LAB MANUAL

FOR

ENGINEERING MECHANICS LAB

1ST SEM

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DEPARTMENT OF MECHANICAL ENGINEERING

CONTENT

P-1 : EQUIPMENTS RELATED TO ENGG. MECHANICS

1.1 Practical Statement

To study various equipment related to engineering mechanics.

1.2 Practical Significance

To know the function of various equipment related to engineering mechanics. This is standard format followed for all practical of Engineering Mechanics lab manual.

1.3 Relevant Theory

[REFER TOPIC NO - 1.1 to 1.4]

1.4 Practical Outcomes (PrO)

After completing the practical you will be able to :

PrO1: Understand the various equipment related to engineering mechanics.

1.5 Practical Setup

You have to visit the laboratory of ENGG. MECHANICS & list out various equipment available in your lab.

1.6 Resources Required

Sr. No.	Suggested Resources required Machines / Tools / Instruments with vital specification	Qty	Actual Resources required Machines / Tools / Instruments with broad specification	Remarks

1.7 Precaution

General precautions related to laboratory :

- BE PREPARED : Read the lab procedure in the lab manual before you begin any experiment.
- THINK SAFETY : Work deliberately and carefully.
- ALL STUDENTS MUST BE SUPERVISED : Never work alone
- KNOW THE PRECAUTIONS FOR PARTICULAR EQUIPMENT OR MACHINES : The laboratory manual and/or instructor will review specific safety issues on individual experiments before you perform any practicals.
- ALL STUDENTS MUST WEAR APPROPRIATE LABORATORY ATTIRE : No open toed shoes; no loose-fitting clothing; jewelry should be removed; long hair should be tied back.
- REPORT ANY PERCEIVED SAFETY HAZARDS : Immediately report any spills, equipment malfunctions, injuries or other perceived safety hazards to your Instructor / TA / or staff member.
- All students must wear appropriate safety equipment, for e.g., shoes etc.
- No food or beverage in the laboratory.
- Keep your work area clean.

1.8 Suggested Procedure

Each machines/equipment should be use for a particular experiment. Some of the machines/ equipment should be use for more than one experiment also. This should be discuss in detail.

1.9 Observation Table and calculations

Name of Instrument / Equipment / Machine	No. of experiment in which this Instrument / Equipment / Machine is used	Remarks

1.10 Results and/or Interpretation

You have to write here the result obtained from each practical and its interpretation.

1.11 Conclusions and/or Validation

You have to write here the conclusions / validation for the practical.

1.12 Practical related Questions

You have to give answer to question which are related to the practical, in separate page.

1.13 Disposal of Waste

Classify the waste materials to be throw in this experiment in the following bins :

Type of Waste	Bin	Details
Biodegradable waste	Green bin	
e-Waste	Black bin	
Plastic and metal waste	Blue bin	
Any Other		

P-8/9 : LAW OF POLYGON (ANALYTICAL AND GRAPHICAL METHOD)

8.1 Practical Statement

Determine resultant of concurrent force system applying Law of Polygon.

8.2 Practical Significance

Determine resultant force of concurrent force system applying Law of Polygon of force using force table by Analytical method / Graphical method.

8.3 Relevant Theory

Resolution of force : Splitting of a single force in two components without changing its effect defined as resolution of force.

Composition of forces : To find a resultant force for given two or more forces defined as composition of forces.

Polygon law of forces : If a number of forces acting simultaneously on a body be represented in magnitude and direction, by the sides of a polygon taken in order, then the resultant of all these forces may be represented, in magnitude and direction, by the closing side of the polygon, taken in opposite order.

Assumptions:

1. Pulleys are assume to be frictionless.
2. Self-weight of thread is neglect.

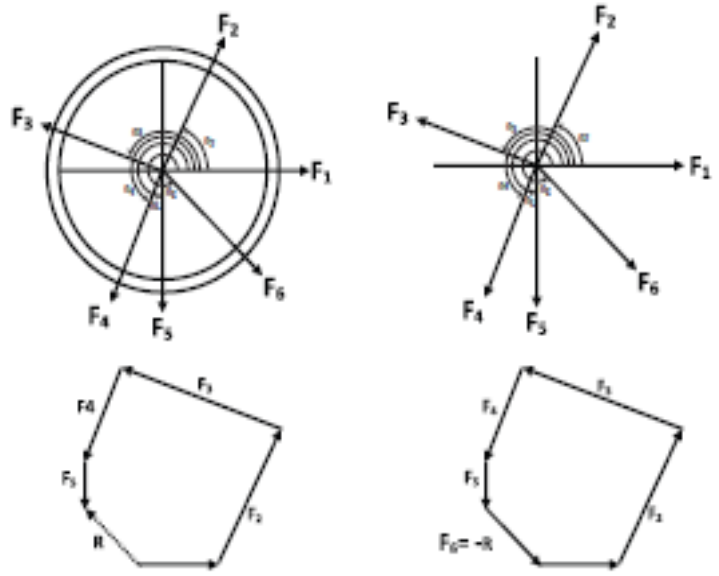
8.4 Practical Outcomes (PrO)

After completing the practical you will be able to :

PrO1 : Understand the law of polygon for forces.

PrO2 : Interpret the relation between the Analytical & Graphical method.

8.5 Practical Setup



8.6 Resources Required

Sr. No.	Suggested Resources required Machines / Tools / Instruments with vital specification	Qty	Actual Resources required Machines / Tools / Instruments with broad specification	Remarks
1	Universal force table	1		
2	Spirit level	1		
3	Slotted weights with hangers	4 to 6		
4	Pulleys with fixing device	4 to 6		
5	Steel ring with diameter 3 to 5 cm	1		
6	Threads	4 to 6		

8.7 Precaution

1. At equilibrium stage, central steel ring should be on the center of force table.
2. Adjust weight of each hanger in such a way that we get properly equilibrium condition.

8.8 Suggested Procedure

(1) Study the apparatus given and draw sketch of its main features.
(2) Make horizontal the top of universal force table with the help of spirit level and foot screw.
(3) Fix four to six as per requirement pulleys at the edge of universal force table at different position so the forces have remained chance to come in equilibrium.
(4) Take same number of threads as equal number of pulleys.
(5) Join one end of each thread with steel ring so there should be free movement between thread and ring.
(6) Hang the slotted weights at another end of each thread, which are passing over the pulleys.
(7) Now adjust the forces (weights) in such a way the ring comes in center of universal force-table and force system get the equilibrium condition.
(8) Note the magnitude and the direction (angle) of each force.
(9) For next try, change the direction of forces by changing the position of pulleys and repeat step 4 to 8.
(10) Calculate the magnitude and direction of resultant force by analytical method.

P.9 GRAPHICAL METHOD

(11) Construct space and vector diagram with scale on the graph paper.
(12) The closing side of the polygon, taken in opposite order will give the magnitude and direction of the resultant according to scale.
(13) Compare observed last force with analytical and graphical values.

8.9 Observation Table and calculations

Sr. No.	FORCE F_1		FORCE F_2		FORCE F_3		FORCE F_4		FORCE F_5		FORCE F_6	
	Mag. (N)	Dir. π_1	Mag. (N)	Dir. π_2	Mag. (N)	Dir. π_3	Mag. (N)	Dir. π_4	Mag. (N)	Dir. π_5	Mag. (N)	Dir. π_6
1												
2												
3												
4												

Sample Calculations :

(I) $\Sigma H = F_1 \cos\theta_1 + F_2 \cos\theta_2 + F_3 \cos\theta_3 + F_4 \cos\theta_4 + F_5 \cos\theta_5$

(II) $\Sigma V = F_1 \sin\theta_1 + F_2 \sin\theta_2 + F_3 \sin\theta_3 + F_4 \sin\theta_4 + F_5 \sin\theta_5$

(III) Resultant force :

(a) $R = \sqrt{(\Sigma H)^2 + (\Sigma V)^2}$ (b) $\alpha = \tan^{-1}\left(\frac{\Sigma V}{\Sigma H}\right)$

8.10 Results and/or Interpretation

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8.11 Conclusions and/or Validation

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8.12 Practical related Questions

1. Distinguish between closed polygon and open polygon.
2. Draw the polygon of forces for following case :
   Three forces (push type) of 2 kN, 3 kN and 4 kN acting at an angle of 120° with one another.

8.13 Disposal of Waste

Classify the waste materials to be throw in this experiment in the following bins:

Type of Waste	Bin	Details
Biodegradable waste	Green bin	
e-Waste	Black bin	
Plastic and metal waste	Blue bin	
Any Other		

P-10 : RESULTANT FORCE OF PARALLEL FORCE SYSTEM

10.1 Practical Statement

Determine resultant force of parallel force system by graphically.

10.2 Practical Significance

Verify the support reactions of the given simply supported beam.

10.3 Relevant Theory

Moment : The tendency of force to turn or bend the body defined as moment.

Moment = Force × Perpendicular Distance

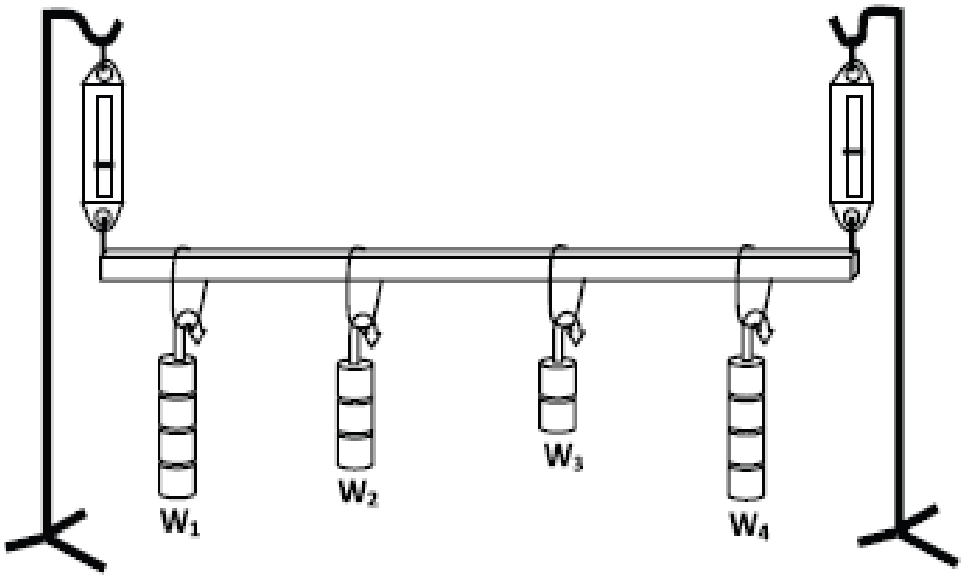
Condition of Equilibrium of coplanar non-concurrent forces : If coplanar non-concurrent force system is in Equilibrium; the algebraic sum of components of all forces will be zero and algebraic sum of moments about any point on a body will be zero. i.e. ($\Sigma H = 0, \Sigma V = 0$ & $\Sigma M = 0$)

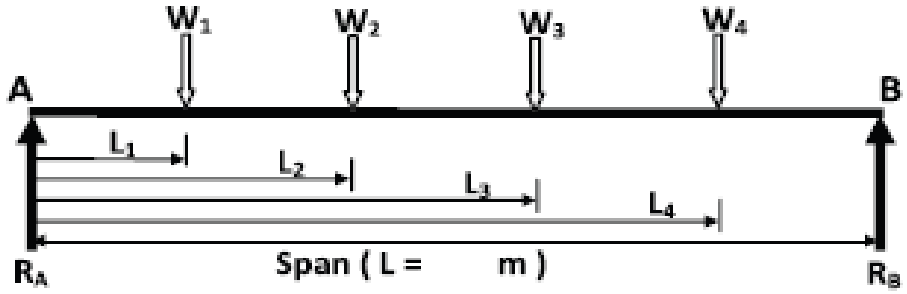
10.4 Practical Outcomes (PrO)

After completing the practical you will be able to :

1. Understand the conditions of equilibrium of parallel forces.
2. Interpret the relation between the Analytical & Graphical method.

10.5 Practical Setup





10.6 Resources Required

Sr. No.	Suggested Resources required Machines / Tools / Instruments with vital specification	Qty	Actual Resources required Machines / Tools / Instruments with broad specification	Remarks
1	Stands with hook	2		
2	Spirit level	1		
3	Set of slotted weights with hangers	4 to 6		
4	Spring balances	2		
5	1 to 1.5 m long wooden beam with distance marking	1		
6	Threads	4 to 6		

10.7 Precaution

1. The reading of the spring balance should be take carefully.
2. The distance of load should be measure carefully.

10.8 Suggested Procedure

(1) Hang both spring balances with the help of stands (as shown in figure).
(2) Hang the wooden beam at the lower ends of the spring balances as shown in figure.
(3) Keep the stands in such a position so we can get desire span (L).
(4) Level the wooden beam with the help of spirit level.
(5) Hang the different slotted weights (loads) at desire distances from the left support (A).
(6) Note the support reactions on left and right balances as R_A & R_B.
(7) For next reading change the loads and position as requires and repeat the steps 5 and 6.
(8) Tabulate the readings of support reactions and magnitude of loads and distance of each load from left support and then calculate support reactions.
(9) Verify the calculated and observed values of support reactions.

To find out support reactions by Graphical Method follows the steps :

(1) Draw space diagram to the suitable scale and give Bow's notations on graph paper.
(2) Represent known forces W_1 and W_2 in vector form as ab & bc in vector diagram.

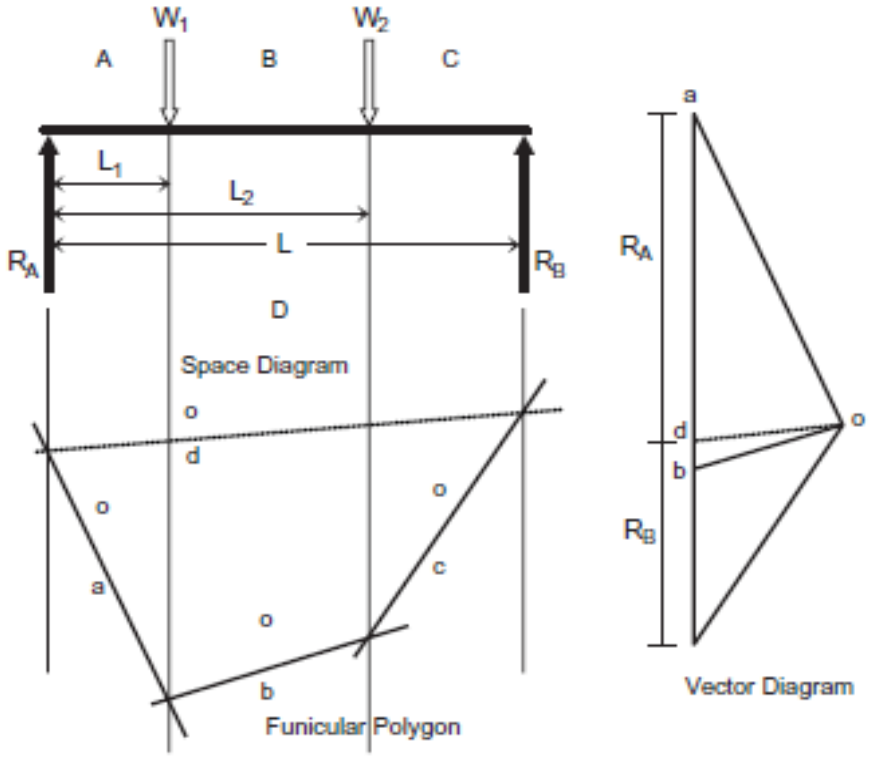
(3) Take a point O outside vector diagram & join points of all forces in vector diagram to point O.

(4) Extend the line of action of forces below the space diagram.

(5) Draw a line parallel to space diagram in particular space A, B & C below space diagram respectively and construct funicular polygon.

(6) Close the polygon by dotted line in space D.

(7) Draw a line from point O parallel to closing line cutting the vector diagram at d, cd represents the support reaction R_A and da represent the support reaction R_B.



10.9 Observation Table and calculations

Sr. No.	Loads in (N) or (kN)				Position of Load from Left Support (A) in (N) or (kN)				Observed Support Reaction in (N) or (kN)		Support reaction in (N) or (kN)			
											Analytical		Graphical	
	W_1	W_2	W_3	W_4	L_1	L_2	L_3	L_4	R_A	R_B	R_A	R_B	R_A	R_B
1														
2														
3														
4														
5														

Calculations :

(I) Take moment about support A and use equilibrium condition $\Sigma M = 0$ with +ve sign as anticlockwise and on simplification find R_B.

$R_B \times L - W_1 \times L_1 - W_2 \times L_2 - W_3 \times L_3 - W_4 \times L_4 = 0$

(II) Take moment about support B and use equilibrium condition $\Sigma M = 0$ with +ve sign as anticlockwise and on simplification find R_A.

$R_A \times L - W_1 \times (L - L_1) - W_2 \times (L - L_2) - W_3 \times (L - L_3) - W_4 \times (L - L_4) = 0$

10.10 Results and/or Interpretation

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10.11 Conclusions and/or Validation

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10.12 Practical Related Questions

1. A simply supported beam of span 4 m carry point loads of 5kN, 2kN & 3kN at distance of 1m, 2m & 3m from left support respectively. Calculate support reactions.
2. Solve above problem, by graphical method.

10.13 Disposal of Waste

Classify the waste materials to be throw in this experiment in the following bins:

Type of Waste	Bin	Details
Biodegradable waste	Green bin	
e-Waste	Black bin	
Plastic and metal waste	Blue bin	
Any Other		

P-11 : LAMI'S THEOREM

11.1 Practical Statement

Verify lami's theorem.

11.2 Practical Significance

To verify the lami's theorem.

11.3 Relevant Theory

Equilibrium : A body is to be in equilibrium, when it does not change its position with respect to surrounding. When the body is in equilibrium it's resultant is zero. The equilibrium of a body under effect of three forces are observe experimentally and found analytically & graphically as follows.

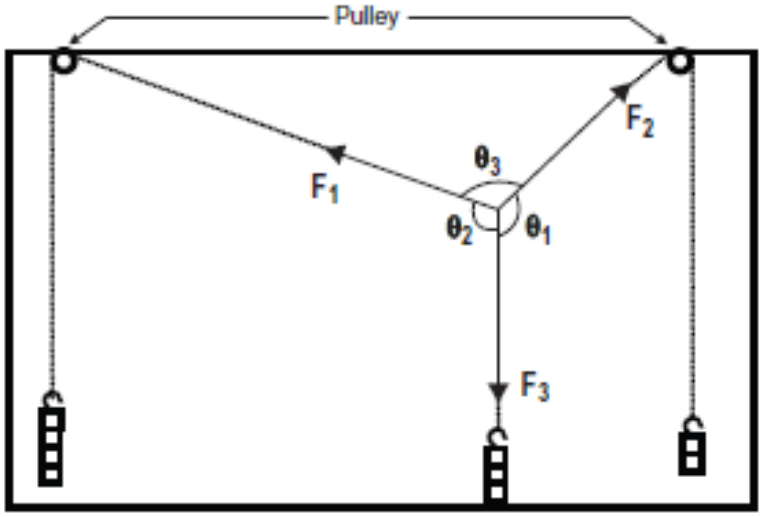
Analytically : Lami's Theorem: If three forces acting on a body are in equilibrium, then each force will be proportional to the sine of the angle between remaining two forces.

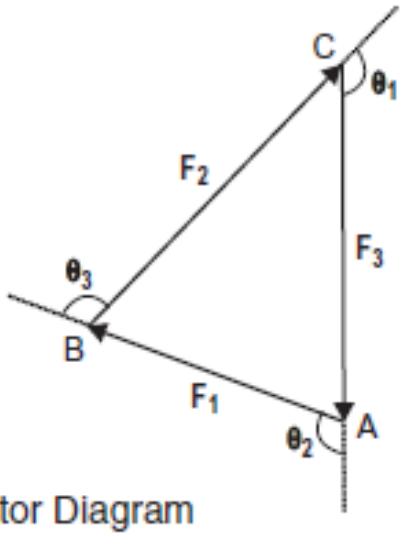
Graphically : Law of Triangle of the forces: If three forces acting on a body are in equilibrium, they can be represent in magnitude and direction by the sides of a triangle in order.

11.4 Practical Outcomes (PrO)

1. Understand the lami's theorem.
2. Interpret the lami's theorem by Analytical & Graphical method.

11.5 Practical Setup





Vector Diagram

11.6 Resources Required

Sr. No.	Suggested Resources required Machines / Tools / Instruments with vital specification	Qty	Actual Resources required Machines / Tools / Instruments with broad specification	Remarks
1	Drawing board	1		
2	Drawing sheet	1		
3	Pulley with fixing device	2		
4	Set of slotted weights with hangers	3		
5	Threads	3		
6	Pins and adhesive tape	As required		

11.7 Precaution

1. Measure the angles between forces carefully.
2. Draw vector diagram with accuracy in length for magnitude & for angle for direction of each forces.

11.8 Suggested Procedure

(1) Fit the drawing board vertically on the wall.

(2) Fix the pulleys at the upper edge of the drawing board at a desired distance

(3) Paste the drawing sheet on the drawing board with the help of adhesive tape.

(4) Hang the slotted weights at the end of three threads as shown in figure, so it will form coplanar concurrent force system.

(5) When the system of forces comes in equilibrium mark the position of each threads on the drawing sheet with the help of mirror and pencil.

(6) Note the magnitude and mark the direction of all three forces on the drawing sheet.

(7) For next reading change the magnitude of forces by changing the weights and repeat the steps 4, 5 and 6.

(8) Draw the applied forces F_1, F_2 and F_3 on the drawing sheet by joining marked points.

(9) To verify the law of triangle of forces we can construct perfect triangle on graph of forces F_1, F_2 and F_3 as the sides (AB, BC & CA) of the triangle in order, which are represent in magnitude and direction with the help of θ_1, θ_2 and θ_3.(Graphical Value)

(10) To verify Lami's theorem, put the values of quantities F_1, F_2, θ_1, θ_2 and θ_3 in the Lami's Formula and find the value of F_3. (Analytical Value)

(11) Compare the observed third force (F_3) with analytical and graphical values.

11.9 Observation Table and calculations

Sr. No.	FORCE F_1		FORCE F_2		FORCE F_3		Resultant Force (R)			
	Magnitude (N)	Direction π_1	Magnitude (N)	Direction π_2	Magnitude (N)	Direction π_3	Magnitude (N)	–	Magnitude (N)	–
1										
2										
3										
4										
5										

Sample Calculations :

(I) $K_1 = \frac{F_1}{\sin \theta_1} =$

(II) $K_2 = \frac{F_2}{\sin \theta_2} =$

(III) $K_3 = \frac{F_3}{\sin \theta_3} =$

$$K_1 = K_2 = K_3 = \frac{F_1}{\sin \theta_1} = \frac{F_2}{\sin \theta_2} = \frac{F_3}{\sin \theta_3} = K$$

11.10 Results and/or Interpretation

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11.11 Conclusions and/or Validation

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11.12 Practical related Questions

1. What are the conditions to apply Lami's theorem?
2. A ball of radius 12 cm weighing 200 N is connect to a vertical wall using a 35 cm string. Find the tension in the string & reaction of the wall against the ball.
3. A lamp weighing 50 N is suspend from a ceiling. A horizontal force of 20 N acts on the string that is use to suspend the lamp. Find the tension in the string & the angle of inclination of the string from the vertical direction.

11.13 Disposal of Waste

Classify the waste materials to be throw in this experiment in the following bins:

Type of Waste	Bin	Details
Biodegradable waste	Green bin	
e-Waste	Black bin	
Plastic and metal waste	Blue bin	
Any Other		

P-15 : COEFFICIENT OF FRICTION

15.1 Practical Statement

Determine co-efficient of friction for motion on horizontal & inclined plane.

15.2 Practical Significance

Determine the coefficient of friction between two given material surfaces.

15.3 Relevant Theory

When there is a motion or tendency of motion of body, over the contact surface the frictional force will produce to oppose it. The direction of friction force will be opposite of direction of motion. When the body is in such a position just before comes in the motion the frictional force will be maximum. This maximum frictional force known as Limiting Friction.

Coefficient of friction : It is a ratio of limiting frictional force to normal reaction.

Angle of friction is the angle between normal reaction and resultant force of frictional force and normal reaction.

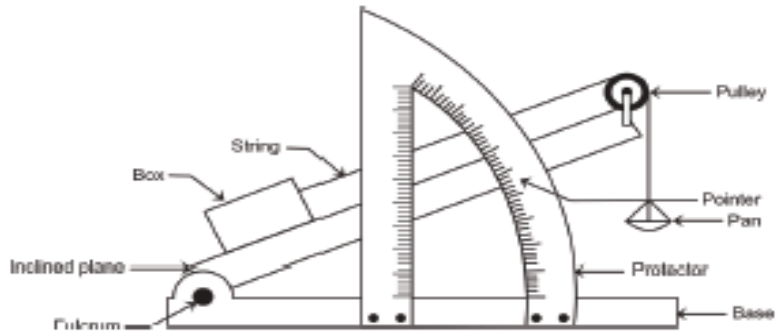
15.4 Practical Outcomes (PrO)

After completing the practical you will be able to:

PrO1 : Calculate coefficient of friction between two different surfaces.

PrO2 : Interpret the effect of change of mass, change of angle of inclination or both on the coefficient of friction.

15.5 Practical Setup



15.6 Resources Required

Sr. No.	Suggested Resources required Machines / Tools / Instruments with vital specification	Qty	Actual Resources required Machines / Tools / Instruments with broad specification	Remarks
1	Friction bench	1		
2	Wooden box and Pan	1		
3	Set of slotted weights 1 g, 2 g, 5 g, 10 g, 20 g, 50 g, 100 g, 200 g, 500 g	4 to 6		
4	Sprit level	1		
5	String	2		

15.7 Precaution

1. Align the friction bench truly accurately.
2. Clean the surface so that no grease or dirt sticking to the surface.
3. The weight should be place in the pan gently without any jerk or impact.
4. The block should just begin to move it should not move abruptly.

15.8 Suggested Procedure

(1) Make the surface of friction bench as a horizontal plane by using Sprit Level.
(2) Take and note weight of empty box and empty pan which are you going to use.
(3) Put some extra weight in box then initially apply insufficient pull force (P) to pull it through string as shown in figure. Sothere will be a tendency of motion of box only.
(4) Now increase force (P) by putting certain weight in pan and observe the motion of the box. If force is insufficient to pull it then give increment in pull force (P).
(5) Finally find required minimum pull force (P) for the motion of the box.
(6) Note : Total weight W (wt. of box + extra wt. put in box) & required minimum pull force P (wt. of pan + extra wt. put in pan) to be calculated.
(7) Now give increment in extra weight in box and find again required minimum pull force by repeating step 3 to 6 & take 4 to 5 more set of readings.
(8) Plot on graph : Total Weight (W) on X-axis v/s minimum pull force (P) on Y-axis.
(9) Slope of graph represents the co-efficient of friction (μ) between those two surfaces.
(10) Change the contact surfaces and repeat all above steps (2 to 10) for other type of contact surfaces.

15.9 Observation Table and calculations

Surfaces in contact :						
W = Wt. of Box ( ) + Wt. placed in the Box & P = Wt. of Pan ( ) + Wt. placed in the Pan						
Sr. No.	Weight (W) (in Gram)	Force (P) (in Gram)	Coefficient of Friction $\lambda = \frac{P}{W}$	Average λ	From Graph λ	Angle of Friction (ε)
1						
2						
3						
4						
5						

Sample Calculations :

$$\mu = \frac{P}{W}$$

15.10 Results and/or Interpretation

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15.11 Conclusions and/or Validation

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15.12 Practical related Questions

1. Compare the value of coefficient of friction μ between the two surfaces with the value given in a standard book.
2. Would the value of coefficient of friction μ be the same, if the materials on the plane and block interchanged?
3. List the factors on which friction depends.

15.13 Disposal of Waste

Classify the waste materials to be throw in this experiment in the following bins:

Type of Waste	Bin	Details
Biodegradable waste	Green bin	
e-Waste	Black bin	
Plastic and metal waste	Blue bin	
Any Other		

P-16 : CENTROID OF PLAIN LAMINA

16.1 Practical Statement

Determine centroid of geometrical plain lamina/figure.

16.2 Practical Significance

Determine the centroid of lamina using the plumb line method

16.3 Relevant Theory

Centroid : The point at which whole area of a plain lamina is assume to be concentrate called centroid. This term is use for two dimension figures for which area is important.

Centre of Gravity : The point at which whole mass of a solid body is assume to be concentrated, is call Centre of Gravity. This term is use for three dimensional figures for which mass is important.

16.4 Practical Outcomes (PrO)

After completing the practical you will be able to:

PrO1 : Examine the concept of centre of gravity.

PrO2 : Use the force of gravity to deduce the centre of gravity.

16.5 Practical Setup

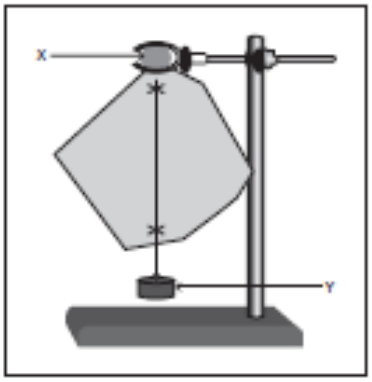

Fig. 1

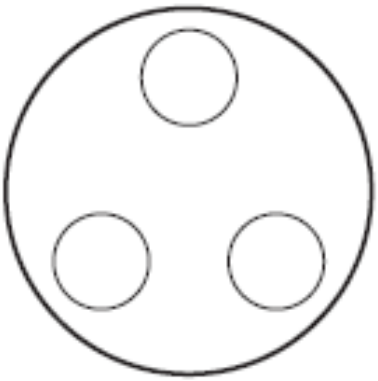

Fig. 2

16.6 Resources Required

Sr. No.	Suggested Resources required Machines / Tools / Instruments with vital specification	Qty	Actual Resources required Machines / