ENGINEERIN MECHANICS PRACTICAL FILE

1st Semester CIVIL ENGG.

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03.	Verification of Lami's theorem	22-02-19	25-02-19	
04.	Forces in members of a jib crance	25-02-19	01-03-19	
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	string is 50N, 70N and 60N respectively. Find graphically the magnitude of the pulles on two another string.			
12.	Find the magnitude and direction of resultant forces which are given in the experimental work.	01-04-19	05-04-19	
13.	Find graphically the resultant of like parallel forces are shown in figures. Also find where the point resultant.	05-04-19	15-04-19	
14.	Find graphically the resultant of forces shown in the figures. Also find the point where resultant forces acting.	15-04-19	22-04-19	
15.	Determine the reaction forces of a simply supported beam as shown in the figure.	22-04-19	10-05-19	[illegible signature] 28/5/19

Engineering Mechanics

Experiment No. – 01

Aim :

To verify the law of polygon of forces, by using force board.

Apparatus required :-

Consist of a wooden board with two wall brackers, four adjustable frictionless pulleys and a set of weight.

Theory :-

law of polygon of forces state that "If a number of forces, acting simultaneously on a particle, be representated in magnitude and direction by the sides of a polygon taken in order, then the resultant of all these forces may be representated in magnitude and dir^n, by the closing side of the polygon, taken in opposite order."

If any number of complanner forces acting on a particle be presented in mag. and dir^n, taken in Order. They shall be in equilibrium a closed polygon, taken can be down whose sides represent these forces both in magnitude and dir^n. The converse of polygon law of forces is true in the sence that of any number of co-planner forces acting at a

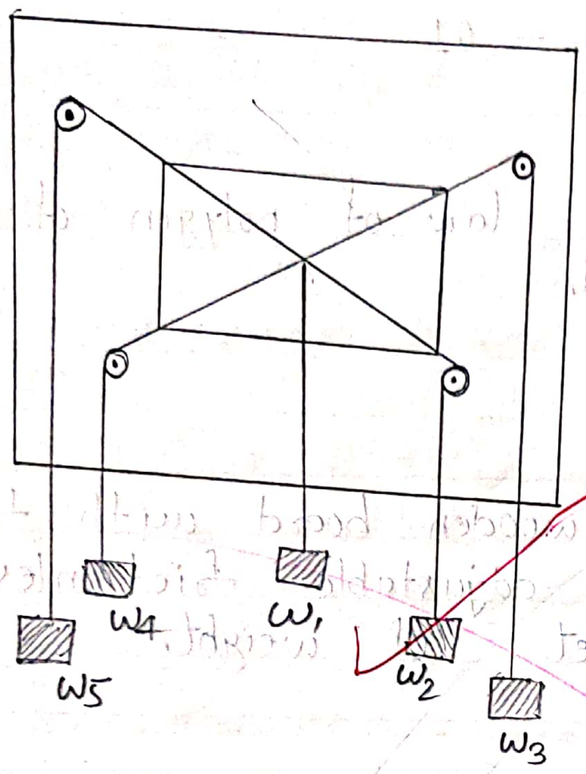


Figure-(a)

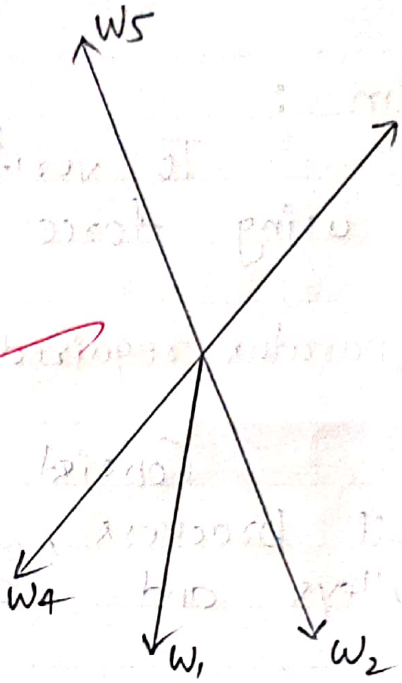


Figure-(b)

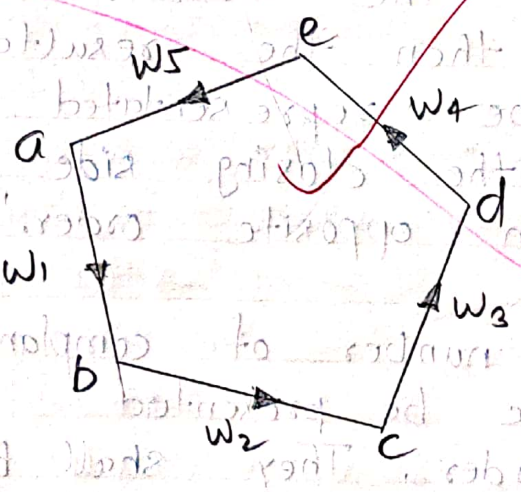


Figure-(c)

point are in equillibrium and if sides are drawn parallel and proportional to the forces then they can not be represented by the sides of such a polygon as only number of such.

Polygons can be drawn. Therefore the the converse of polygon law of forces is not true in the same way as the converse of triangle law of forces.

Suggested Experimental Work :-

Step 01 :

Fix the white sheet of paper on the force board with the help of drawing pins.

Step 02 :

Attach your strings passing through the four pulleys whose one ends is attached to common mode of and other end is connected to the known weight. Attach one more string with the central node whose other end is connected with the pan.

Step 03 :

Place weights in the pan so that the central node is in the central position of the board i.e. these are in equillibrium.

Step 04 :

After this mark the points on the sheet on the points of the strings in the same direction.

Step 05 :

Remove the white sheet and drawn lines with the help of the points marked. These lines meet at a point.

Step. 06 :

Drawn Lines selecting a suitable scale for loads on the sheet and complete a polygon as shown in figure.

Step 07 :

Repeat the experiments by changing the weights.

Results and Discussions :~

(1.) Measure the last line of the polygon (force closes the polygon). This will be equal to the fifth for verification of the law.

(2.) Find out the persentage error.

Let,

Scale 1cm = 9m weight.

Si. No.	Weights (In Kg)					Experiment at weight $ea = \vec{w_5}$	Percentage error $= \frac{w_5}{\omega s} \times 100$
	W_1	W_2	W_3	W_4	W_5		
1.	20	30	40	50	34	33.25	2.205
2.	22	34	42	60	38	37.78	0.576
3.	16	21	32	44	27	27.27	01

Results :–

Average, error percentage = 3.116

Precautions :–

- There should not be any knot in the string.
- Weights should be frictionless.
- Pulleys should be placed gently.

- While putting the points on the sheets the threads should not be disturbed.

- Threals and weights should not touch the board. Board should be vertical.

Experiment No. - 02

Aim :-

To verify the principal of moments using the bell crank lever apparatus.

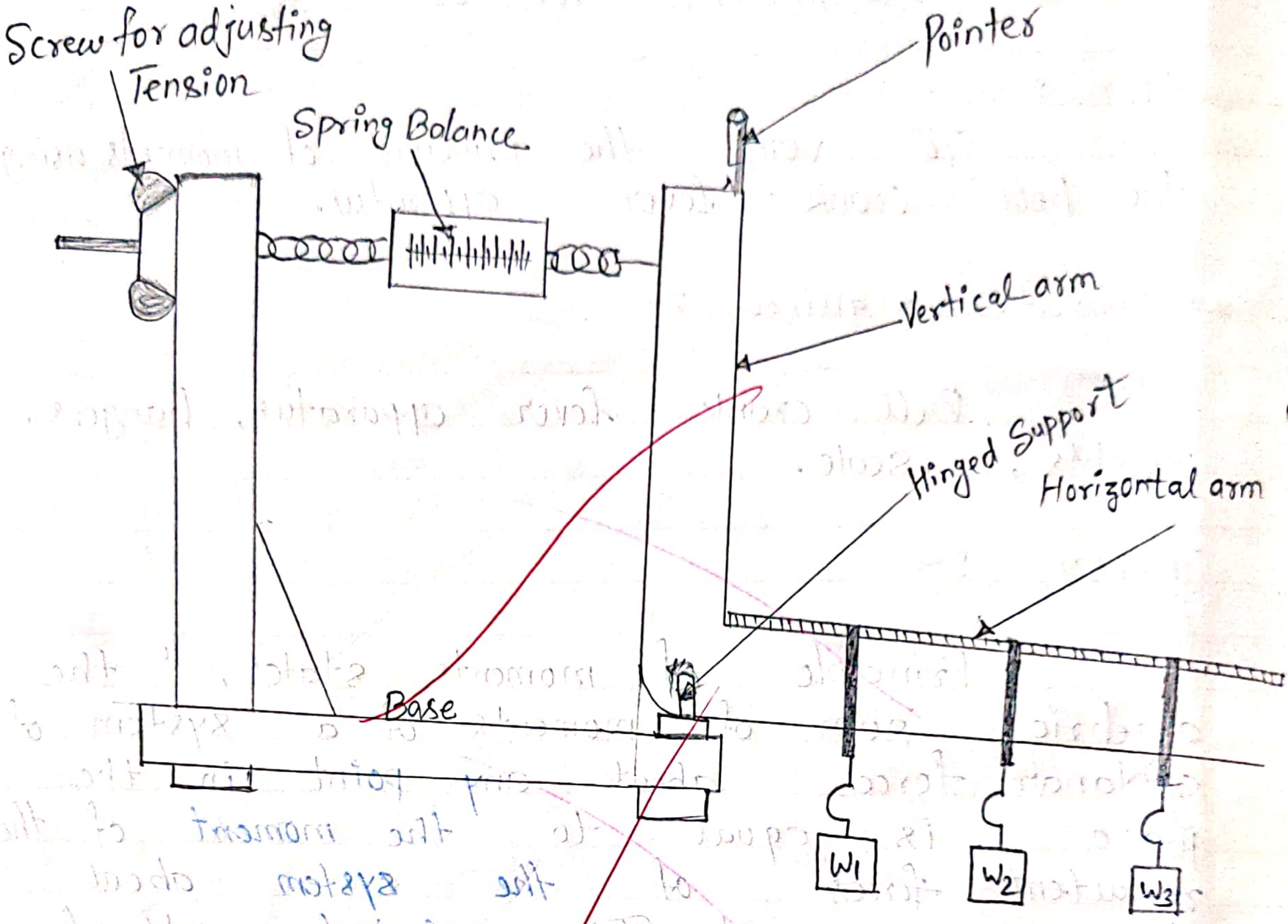
Apparatus required :-

Bell crank lever apparatus, hangers, weights, scale.

Theory :-

Principle of moments states, " the algebric sum of moments of a system of coplanar forces about any point in the place is equal to the moment of the resultent forces of the system about the same point. This principal would be varified for a bell crank lever arrangement.

A laver whose two arms from a right angle, or nearly a right angle and having its felcrum of the appex of the angle is referred to as a bell crank lever. These levers were originally used to operate the bell from a long distance especially where change in direction of bell wires was involved and hence the name.



→ Bell Crank Lever Apparatus

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Experiment No. - 03

Aim :- To verify Lami's theorem.

Apparatus Required :-
Three sets of slotted weights thread, white papper, scale, protractor compass and pencil.

⇒ **PROCEDURE :-**
The weight in the hangers P, Q and R are adjusted such that the point O is at reast. A small displacement is given to the system so as to overcome the friction in the pulleys. A drawing paper is fixed on the board, behid the strings. The forces are the three strings is taken on the sheet of papper, using an adjustable lamp arrangment in front of the threads. The face sheet is removed and the lines are joined to get the image of the threads. These lines meet at a point O.

Formula :-
To verify Lami's theorem, it is to be shown that.

$$\frac{P}{\sin\alpha} = \frac{Q}{\sin\beta} = \frac{R}{\sin\gamma}$$

where, P, Q and R are the forces, α, β and γ are the angles opposite to P, Q and R respectively.

→ To Verify LAMI'S THEOREM :-

In all the three figures drawn in the trace sheet, the angles between the forces are marked. The angle between the forces R, Q & R are removed / marked as α. The angle between the forces R & P is marked as β. The angle of between P & Q is marked as γ as shown in the figure. The angles are measured and entered in the corresponding tabular coloum. To check the accuracy of angle measurement for each case, the sum of the three angles measured should be equal to 360°

i.e. $(\alpha + \beta + \gamma) = 360°$

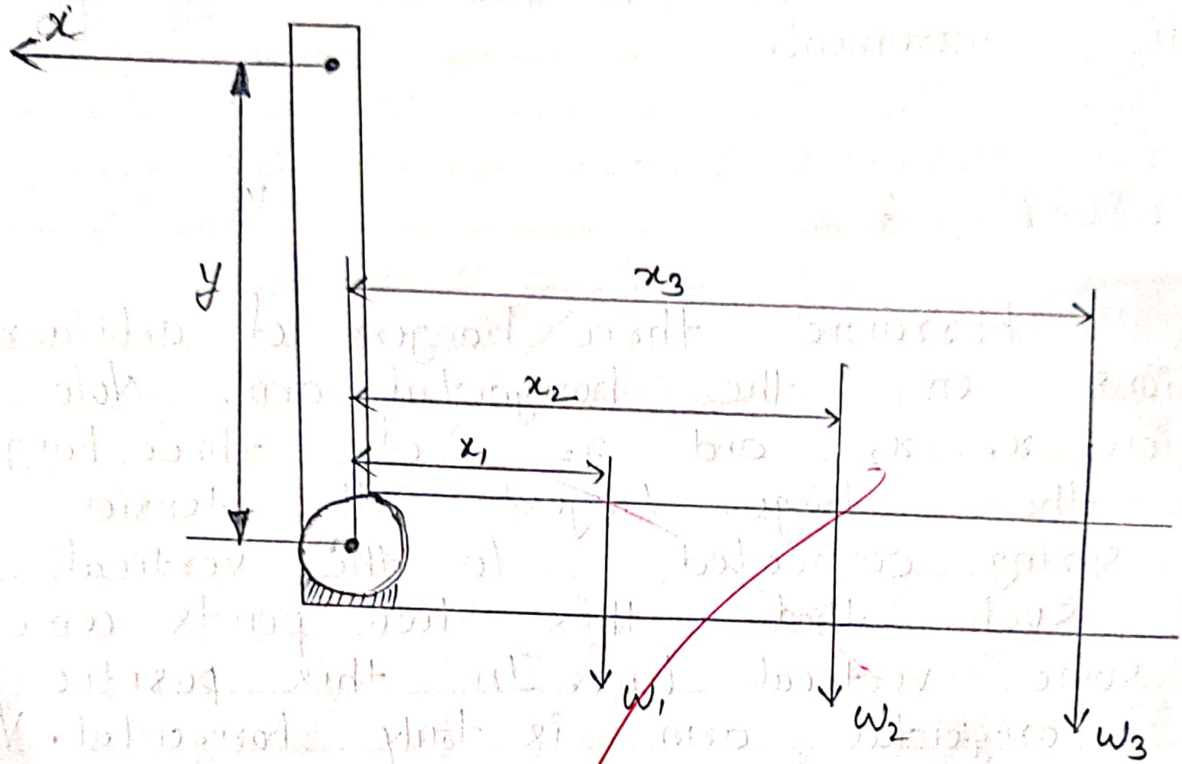
Then the calculation are done using the given formula and the values are entered in the tabular column.

Now bell crank levers are used in machines to convert the direction of reciprocation movement.

→ PROCEDURE :~

01. Arrange three hangers of arbitarry locations on the horigantal arm. Note the location x_1, x_2 and x_3 of three hangers from the hinge. Adjust the tension in the spring connected to the vertical arm such that thes two points come in the same vertical line. In this position the horizental arm is truly horigontal. Note the tensile force in the spring as the initial tension T_1. Also note the location y of the spring from the hingle.

02. Hang the weights W_1, W_2 & W_3 from the hangers. This will cause the arms to tilt and the pointers to move the spring such that the pointers once again come in the same vertical line. The horizental arms is once connected. Note the tensile force in the spring as the final tension T_f. The tensile force T on the vertical is the difference $T_f - T_s$.



⟹ Free Body Diagram

03. Since the external forces are being supported by the single hingle at the apex of the arms; implied that the resultant of these external applied forces passes through the supporting hinge. Therefore to verify the principle of moments we need to take moments (Em) of all the external forces (which includes the weight of the hangers hanging from the horizental arm and the tension in the spring connected to the vertical arm) about the hinge and if the total sum is zero. Verifies the law of moments since the moment of the resultant is also zero at the hingle.

4. Repeat the above steps by changing the weights and their location on the horizental arm for two more set of observations.

→ CALCULATIONS :~

Summation moments of all external forces at the hingle O.

$$EM_O = T \times Y - W_1 \times X_1 - W_2 \times X_2 - W_3 X_3$$

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→ Results :~

The sum of moments of all the applied external forces on the bell crank lever. within limits of experimental error being close to zero, is in accordance to the principal of moments.

Hence, the experiment is verified.

→ PRECAUTIONS :~

01. Do not overload the horizental arms as it may bend or crack at the hinge.

02. Note if any, the zero error of the spring balance and accordingly correct the readings of the tensile force.

03. Carefully placed the loads in the hangers as they may slip and cause accident.

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→ DESCRIPTION :~

A drawing board is supported vertically on a wall. The two smooth pulleys are fixed at the two top cornor of the board, so that they can rotate freely. Two weights hangers P & Q are attached to the two ends of a long thread, after passing through the pulleys. The third weight hangers R is attached to the middle of the thread as shown in fig.

→ Result :~

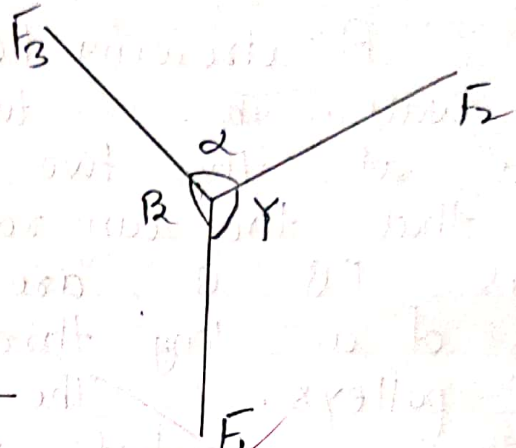
(i) In the tabular coloum in all case it is seen that the values in the least three colums are found to be equal.

i.e. $\frac{P}{\sin\alpha} = \frac{Q}{\sin\beta} = \frac{R}{\sin\gamma}$

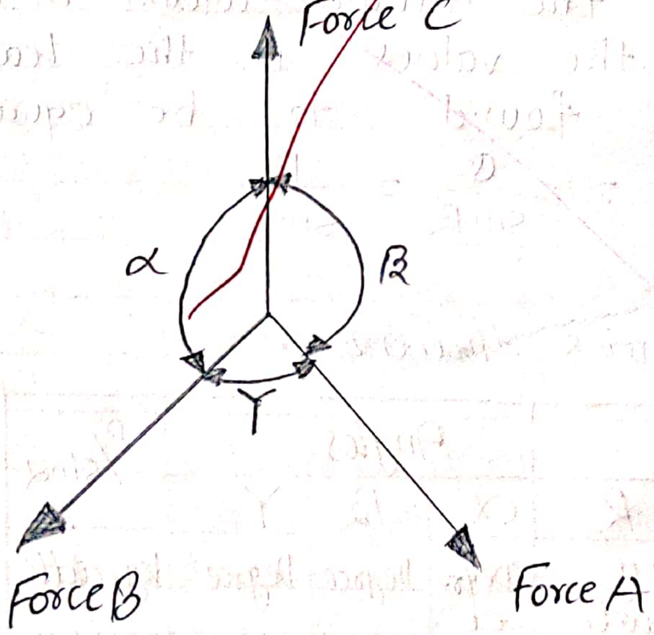
→ To Verify Lami's theorem :~

Sl. NO.	Forces			Angles			$P/\sin\alpha$	$Q/\sin\beta$	$R/\sin\gamma$
	P	Q	R	α	β	γ			
Unit	Kg. wt	Kg. wt.	Kg. wt	Degree	Degree	Degree	kg. wtt	Kg. wtt	Kg wtt
01.	20	10	15	120°	150°	90°	23.09	20	15
02.	30	35	40	45°	45°	270°	42.426	32	56.56
03.	18	16	175°	45°	150°	150°	114.73	25.45	32

Lami's Theorem



$$\frac{F_1}{\sin\alpha} = \frac{F_2}{\sin\beta} = \frac{F_3}{\sin\gamma}$$



→ Calculation :-

(i) P = kg.wt , Q = kg.wt , R = kg.wt
$\alpha = 0°$, $\beta = 0°$, $\gamma = 0°$

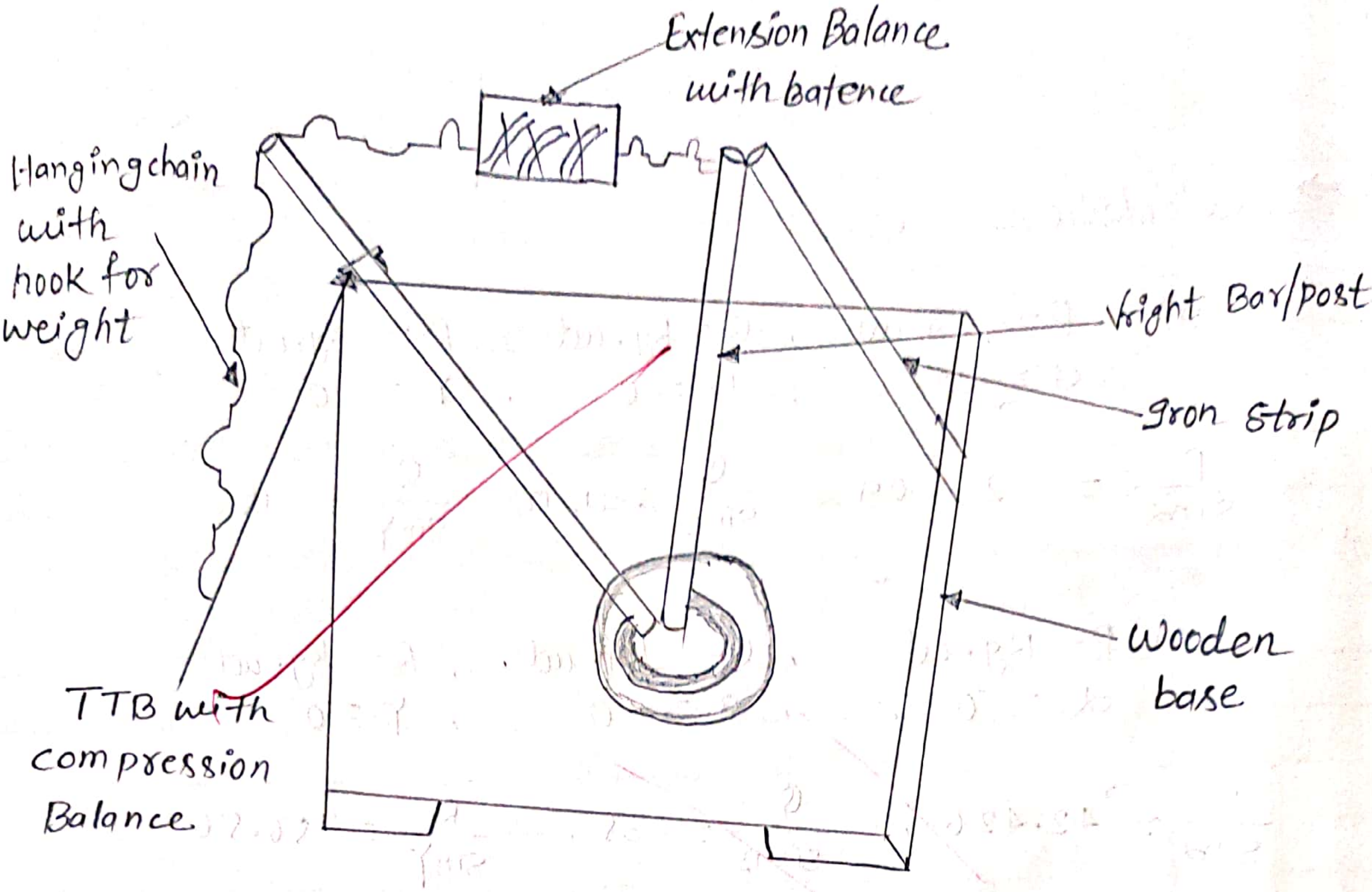
$\frac{P}{\sin\alpha} = 23.09$ $\frac{Q}{\sin\beta} = 120$ $\frac{R}{\sin\gamma} = 15°$

(ii) P = kg.wt , Q = kg.wt , R = kg.wt
$\alpha = 0°$, $\beta = 0°$, $\gamma = 0°$

$\frac{P}{\sin\alpha} = 42.426$, $\frac{Q}{\sin\beta} = 35$, $\frac{R}{\sin\gamma} = 56.56$

(iii) P = kg.wt , Q = kg wt , R = kg wt
$\alpha = 0°$, $\beta = 0°$, $\gamma = 0°$

$\frac{P}{\sin\alpha} = 114.73$, $\frac{Q}{\sin\beta} = 25.45$, $\frac{R}{\sin\gamma} = 32$.


