio of tension in string in two cases.

Sol: When mass is lifted up with acceleration 4.9m/s^2

T_1 = m(g + a) = 1(9.8 + 4.9) = 14.7N

When mass is lowered with same acceleration

T_2 = m(g - a) = 1(9.8 - 4.9) = 4.9N

$\therefore \frac{T_1}{T_2} = \frac{14.7}{4.9} = 3:1$

W.E – 13: The apparent weight of a man in a lift is W_1 when lift moves upwards with some acceleration and is W_2. When it is acceleration down with same acceleration. Find the true weight of the man and acceleration of lift

Sol: (a) W_1 = m(g+a), W_2=m(g-a)

$W_1 + W_2$ = 2mg ⇒ $W_1 + W_2$ = 2W ($\because W = mg$)

$\Rightarrow \frac{W_1+W_2}{2} - W$

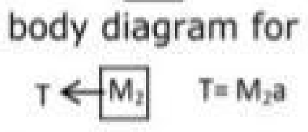
(b) $\frac{W_1}{W_2} = \frac{m(g+a)}{m(g-a)} = \frac{g+a}{g-a}$

$\frac{g}{a} = \frac{W_1+W_2}{W_1-W_2} \Rightarrow a = g\left(\frac{W_1-W_2}{W_1+W_2}\right)$

Connecting Bodies:

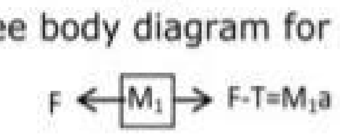
- If masses are connected by strings then acceleration of system and tension in the strings on smooth horizontal surface are

Free body diagram for M_2



.......(1)

Free body diagram for M_1



.........(2)

From (1) and (2)

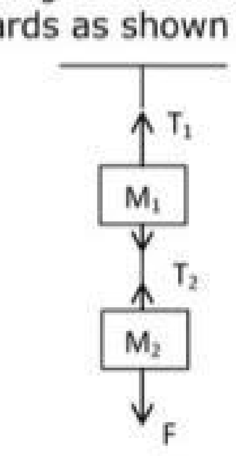
$a = \frac{F}{(M_1+M_2)}$ and $T = \frac{M_2F}{(M_1+M_2)}$

b) 

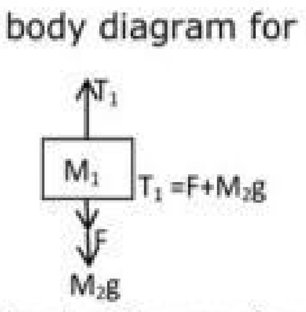
$a = \frac{F}{M_1+M_2+M_3}$; $T_1 = \frac{(M_2+M_3)F}{(M_1+M_2+M_3)}$

$T_2 = \frac{M_2F}{(M_1+M_2+M_3)}$

- If masses are connected by a string and suspended from a support then tension in the string when force F is applied downwards as shown in the figure

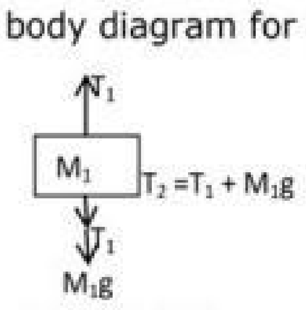


Free body diagram for M_2



.... (1)

Free body diagram for M_1



.... (2)

From (1) and (2)

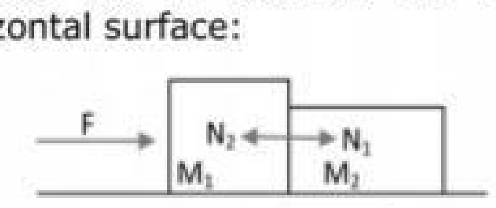
$T_2 = F + (M_1 + M_2)g$

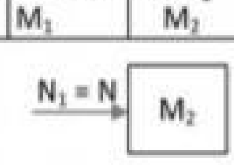
Contact Forces: When two objects are in contact with each other, the molecules at the interface interact with each other. This interaction results in a net force called contact force. The contact force can be resolved into two components

a) Normal force (N): Component of the contact force along the normal to the interface. Normal force is independent of nature of the surfaces in contact

b) Friction (f): component of the contact force along the tangent at the interface. Friction depends on the roughness of the surfaces in contact. This component can be minimized by polishing the surfaces

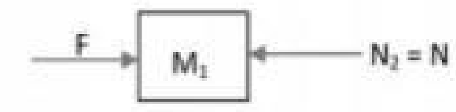
- The tension and contact forces are self adjustable forces. Their magnitude and direction change when other forces involved in a physical arrangement change.
- Masses are in contact on a smooth horizontal surface:





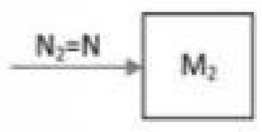
Contact force $N_1 = N_2 = N = M_2a$

Free body diagram for M_1



F-N = M_1a ...... (1)

Free body diagram for M_2

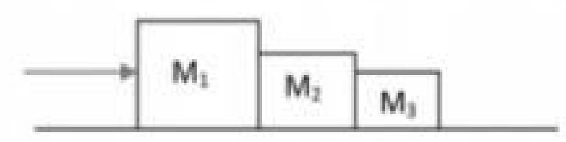


N = M_2a --- (2)

From (1) and (2)

$a = \frac{F}{(M_1+M_2)}$; contact force. $N = \frac{M_2F}{M_1+M_2}$

- Contact forces are as shown in the figure



a) Acceleration of system

$a = \frac{F}{(M_1+M_2+M_3)}$

b) Contact force between M_1 and M_2

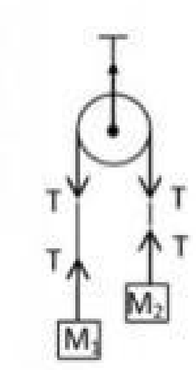
N = $(M_2 + M_3)a$

c) Contact force between M_2 and M_3, $N_3 = M_3a$

INTERMEDIATE special JUNIOR

Atwood's Machine: -

- Masses M_1 and M_2 ($M_1 > M_2$) are tied to a string which passes over a frictionless light pulley. The string is light and inextensible.



Acceleration of the system, $a = \frac{(M_1-M_2)g}{M_1+M_2}$

Tension in the string, $T = \left(\frac{2M_1M_2}{M_1+M_2}\right)g$

Thrust on the pulley, $2T = \left(\frac{4M_1M_2}{M_1+M_2}\right)g$

- If the pulley begins to move with acceleration $\vec{a}$ then

i) If the pulley accelerates upward, then

$a_{net} = \left(\frac{M_1-M_2}{M_1+M_2}\right)(g+a)$

and $T_{net} = \left(\frac{2M_1M_2}{M_1+M_2}\right)(g+a)$

ii) If the pulley accelerates downward, then

$a_{net} = \left(\frac{M_1-M_2}{M_1+M_2}\right)(g-a)$

and $T_{net} = \left(\frac{2M_1M_2}{M_1+M_2}\right)(g-a)$

- Thrust on the pulley when it comes downward with acceleration 'a' is $T = \frac{4M_1M_2}{(M_1+M_2)}(g-a)$

W.E -14: The maximum tension a rope can withstand is 60 kg-wt. The ration of maximum acceleration with which two boys of masses 20kg and 30kg can climb up the rope at the same time is

Sol: m_1 = 20kg, m_2=30kg, T=60kgwt=600N

For 'm_1'; $T-m_1g=m_1a_1$

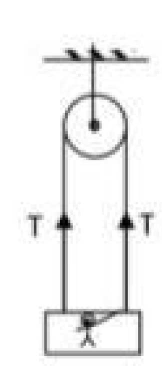
600-20 x 10 = 20 x $a_1 \Rightarrow a_1=20ms^{-2}$

For 'm_2'; $T-m_2g=m_2a_2$

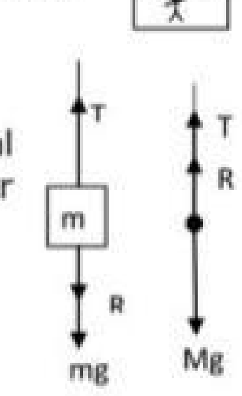
600-30x10=30x$a_2 \Rightarrow a_2=10ms^{-2}$

$a_1:a_2$ = 20 : 10 = 2:1

W.E - 15: A man of mass 60kg is standing on a weighing machine kept in a box of mass 30kg as shown in the diagram. If the man manages to keep the box stationary, find the reading of the weighing machine.



Sol: We know that Normal reaction = scale reading for man. T = Mg - R



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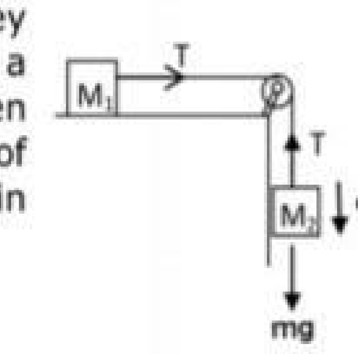
For box: T = mg + R

Mg – R = mg + R ;   2R = (M – m)g

R = $\frac{(60-30)\times10}{2}$ = 150N

- Two blocks are connected by a string passing over a pulley fixed at the edge of a horizontal table then the acceleration of system and tension in the sting ($M_2 > M_1$)



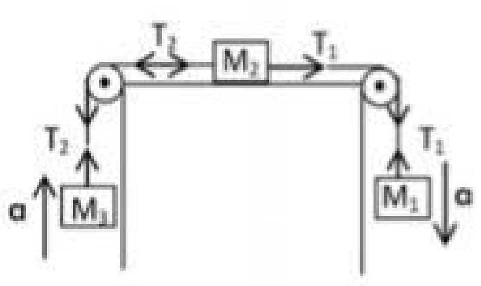
$M_2g - T = M_2a$

and $T=M_1a$

$\Rightarrow a = \frac{M_2g}{(M_1+M_2)}$

$T = M_1a = \frac{M_1M_2g}{(M_1+M_2)}$

- Acceleration and Tension in the string when bodies are connected as shown in the figure if $M_1 > M_3$.



$M_1g - T_1 = M_1a$; $T_1 - T_2 = M_2a$

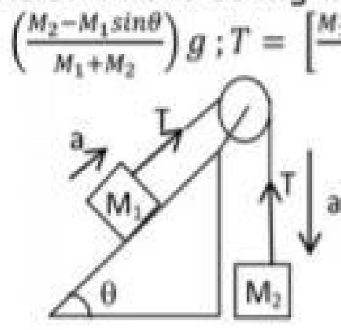
$T_2 - M_3g = M_3a$

$\Rightarrow a = \frac{(M_1-M_3)g}{(M_1+M_2+M_3)}$ $T_2 = \frac{M_3g(2M_1+M_2)}{M_1+M_2+M_3}$;

$T_1 = \frac{M_1g(2M_3+M_2)}{M_1+M_2+M_3}$

- Masses are attached to a string passing through the pulley attached to the edge of an inclined plane acceleration of system and tension in the string if M_2 moves down

$a = \left(\frac{M_2-M_1sin\theta}{M_1+M_2}\right)g$; $T = \left[\frac{M_1M_2(1+sin\theta)}{(M_1+M_2)}\right]g$

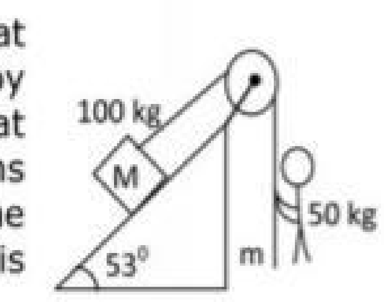


Trust on the pulley : Resultant Tension =

$T_g = \sqrt{T^2+T^2+2T^2\cos(90-\theta)}$

$T_g = \sqrt{2T^2(1+sin\theta)} = T\sqrt{2(1+sin\theta)}$

W.E – 16: By what acceleration the boy must go up so that 100kg block remains stationary on the wedge. The wedge is fixed and is smooth.($g=10m/s^2$)



Sol: For the block to Remain stationary,

T = Mg sinθ

= 100 × 10 × sin53

=100 × 10 × $\frac{4}{5}$ = 800 N

For man; T – mg = ma

T = m(g+a) ⇒ 800 = 50(10+a) a = 6m/s^2

- If position of masses is interchanged, then the tension in the string and acceleration remains unchanged. Acceleration and Tension in the string when bodies are connected as shown in the figure.