Extension Balance with batence
Hangingchain with hook for weight
Uright Bar/post
Iron Strip
Wooden base
TTB with compression Balance

Experiment No. :- 04

Aim :-

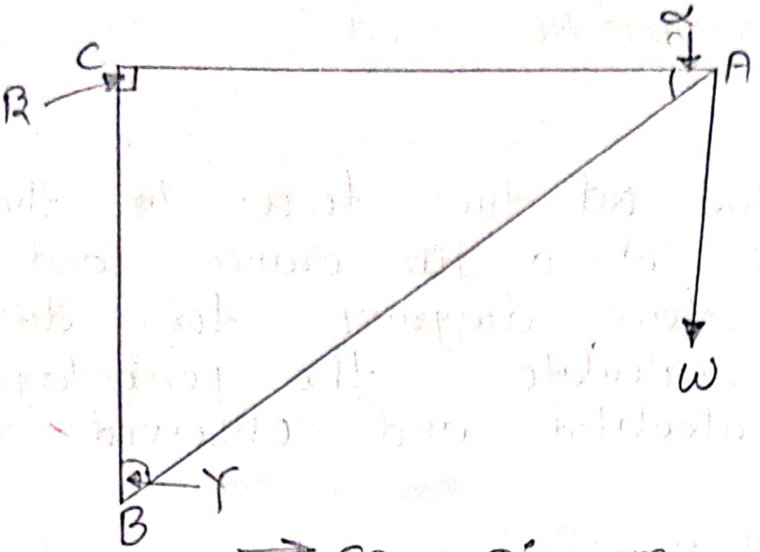
To find out the forces in the job and the tie of a jib crance and to draw the force diagram for different loads. Also calculate the percentage error b/w the calculated and observed values.

Apparatus required :-

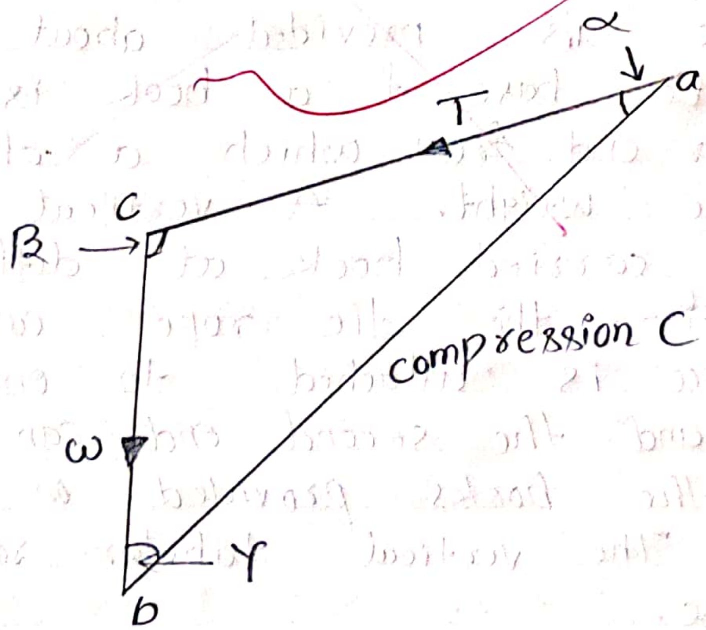
The jib crance apparatus consists of a tabular jib with a compression balance. The balance is provided about an axis fitted to the base of a hook is attached to the other end from which a chain hangs to carry the weight. A vertical tabular rod rod (post) carried hook at different levels. One end of the tie rope carrying a spring balance is attached to one end of the jib and the second end can be attached to any of the hooks provided on the vertical tabular rod. The vertical tabular rod is fixed to a base.

Theory :-

Triangle law of force will be applied in the apparatus. It states of two forces acting simultaneously on a particle berepresented



→ Space Diagram



Vector diagram

magnitude and direction by acting the two sides of triangle taken in order, their resultant may be represented in magnitude and dir^n by the third side of the triangle, taken in opposite order.

→ Sugested Experimental work :~

Step-1 : Note down the initial reading oan zero error in the compression balances and the tension spring balance separetly.

Step-02 : Suspend a known wt from the i.e the hook and hanging chain and note book the final reading of the balance separately.

Step-03 : Substract the initial reading from the final readings. The tension spring balance will be give the observed value of the force in the tie and that of the observed value of the force in the tie and that of the compression balanee, the observed value of the fore in the job.

Step : 04

Measure the length of the vertical post, ties jib.

Step : 05 :— From there measurement drawn the space diagram.

Step: 06 :- Select the suitable scale and draw the parallel to BC and cut equal to draw co- parallel to CA & ab paralled to AB meeting at a then vectors ca & ab represents forces in the tie and jib respectively.

Mathematically,

In ABC measure α, β and γ using sine law, we get,

$$\frac{W}{\sin\alpha} = \frac{c}{\sin\beta} = \frac{T}{\sin\gamma}$$

The value of C & T can be calculated. The prent age angle can be calculated in the observed & calculated values of the forces in the jib and ties.

Step : 07

Increase the weight at a and prosessed as before take in the way about cranee reading.

Sample Data Sheet :-

D_1 = diameter of the angle B = 30 MM
D_2 = " " " " e = 28 MM
W = Load lifted by the M/C and = 280 N
P = effort applied to lift the weight = 260 N

In obs revolution of effart wheet A, then distance moved by effort = πD

Length of string that winds on the larger axe B in one revolution = πD_1

Length of spring that unwinds from the axle cine one revolution = πd_2

Since,

$d_1 > d_2$:

The winding of rope on C is more than the unwinding on B.

∴ In one revolution the length of spring will wound on axle B = $\pi d_1 - \pi d_2$

∴ Distance through which the load is lifited

$$= \frac{\pi(d_1 - d_2)}{2}$$

$$\therefore \text{V.R.} = \frac{\text{Distance moved by the effort}}{\text{" " " " load}}$$

And load lifited by $= \dfrac{\pi D}{\frac{1}{2}(\pi d_1 - \pi d_2)}$

$$= \frac{2D}{d_1 - d_2}$$

Since distance moved by the load is half, as the rope is passing over the pulley.

Now mechanical advantage M.A. $= \frac{W}{P}$

$\eta = M.A / V.R$

Zero error in the tension spring balance
" " " " Compression balance.

Length of the tie, cm
" " " jib, cm
" " " post, cm

Sl No.	Final reading on balance Tie, Jib	Observed forces from balance Tie, Jib	calculated force graphically Tie, Jib	% error Tie, Jib
1.	260°	280°	268.5	4.10%

→ Result :-

Mean percentage error is 0.6

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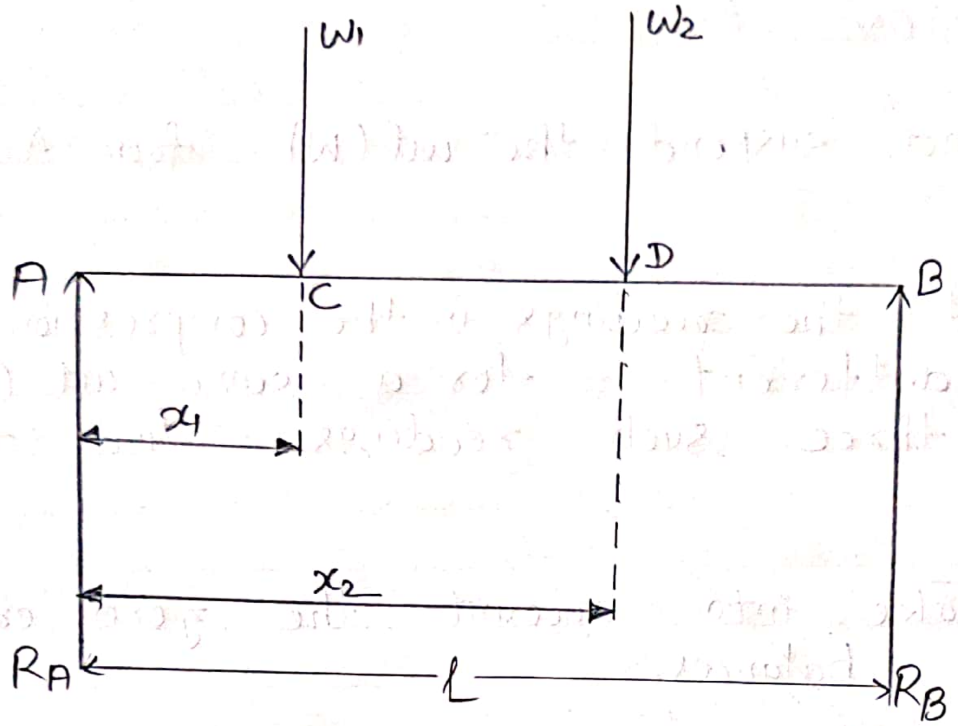
→ PRECAUTION :-

01. Do not suspend the wt (W) from A with a jerk.

02. If the readings in the compression balances are different for a same wt (W) then three such readings find their mean.

03. Take into account the zero error of the balances.

04. Measure the length with a fix mirlensible thread.



⟹ Beam loaded with weight

Experiment No. : 05

Aim :-

To verify the reaction of a simply supported beam at the supports.

Apparatus required :-

Consist of two dial type compression balance and a wooden let fixed at a wooden board.

Theory :

If a system of coplanner forces acting an a rigid body keep it in equilibrium then the algabric sum of their moments about any point in their plane is zero.

Reactions in a simply supported beam are determined by using the principal of moments of all the force about a point is zero, for equilibrium condition. Virnigon's principle of moments states. "If a number of coplanner forces are acting simultaneously on particle, the algebric sum of the moments of all the forces about any point is equal to the moment of their resultant force about the same point.

In the figure, AB is a simply supported beam at A and B when two loads W_1 & W_2 are applied at points C & D situated at distances x_1 & x_2 respectively from end A. the from Newton's third law, reactions R_A & R_B are developed at A & B supports. Applying conditions of equilibrium.

We have :-

(A) $\Sigma V = 0, \therefore R_A + R_B = W_1 + W_2$ — (i)

(B) $\Sigma V = 0$, Taking moment about A,

$$-R_B L + W_2 x_2 + W_1 x_1 = 0$$

$$R_B L = W_2 x_2 + W_1 x_1$$

$$R_B = \frac{W_1 x_1 + W_2 x_2}{L} \quad \text{— (ii)}$$

From (i) and (ii)

$$R_A = W_1 + W_2 - R_B \quad \text{— (iii)}$$

→ Suggested Experimental work :~

Step 01 :~ Measure the distance L.

Step 02 :~ Name the zero error in the compression balances. When the beam is supported at it ends A & B. Let then be r_1 & r_2.

Step 03 :~ Suspend to weights W_1 & W_2 at distances x_1 & x_2 from A.

Step 04 :~ Note the reaction on the beam given by the readings of compression balances and takes into account the zero error from each reading. Readings thus obtained are R_A & R_B.

Step 05 :~ Calculate the R_A calculated and R_B calculated from equation (ii) & (i).

Step 06 :~ Repeat the experiment by talking different positions of W_1 & W_2.

Step 07 :~ Find out percentage error between (i) & (ii).

SAMPLE DATA SHEET :~

01 m = 100 cm

Zero error in compression balance No. - 1

Zero error in compression balance No. - 2

Sl. No.	Weights on beam and their distance from point A.				Final reading at A & B		Reactions observed		Reaction from calculation		% error in R_A & R_B	
	W_1	W_2	x_1	x_2	Ta	Tb	R_A = Ta - Tb	R_B = Ta - Tb	R_A cal.	R_B cal.	R_A	R_B
01.	50	100	2	4	34.5	200.45	66.50	83.42	66.67	83.3	0.254	0.144
02.	80	120	2	3	160.27	230.60	130	70.07	70.07	70	0.092	0.1
03.	60	80	1	2	42.40	57.42	103.53	36.42	36.42	36.6	0.067	0.049

Results :-

Mean % error in RA = 0.368
Mean % error in RB = 0.244

→ PRECAUTIONS :~

- Zero error of the compression must be taken into account.
- Weights should not be put on the beam with a jerk.
- ~~Slightly press the beam to the remove any frictional resistance at the supports before taking the readings.~~
- All distances x_1, x_2 & C should be measured accurately.
- Readings of spring balances at A & B should be taken.

Experiment No. 06

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Aim :-

To determine the mechanical advantage, velocity ratio and efficiency of a differential wheel and axle.

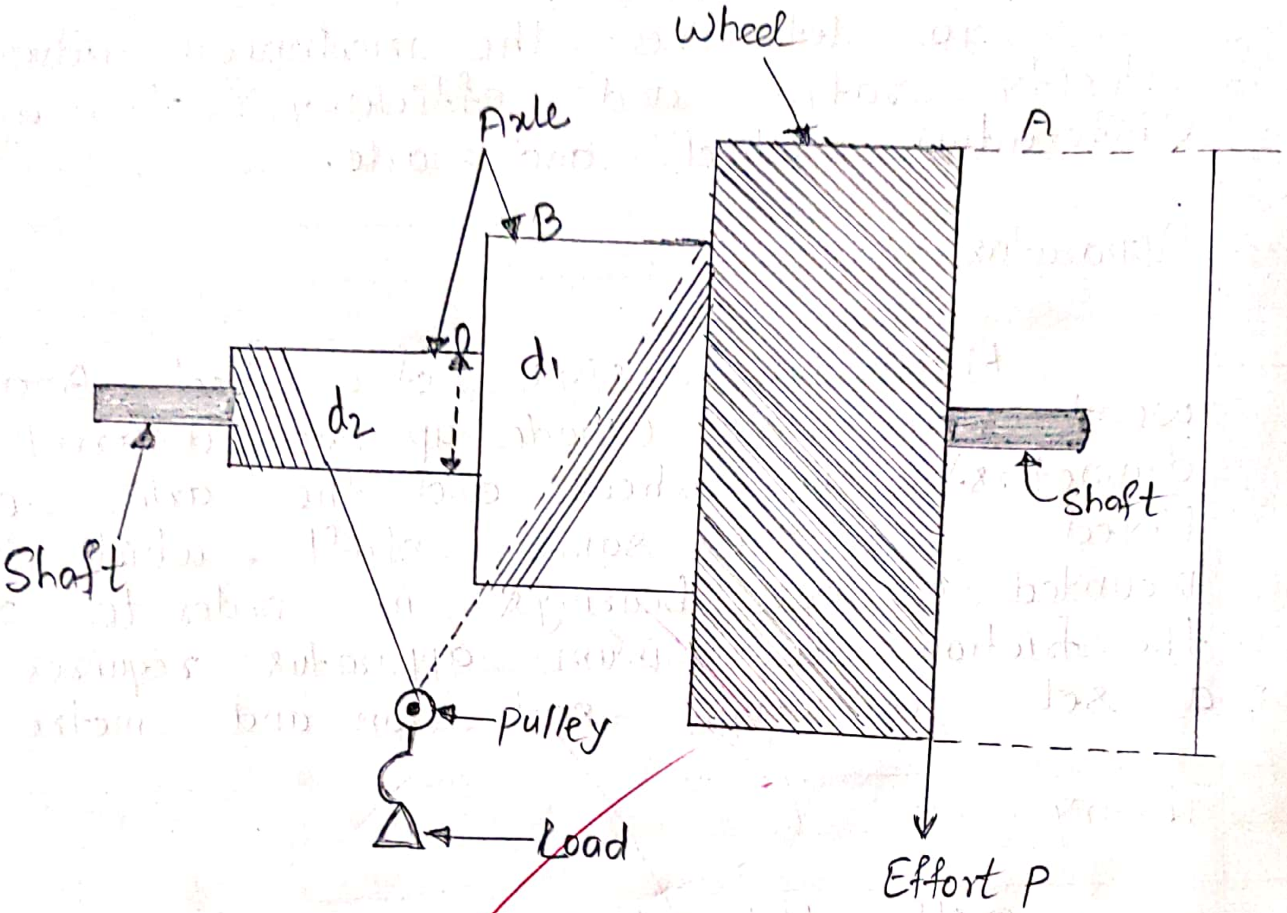
Apparatus Required :-

Apparatus consists of a wheel A and B wond axle BC (made up two different diameters.) The wheel and the axle are keyed to the same shaft, which is maunted on ball bearings in order to reduce the friction to minimum apparatus requires rope, a set of weight, scale pan and metre scale.

Theory :-

Differential wheel and axle is used to lift heavy loads in differential wheel and axle, the axle used is a compound axle. The axle is made in two different diameters and is fitted on the same shaft to which the wheel the wheel is keyed.

A rope is wound round the two parts of the axle through a pulley having a hook to lift to load w. The direction of the winding is opposite to each other. Another rope is wound over the wheel at the free end of which,



⟹ Differential Wheel and Axle

effect P is applied.

The directions of windings of these two strings on the axle are such the wheel string of wheel unwinds, then string of extreme right axle unwind, but it winds on the centre axle. It means that directions of windings of two string on wheel and extreme right axle should be same.

Let,

D = Diameter of the effort wheel A
d_1 = Diameter of the axle B
d_2 = Diameter of the axle C
W = Load lifted by the M/C and
P = Effort applied to lift the weight.

In one revolution of effort wheel A, then distance moved by effort $= \pi D$

Length of strinking that winds on the larger axle B in one revolution $= \pi d_1$

Length of string that unwinds from the axle C in one revolution $= \pi d_2$

Since,

$d_1 > d_2$, the winding of rope on C is more than the unwinding on B.

∴ In one revolution the length of string which will wound on axle is $\pi(d_1 - d_2)$.

∴ Distance through which the load is lifted

$$= \frac{\pi d_1 - \pi d_2}{2}$$

$$\therefore V.R. = \frac{\text{Distance moved by the effort}}{\text{Distance moved by the load}}$$

Add load lifted by,

$$= \frac{\pi D}{1/2(\pi d_1 - \pi d_2)}$$

$$= \frac{2D}{d_1 - d_2}$$

(Since distance moved by the load is half, as the rope is passing over a pulley).

Now, Mechanical advantage $M.A = W/P$

$$\eta = \frac{M.A}{V.R}$$

$$\text{Efficiency} = \frac{W/P}{2D} \times 100$$

$$= \frac{2D}{d_1 - d_2} = \frac{W}{P} \times \frac{d_1 - d_2}{D} \times 100\%$$

In this machine the axle is called differential for the reason that the joint action of the two parts of the axle is differential i.e. the action of one subs- tracts from the action of the other.

→ Suggested Experimental Work :-

Step 01 : Wind the string on the effort wheel and attach scale pan / hanger ~~to~~ any effort P.

Step 02 : Wind other string on the larger axle and bring it to other side of smaller axle.

Step 03 : Put movable pulley to carry load through scale pan.

Step 04 : Now place the weight slowly in the effort pan unless and untill the load pan just starts to lift up.

Step 05 : Note the weight placed in the effort pan.

Step 06 : Repeat the above procedure to different weight in load pan.

SAMPLE DATA SHEET

Diameter of wheel (load drum) D, cm = 282 cm
Diameter of bigger axle d_1 cm = 130 mm
" " smaller " d_2 " = 65 mm

$$V.R. = \frac{2D}{d_1 - d_2}$$ To be worked out 8.27

Weight of load pan/hanger a gm = 25 gms
" " effort " " a gm = 307 gms

Sl. No.	Load: wt. in pan. w_1 (gm)	Load: Total weight $W = a + w_1$ (gm)	Effort: wt in Pan, w_2 (gm)	Effort: Total w. $P = b + w_2$ (gm)	$M.A = W/P$	$V.\eta = \frac{M.A}{V.A} \times 100$
01.	60	69	52	70	0.85	46%
02.	70	78	68	68	0.875	52%
03.	90	102	65	65	0.947	38%

PRECAUTIONS :-

- String should not be overlapped.
- There should be any knot string
- Weights should be placed gently
- Machine should be frictionless
- Do not increase the effort by throwing the weight on the pan, Increase the effort gently.

Experiment No. - 07

Aim :-

To calculate the mechanical advantage, velocity ratio and efficiency of single puchase winch crabs.

Apparatus required :-

Single purchase winch crabs apparatus, weights, hangers rope etc.

Theory :-

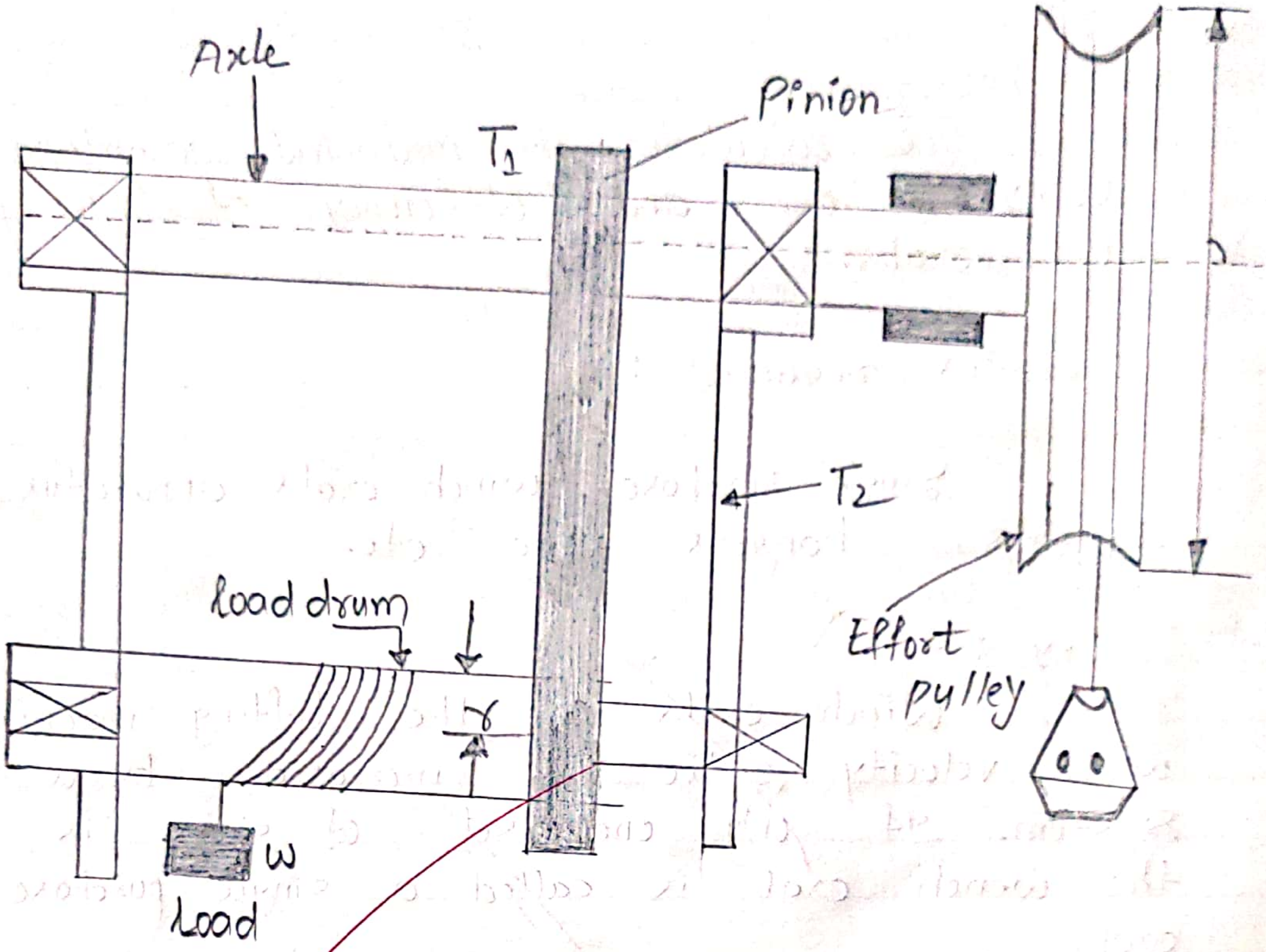
Winch crabs are the lifting machines in which velocity ratio is increased by a year system. If only one set of gears is used, the wench crab is called a single purchase winch crab.

(i) Single purchase winch Crab :-

It consist of a load drum of radius r connected to an axle by gears. The toothed wheel on load drum is called spur wheel and the small toothed wheel on axle is called pinion. The axle is in provided with an angle effort pulley of diameter. D.

Let, number of teeth on spur wheel and pinion be T_1 and T_2 respectively.

The effort P be applied at the effort pulley when our revolution is made by the pulley,



→ Single purchase winch Crab

the distance mooved by the effort = $2\pi r$ = πD

When the axle makes one revolution, due to gear arrangement the load drum also moves T_2 number of teeth, which means it makes T_2/T_1 revolutions.

The distance over the load moves = $2\pi r (T_2/T_1)$

Velocity ratio = distance moved by an effort / distance moved by the load

$$= 2\pi R / 2\pi r (T_2/T_1)$$
$$= D/d \ (T_2/T_1)$$

Mechanical advantage (M.A) = W/P

Efficiency (η) = M.A / V.R.

→ Procedure :-

Measure the circumference of the effort wheel and load axle with the help of thread and scale count the number of teeth on pinion and gear wheel. Hang the load W to the thread passing round the load axle. Now place sufficient weights in the effort pan till the load W just starts moving upwards. Note down the weights added in the pan with weight of the pan. Repeat the procedure for different weights.

→ Observations :-

(1.) No of teeth on pinion - $p_1 = T_2 = 84$
(2.) " " " " " - $p_2 = T_4 = 42$
(3.) " " " " " Sutp gears $S_1 = T_2 = 24$
(4.) " " " " Slip gear $S_2 = T_1 = 36$
(5.) Diameter of the effort pulley $= 2R = 30$
(6.) " " " load axle $= 2r = 30$

Sl. No.	Load placed (w)	Effort applied (P)	M.A = w/p	V.R	η = MA/V.R	Adv Average η	Remarks
01.	160	172	0.93	0.8	42		
02.	180	198	0.72	0.62	38	42.33	
03.	200	220	0.65	0.58	47		

→ Result :-

M.A, V.R, Efficiency of the Machine, $\eta = 42.33\%$

→ Precaution :-

(1.) Bearing of axles, the pinion of gears wheel should be properly lubricated so as to reduce friction.

(2.) The weights should be put gently in the pan.

(3.) Weight (w) should be lifted gradually upwards at uniform speed.

(04.) To get effective values of circumference the thickness of the ropes should be put gently in the pan.

(05.) Weights of empty hangers and effort pan should always be determined.

(06.) Load (w) and effort p should hang freely without touching wall etc.

(07.) The wound of the rope on the circumference of the effort pulley should be single i.e. rope should not overload.

Experiment No. – 08

Aim :-

To calculate the mechanical advantage, velocity ratio and efficiency of double purchase winch crabs.

Apparatus required :-

Double purchase winch crab apparatus weight, hangers rope etc.

Theory :-

Winch crab are the lifting machines in which velocity ratio is increased by a gear system. If only two set of gears are used, the winch crab is called a double purchase winch crab.

Double purchase winch Crab :-

Velocity ratio of a winch crab can be increased by providing another axle with a pair of pinion and gear since two pairs of panion and gears are used it is called Double purchase winch crab. It is used for lifting heaver loads.

Let, the number of teeth on the two spur wheels be T_1 and T_3.
and number of teeth on the two pinions be T_2

and T_4 respectively.

The effort P be applied on the effort pulley when the revolution is made by the pulley, the distance moved by the effort = $2\pi R = \pi D$

When axle A makes one revolution, axle B is moved by T_2 teeth i.e. makes T_2/T_1 revolutions and,

The load axle moves $(T_2/T_1)(T_4/T_3)$ revolutions. Therefore, the distance moved by the load $= 2\pi r \, (T_2/T_1) / (T_4/T_3)$

Velocity Ratio = distance moved by the effort / distane moved by the load.

$$= 2\pi R / 2\pi r \, (T_2/T_1) / (T_4/T_3)$$
$$= D/d \, (T_2/T_1) / (T_4/T_3)$$

Mechanical Advantage (M.A) = w/P

Efficiency (η) = M.A / V.R.

Procedure :~

Measure the circumference of the effort wheel and load axle with the help of threated and scale. count the number of teeth on opinion and gear wheel. Hang the load (w) to the threated passing round the load axle.

Now place sufficient weights in the effort pan till the load (w) just starts moving upwards. Note down the weights added in the pan with weight of the pan repeat the procedure for different weights.

→ Observations :~

01. No. of teeth on pinion $-p_1 = T_2 =$ 78
02. " " " " " $-p_2 = T_4 =$ 64
03. " " " " Spur gear $-S_1 = T_1 =$ 120
04. " " " " " " $-S_2 = T_3 =$ 80
05. " " " " " " $-S_3 - T_4 =$ 78

06. Diameter of the effort pulley $= 2R = 60$
07. " " " load axle $= 2r = 120$

Sl. No.	Load placed (W)	Effort applied (P)	M.A = w/p	V.R.	η = M.A/V.R	Average η	Remarks
01.	60	122	0.82	0.62	0.43	66.5	/
02.	80	142	0.78	0.78	0.56		
03.	120	132	0.95	0.59	0.37		

⇒ Result :-

M.A. = 0.85
V.R = 0.663
Efficieny of the machine(η) = 45.33 %

→ Precautions :-

1. Bearing of axle, the pinion and gear wheel should be properly lubricated so as to reduce friction.

2. The weights (w) should be lifted gradually upwards at uniform speed.

3. To get effective values of circumference the thickness of the ropes should be measured.

4. Weights should be put gently in the pan.

05. Weights of empty hanger and effort pan should always be determined. Load (w) and effort (P) should hang freely without touching wall etc.
The wound of the rope on the circumference of the effort pulley should be single i.e. rope should not overlap.

Experiment No. - 09

Aim :-

To determine the mechanical advantage, velocity ratio and efficiency of warm wheel.

Apparatus required :-

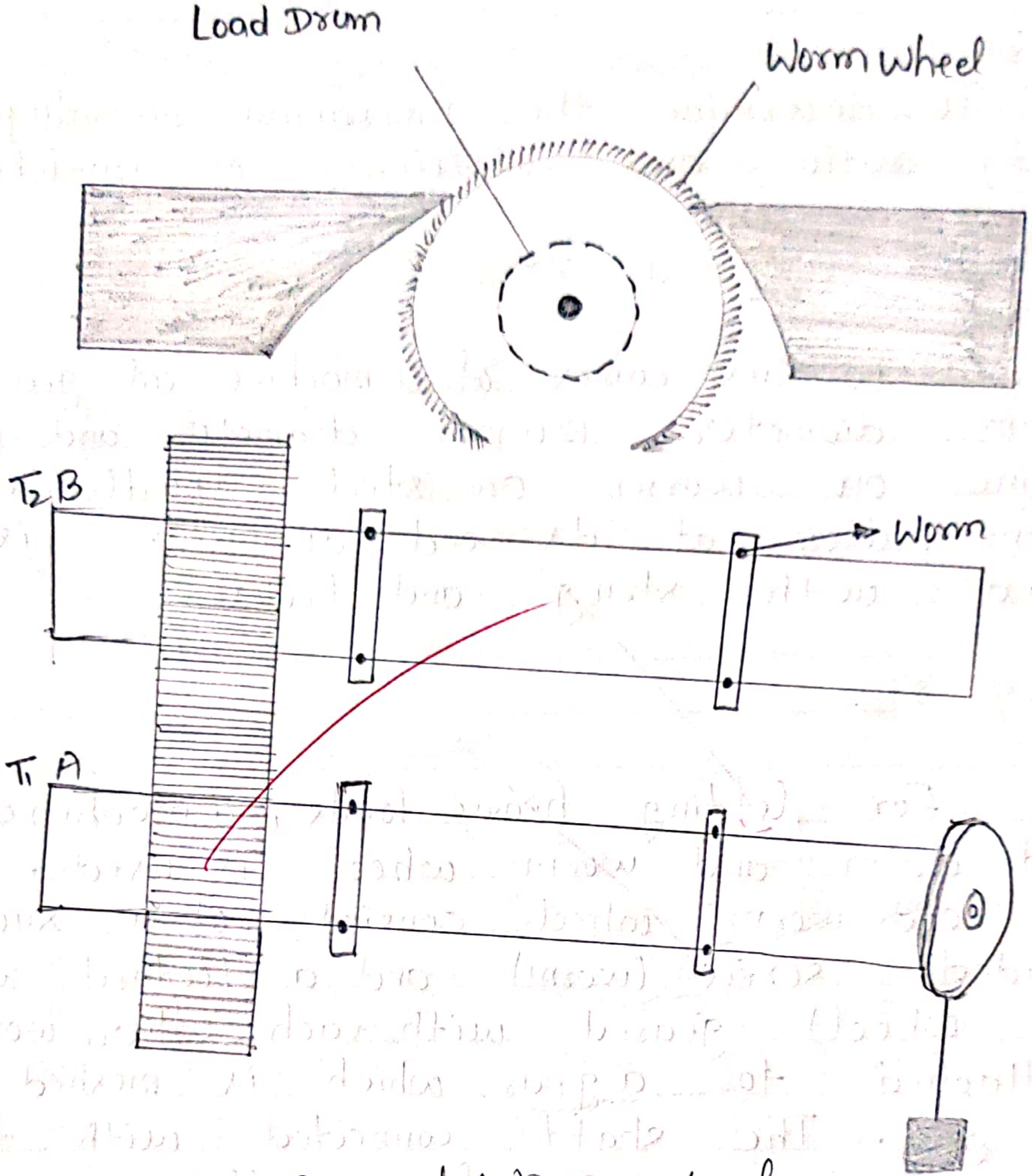
Apparatus comes of a machine cut gear of 250 mm diameter, 120 mm diameter and a machine on warm on steel spindle carrying 120 mm pulley at its end apperatus is fitted with string and hooks.

Theory :-

For lifting heavy loads, a machine named worm and worm wheel is used. A worm and worm wheel consist of a square threaded screw (worm) and a toothed wheel (warm wheel) geared with each other worm is attached to a gear which is meshed to other gear. The shaft connected with this gear is connected after pulley over with passes a rope. The effort P is applied at the end of this rope. A load drum is securely mounted on the warm wheel. A string is wound round the drum to carry weight 'w' to be lifted.

Let,

D = diameter of the effort pulley



⟹ worm and worm wheel

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d = diameter of load drum
T = No. of teeth on worm wheel
T_1 = No. of teeth on the gear connected to the effort pulley.

Let the effort pulley be given N_1 revolutions then the gear A will take N_1 revolutions and number of revolutions N_2 taken by gear B is given by $N_1 T_1 = N_2 T_2$

$$\therefore N_2 = \frac{N_1 T_1}{N_2}$$

The worm will also taken N_2 revolutions. Now the worm wheel take one revolution if worm is given T revolutions. Therefore M the case the worm will take N_2/T revolutions i.e. $N_1 T_1 / T_1 T_2$

Then,
The distance moved by the load = $\frac{N_1 T_1}{T \cdot T_2} \pi d$ —(i)

Whereas distance moved by the effort (P) = $N_1 \pi D$ —(ii)

$$V.R. = \frac{\text{Distance moved by the effort}}{\text{Distance moved by the load}}$$

$$= \frac{T T_2 D}{T_1 d}$$

Now,
Mechanical advantage $M.A = \frac{W}{P}$

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efficiency (η) = M.A / V.R

→ **Suggested Experimental Work :-**

Step 01:

Measure the circumferenc of effort wheel load worm with the help of thread and meter scale as πD and πd.

Step 02:

Note the no of teeth T on the worm wheel T_1 and T_2 of the gears.

Step 03:

Fasten one end of the string on the load drum and wound it in clockwise direction and attach a scale pan for load. Note the total load weight of pan and load placed on it.

Step 04

Note the weight of pan for effort wheel fasten one end of string on the effect wheel and wound it in anticlockwise direction.

→ Step : 05

Put some weight in loading pan and note it. Now put some weights in the pan attached for effort increase the weight in the effort pan till the effort parts start to move down. Load will move up note the effort weight.

→ Step : 06

Repeat the above procedure for different weights in load pan.

SAMPLE DATA SHEET

Number of teeth on worm wheel 1
Diameter of effort wheel D, mm
Diameter of load drum d, mm
Number of teeth on gear connected to the effort pulley.
Number of teeth on the gear connected to the worm T_2

$$V.R. = \frac{T T_2 D}{T_1 d}$$

Weight of load pan/hanger, a, gm = 25 gm
Weight of effort pan/hanger, b, gm = 25 gm

Sl. No.	Load		Effort		M.A = W/P	% η = M.A × 100 / VR
	Wt. in pan worm (gm)	Total wt. W = a + wt (gm)	wt in pan W_2 (gm)	Total wt P = b + W_2 (gm)		
01.	200	280	160	250	4.33	30.8%
02.	180	260	150	300	4.62	
03.	160	320	180	320	3.52	

→ **Result :**

% η = 30.8%

→ **Precautions :-**

- String should not be overlaped.
- There should not be any knot in the string.
- Weights should be placed gently.
- Worm should be greased at regular interval.
- Do not increase the effort by throwing the weight on the pan. Increase the effort gently.

Experiment No. - 10

Aim :-

To find the mechanical advantage, velocity Ratio and Efficiency of simple and compound screw jack.

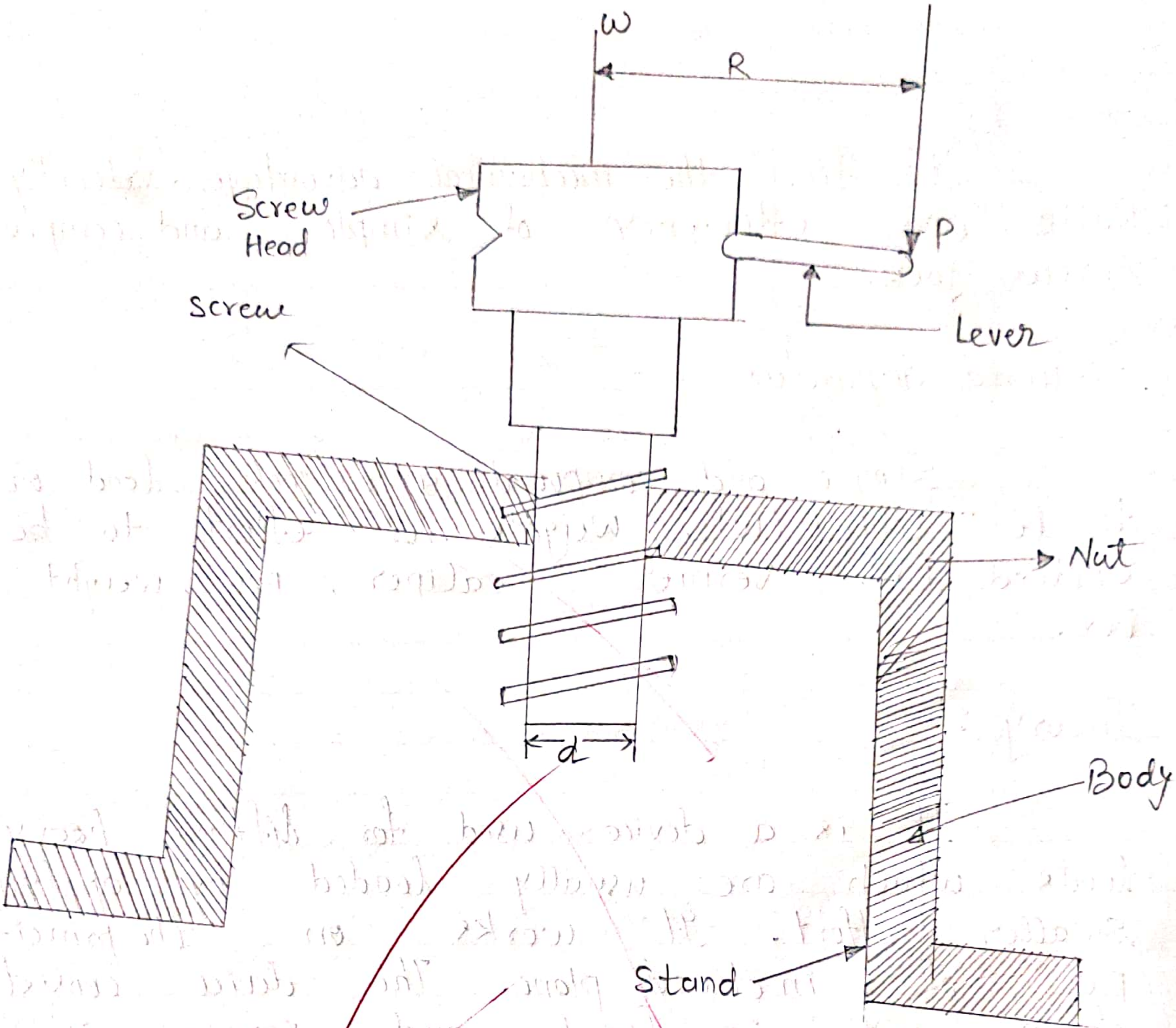
Required apparatus :-

Simple and compound screw jack, load on to be lifted (W), weights or effort to be applied (P), Vernier caliper, pan, weight box.

Theory :-

It is a device used for lifting heavy loads which are usually loaded by applying smaller effort. It works on the principle of inclined plane. The device consist of a nut i.e fixed and screw is roated by means of a lever.

The axial distance moved by the screw when it makes one complete revolution is known as the load of the screw. For single threaded screw load = pitch and for double threaded screw 1 = 2p



Simple Screw Jack

Mechanical Advantage :

It is a ratio of weight lifted to effort applied.

$M.A = W/P$

→ **Velocity ratio :-**

It is the ratio of distance moved by the effort (y) to be distance moved by the load (x).

$V.R. = y/x$

In one complete revolution of the lever by effort P :

Distance traveled by the load = p

and

Distance traveled by effort = $2\pi R$

Therefore,

Velocity ratio = $2\pi R/p$

Compound Screw Jack :-

In one complete revolution of the effort wheel, the distance moved by the effort,

$y = \pi(D+d)$

But since it is a compound screw jack,

Therefore, for the load to be lifted through a distance P, the no. of revolutions required by the effort wheel = No. of teeth on the gear, N.

Therefore for P distance moved by the load, the distance moved by the effort =

$\pi (D+d) N$

Therefore,

Velocity ratio = $\pi (D+d) N/P$

Mechanical Efficiency = M.A./V.R.

$= \frac{W/P}{\pi (D+d) N/P}$

$= \frac{W \cdot P}{P \pi (D+d) N}$

⟹ Experiment 01 observed Data :~

Diameter of turn table, D = 22.6 cm = 266mm

Pitch of Screw thread, P_T = 3.2 mm

Load, W = 450 N

Effort, P = 0.62kg x10 m/s = 6.2 N

Distance moved by load Y = 0.32 cm = 3.2 mm

Distance moved by effort x = 72.0 cm = 720mm

Where,

1kg = 1 N

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$0.62\ kg = \lambda N$

$\lambda N = \frac{0.62 \times 10}{1\ kg}$

Mechanical advantage,

$M.A. = \frac{Load(W)}{effort\ (P)} = \frac{450}{6.2} = 72.58$

$\therefore M.A = 72.58$

→ Velocity ratio,

$V.R. = \frac{\text{Distance moved by the effort, } x}{\text{Distane moved by the load, } y}$

$V.R.\ (approx) = \frac{720}{3.2} = 225.00$

$V.R\ (True) = \frac{\text{Circumference to turn-table}}{\text{pitch}}$

$= \frac{\pi D}{P} = \frac{22 \times 266}{7 \times 3.2}$

$VR\ (True) = 221.96$

→ $\text{Efficiency (approx)} = \frac{M.A}{V.R.\ (approx)} \times 100 = \frac{72.58}{225} \times 100$

$\eta\ (approx) = \frac{72.58}{225} = 32.26\%$

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Efficiency (True) $\eta = \frac{M.A}{V.R.(True)} \times 100$

$= \frac{72.58}{228.96} \times 100$

→ Procedure :-

Put load on the jack and start applying effort gradually and record the observations as the load just moves.

→ Observations :-

let,

Load lifted = W

Effort applied = P

Effort wheel diameter (D) = 130 mm

Diameter of rope (d) = 5mm

Pitch of the screw (P) = 2.5mm

No. of teeth on the gear (N) = 40

Weight of the pan (w) = 150gm

Sl. NO.	W(kg)	P(kg)	M.A = W/p	V.R = π(D+d) w/p	M.A/V.R = wp/pπ(D+d)N
1.	15	20	62.5	210.6	26%
2.	17	30	65.0	208.5	73%
3.	19	40	68.00	221.8	32.5%
4.	21	50	72.5	254.64	29.5%
5.	23	60	73.5	260.00	36.3%

Precautions :-

1. Lubricate the jack well before use.
2. Apply effort gently.
3. Note the effort readings as the load just moves.

Experiment No. – 11

Aim :–

Five strings are tied at a point and are pulled in all directions, equally spaced from one another. If the magnitude of the push on three consecutive strings is 50N, 70N and 60N respectively, Find graphically the magnitude of the push on to another strings.

Apparatus required :–

Pencil, Eraser, scale, compass and sharpner.

Procedure :–

(i) First of all draw the space diagram for a given system of forces and name them according to Bow's notation.

The distance between two strings forces

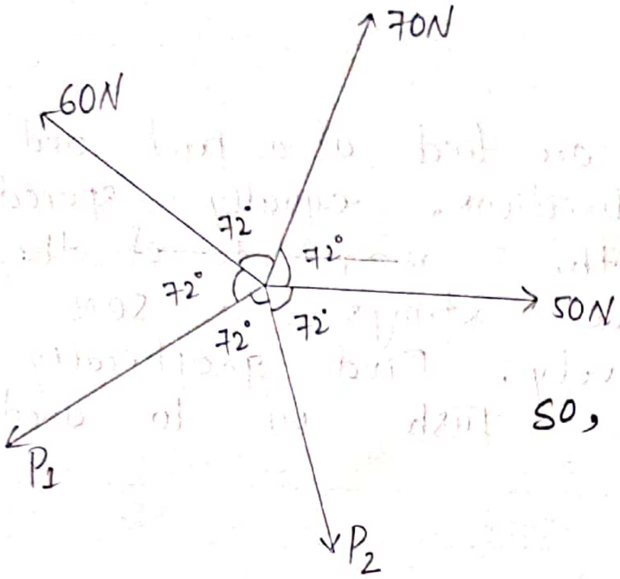
$$= \frac{\text{Angle around a point}}{\text{Total no. of forces equally spaced}}$$

$$= \frac{360^\circ}{5} = 72^\circ$$

Now, draw vector diagram for the given system of forces.

Scale :–

10N = 1 inch



Length of de = 5.6 inch

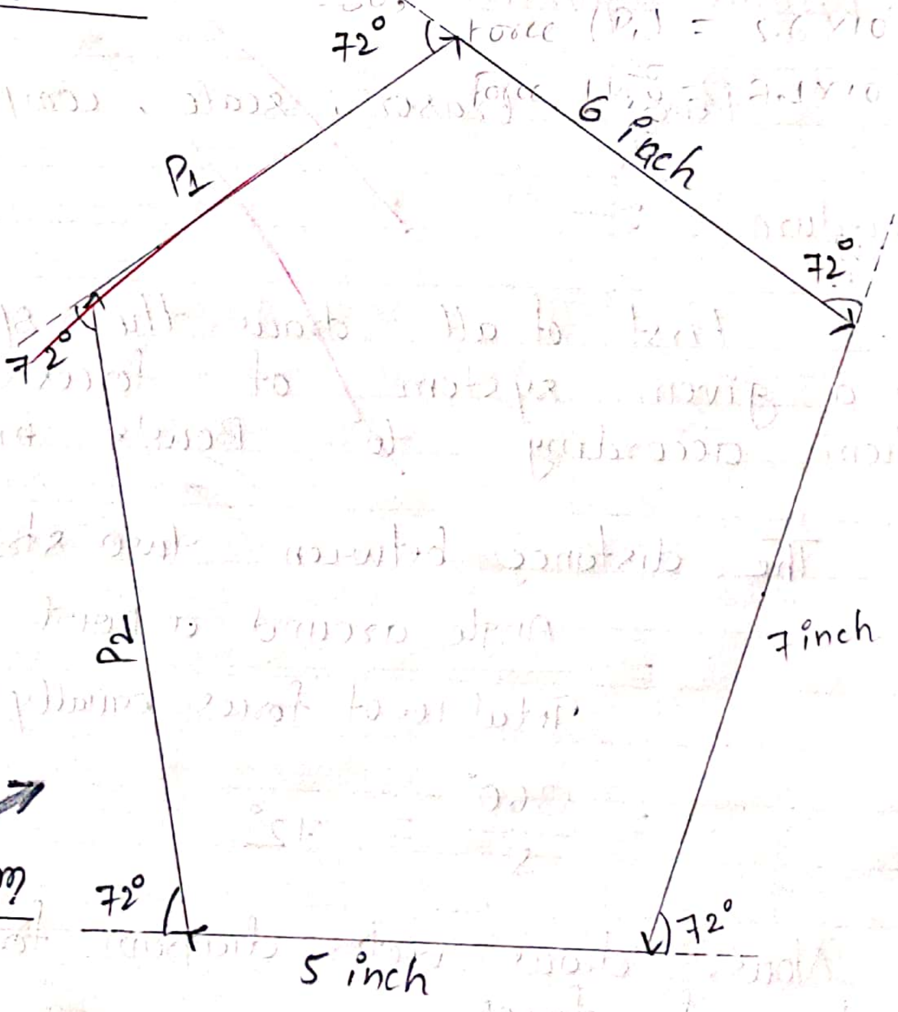
length of ae = 7.1 inch

So,

Force (P_1) = 5.6 × 10 = 56N

Force (P_2) = 7.1 × 10 = 71N

Space Diagram



Vector Diagram

(ii) Select some suitable point and draw a horizontal line AB is equal to 50N to some suitable scale representing the forces AB.

Scale :

1 cm = 10 N

∴ 50 N = 5 cm

(iii) Through b draw a line be equal to 70N as scaling i.e. 7cm parallel to BC.

(iv) Similarly through c draw cd equal to 60N as scaling i.e. 6cm parallel to CD.

(v) Through d draw a line parallel to forces P_1 of the space diagram.

(vi) Similarly through a draw a line parallel to forces P_2 meeting the first line at e, thus closing the polygon abcde which means that point is in equilibrium.

(vii) By measuring the length de and ae and after decoding by scale we get the magnitude of forces P_1 and P_2.

By decoding the scalling we find,

- The force P_1 have a magnitude equal to 6.2 cm X 10 = 62 N

- The magnitude of forces P_2 = 7 cm X 10 = 70 N

→ Result :~

Length of de = 5.6 inch
Length of ae = 7.1 inch

So,
By breaking scale, the unknown forces will be found as :~

force (P_1) = 5.6 X 10 = 56 N
force (P_2) = 7.1 X 10 = 71 N

Experiment No. - 12

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Aim :-

The following forces act at a point :

(i) 20N Inclined at 30° towards north to east
(ii) 25N towards north
(iii) 30 N towards north-east west
(iv) 35 N Inclined at 40° towards south to west.

Find the magnitude and direction of resultant force.

Apparatus required :-

Pencil, scale, compass, Eraser etc.

Procedure :-

First of all draw the space diagram for a given system of forces and name then a/c to Bow's notation.

Now,

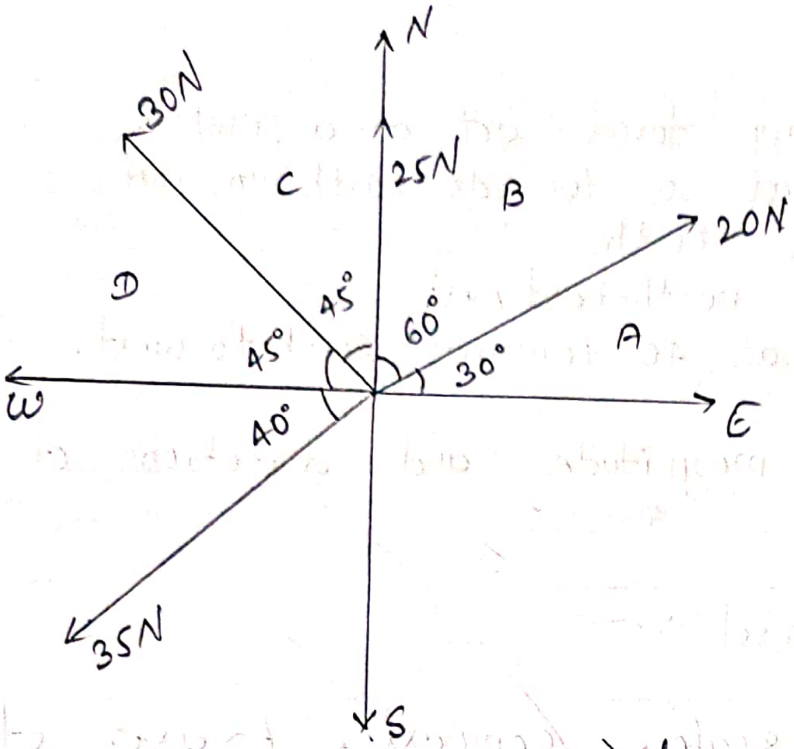
Draw vector diagram for the given system of forces.

(i) Select some suitable point a and draw ab equal to 20N to some scale suitable and parallel to the forces AB.

Scale :-

Scale :-

10N = 1 inch



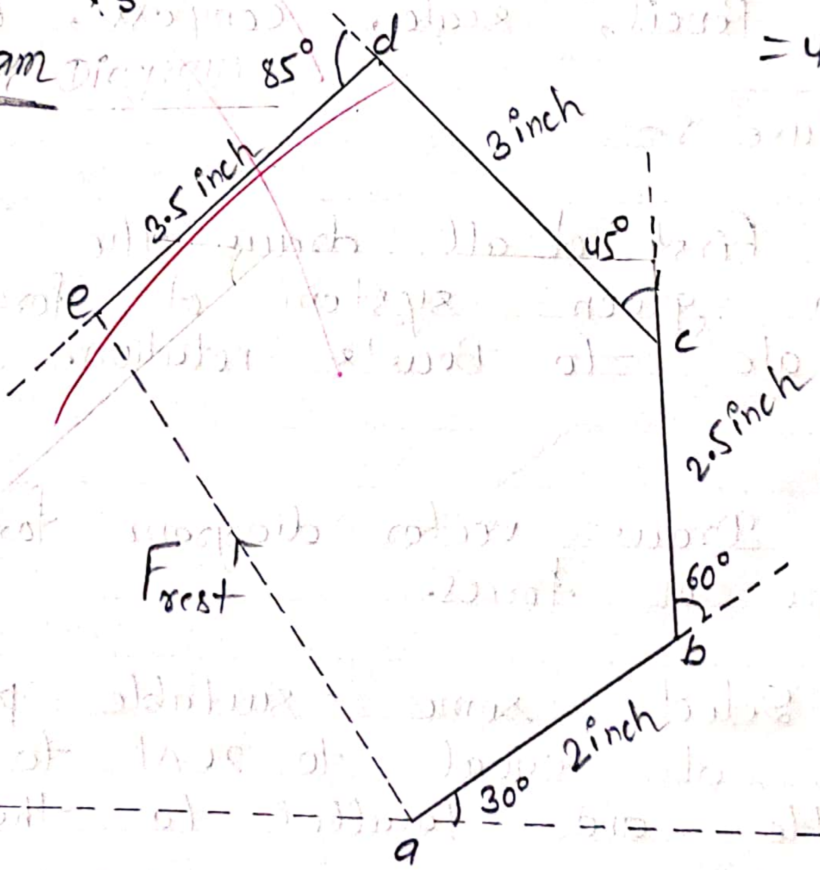
Space Diagram

Length of ae = 4.5 inch

So,

Frest = 4.5 X 10

= 45N



Vector Diagram

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Scale :~

4N = 1 cm

∴ 20N = 5 cm

(ii) Through b draw bc and 25 N to be the scale and parallel to the forces BC of the space diagram.

(iii) Now through c, drawed equal to 30N to the scale and parallel to the force CD of the space diagram.

(iv) Similarly through d draw the de equal to 35N and parallel to the force DE or the space diagram.

(v) Joint ae which gives the magnitude as well as dir^n of resultant forces.

→ Result :~

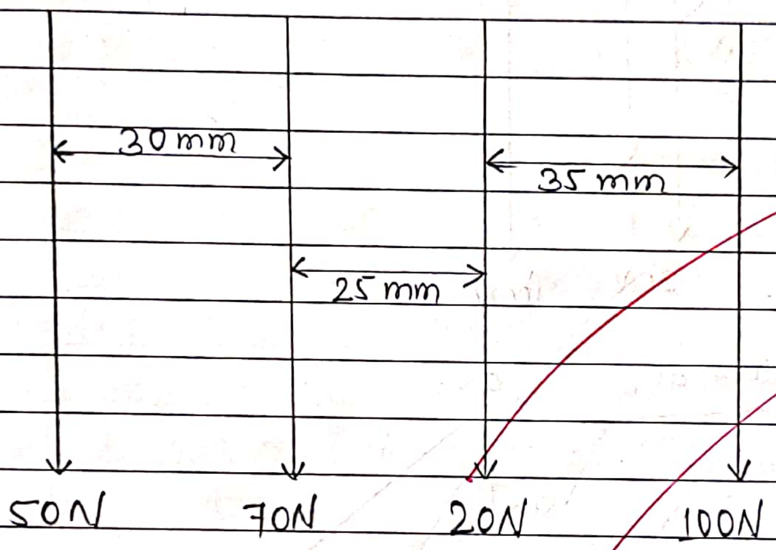
So, By breaking scale we get

F rest = 4.5 X10
= 45 N

Experiment No. - 13

Aim :~

Find graphically the resultant of like parallel forces as shown in figure the distances b/w forces are in mm. Also find the point where resultant act.



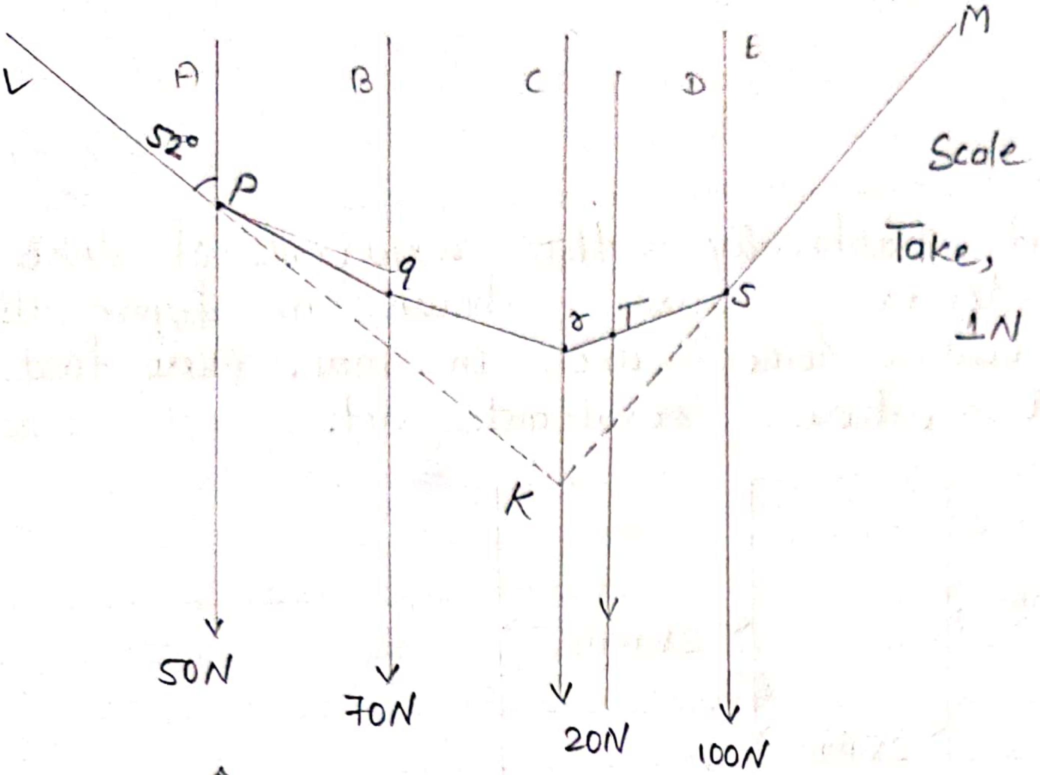
→ **Apparatus required :~**

Pencil, scale, eraser, sharpner, compass, protractor etc.

→ **Procedure :~**

First of all draw space diagram for the given system of forces and name them a/c to Bow's notation.

Now draw vector diagram for given forces as discussed below :~



Scale :-

Take,

1N = 1cm of scale

Space Diagram

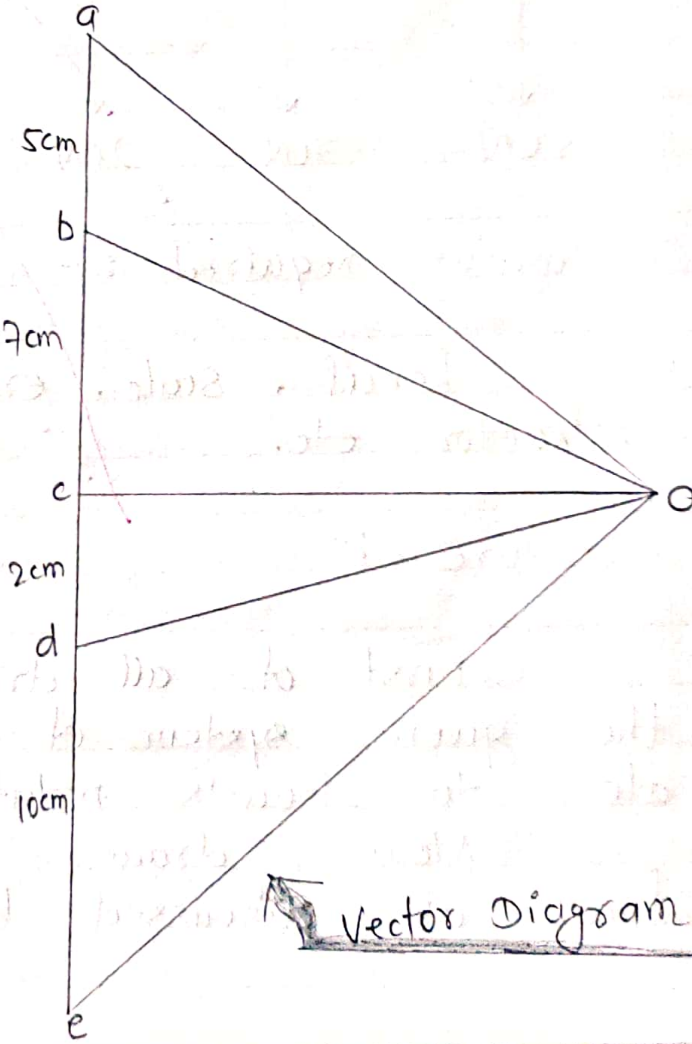
Resultant Force → de = 24cm

So,

Frest = 24X10 = 240N

Position of resultant =

50 mm ahead of force AB at a point 'K'



Vector Diagram

(i) Take some suitable point a and draw ab equal and parallel to force AB i.e. 50 N to some scale.

(ii) Similarly draw bc equal to force BC (i.e 70 N) cd equal to force CD (i.e. 20N) and de equal to force DE (i.e. 100 N).

(iii) Now select some suitable point 'O' and join oa, ob, oc, od and oe.

(iv) Now, taken some suitable point P on the line of action of force AB of the space diagram through P draw a line LP parallel to ao of the vector diagram.

(v) Now, through P draw Pq parallel to bo meeting the line of action of the force BC at q. Similarly through q draw qr parallel to do and through S draw SM parallel to eo.

(vi) Now extain lin LP and MS meating each other at K. through K draw a line parallel to ae which gives the required position of the resultant force.

(vii) By measuring the process to be find the resultant force R ⟶ ae

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→ Calculations :~

By breaking scale :~

Resultant force (Frest) = length of ae × scale ratio

[Frest = 24 × 10 = 240N]

→ Result :~

[Frest = 240N]

Position of resultant = 50mm ahead of force AB at point 'K'.

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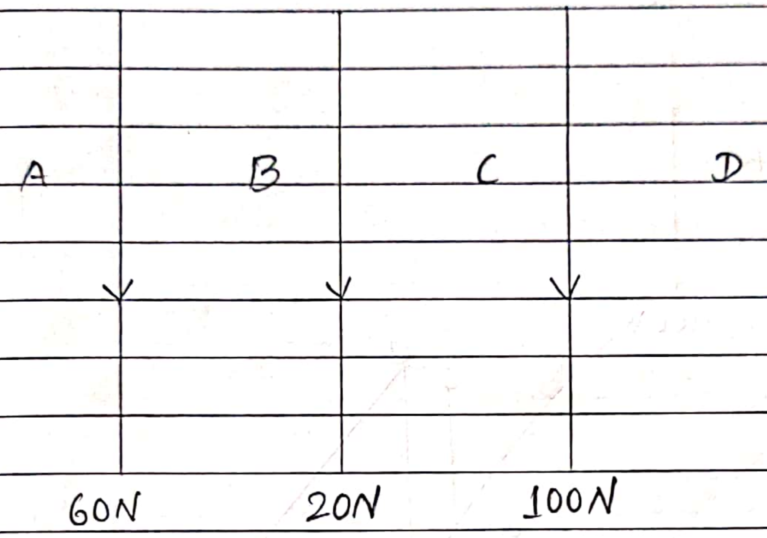
Aim :-

Find graphically the resultant of forces shown in figure :-



Also find the point where the resultant force acts.

Apparatus required :-

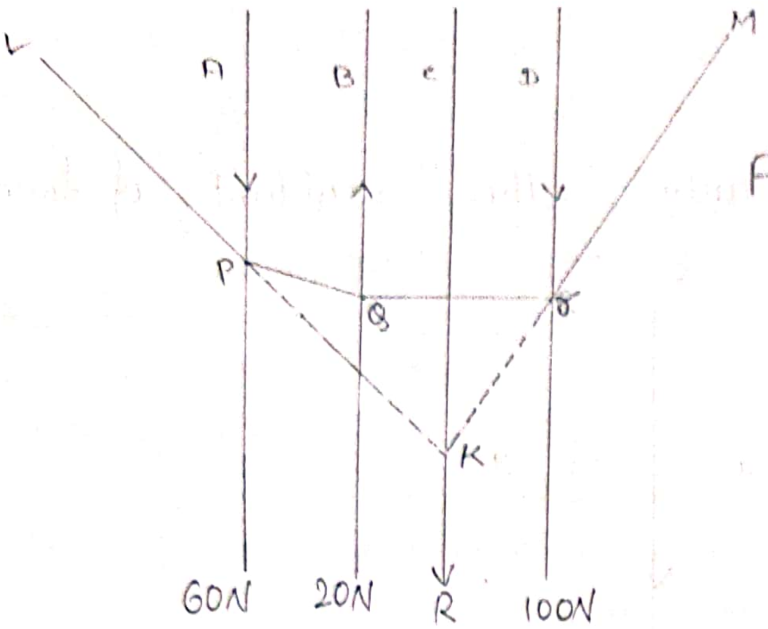
Pencil, Scale, compass, Eraser etc.

Procedure :-

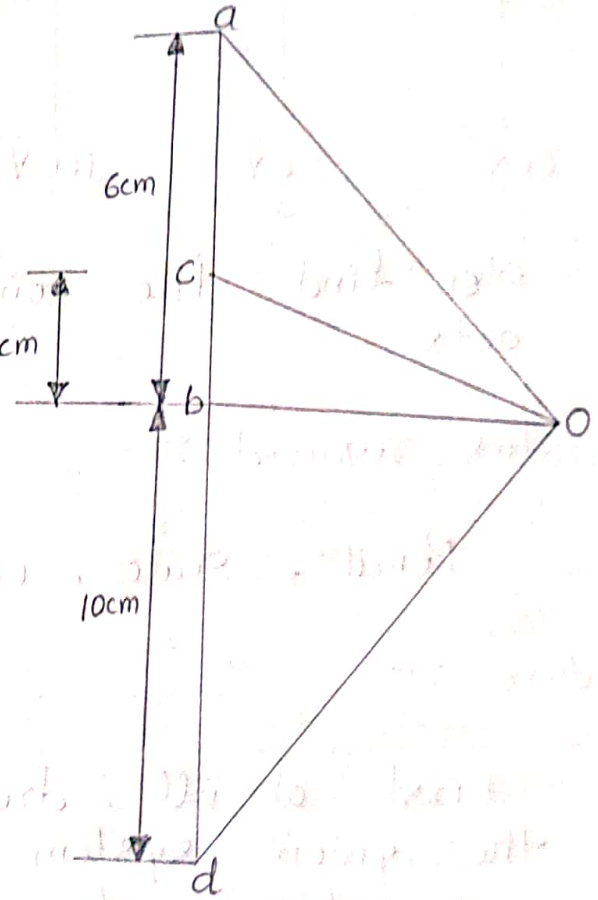
First of all, draw the space diagram for the given system of forces and name them according to Bow's notation.

It may be noted that the force AB (equal to 60N) is acting downwards, force B (equal

Scale :-
10 N = 1 cm



Frest lies at a point K ahead of 23 mm to force AB.



Length of ad = 4+2+8
= 14

Frest → Lad

Frest = 14 X 10
= 140 N

to 20N) is acting upwards and the force CD (equal to 100N) is acting downwards. as :—

(1.) Take some suitable point a and draw ab equal and parallel to force AB (i.e. 60N) to some scale. Similarly, draw bc (upwards) equal to force BC (i.e. 20N) and cd equal to the force CD (i.e 100N) respectively.

(2.) Now select some suitable point o and join oa, ob, oc and od.

(3.) Now take some suitable point P on the line of action of the forces AB of the space diagram. Through P draw a line LP parallel to ao of the vector diagram.

(4.) Now, through P, draw Pq parallel to do meeting the line of action of the force BC at q. similarly through q draw qr parallel to co. Through r drawn rm parallel to do.

(5.) Now extend the lines lP and Mr meeting each other at K. Through K draw a line parallel to ad, which gives the required resultant force.

(6.) By measurement :-

$R = ad = 140N$

Line of action of K from AB =

→ Result :-

length of ad = 4+2+8 = 14

F rest = load

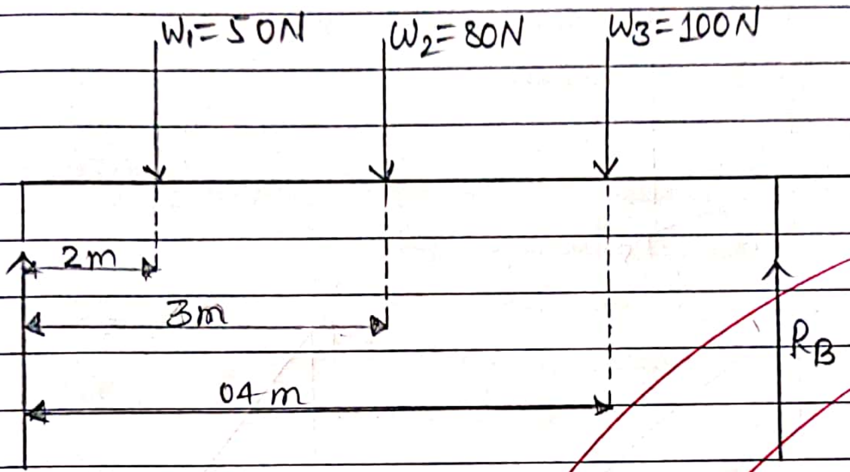
= 14×10 = 140N

Frest lies at a point K ahead of 29 mm to forces AB.

Experiment No. – 15

Aim :–

Determine the reaction force of a simply supported beam as shown in figure:–



Length of load = 6m

given length of load = 06 m

Apparatus required :–

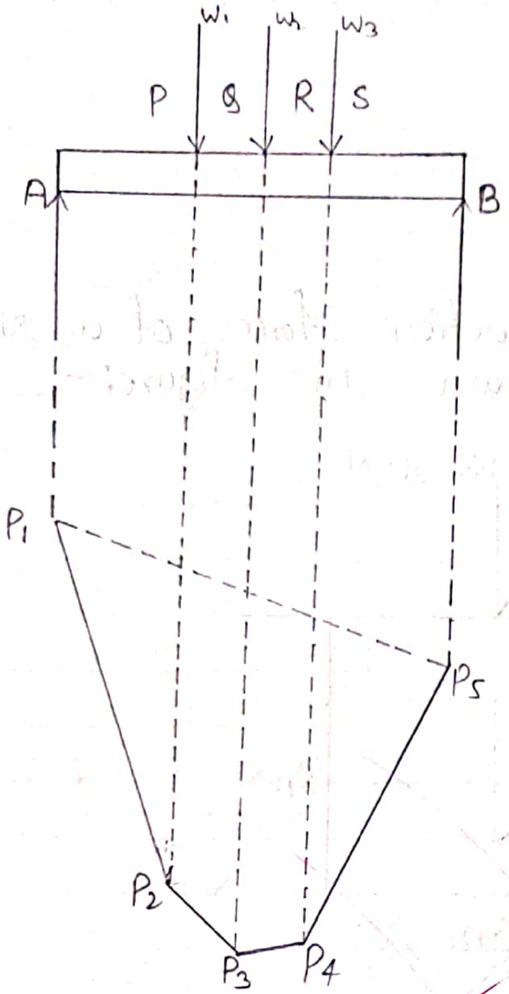
Pencil, Scale, Compass, Eraser etc.

→ Procedure :–

Graphical method can be drawn of reaction of beam by drawing:–

(1.) Construction of scale diagram :– It means construct the diagram of beam to a suitable scale. It also includes the load carried by beam & along with the line

II



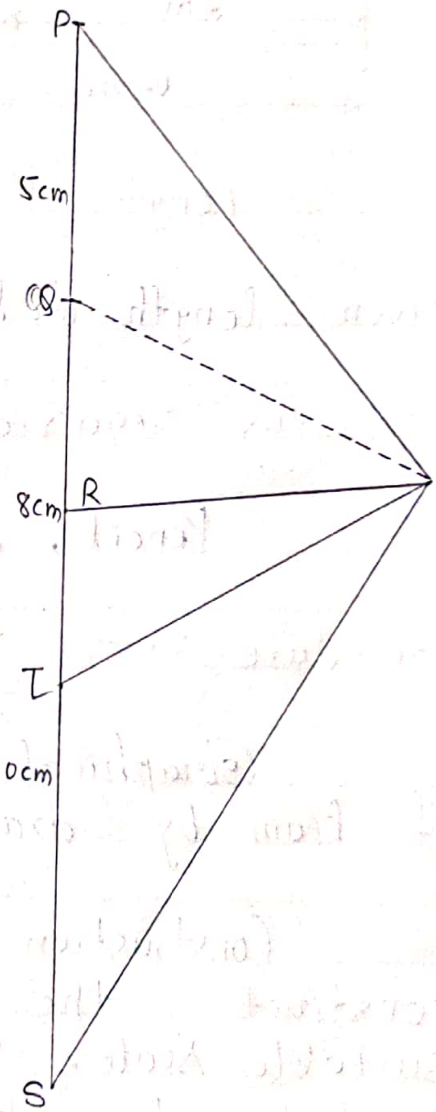
Scale :-

10N = 1cm

W_1 = 50N

W_2 = 80N

W_3 = 100N



Length of P_5 = 5+8+10

= 23cm

Length of P_L = 103mm = 10.3cm

Length of P_S = 127mm = 12.7cm

Hence,

Support reaction force R_A = 10.3 × 10 = 103N

Support reaction force R_B = 12.7 × 10 = 127N of action or reaction. Now, Name the different load including the reaction by Bow's notation method.

2. Constraction of vector diagram :—

After drawing space diagram of the beam the naming of load according to Bow's notation method, The next step is to construct vector diagram as following steps :—

(i) Select some suitable point P near the space diagram & draw pq parallel & equal to load PQ to some scale.

(ii) Similarly through q and r draw as rs parallel to load QR & RS of equal magnitude to some scale.

(iii) Select any suitable point O and join op, oq, or & os.

(iv) Now extain the line of action of load & two reaction in space diagram.

(v) Select some suitable point P_1 on the line of action of RA. through P_1 draw

P_1, P_2 parallel to OP. Intersecting the line of action of load w_1 and P_2.

(vi) Similarly draw P_2, P_3, P_3P_4, P_4P_5 parallel to eq, or, os respectively.

(vii) Join P_1 with P_5 and through O draw a line at parallel to this line.

(viii) Now the length TP, st in the vector diagram give the magnitude of the reaction R_A and R_B.

→ Result :~

(i) Length of P_5 = 23 cm
(ii) Length of P_4 = 103 cm
(iii) Length of P_5 = 12.7 cm

So,

Support reaction force R_A = 103 N
Support reaction force R_B = 127 N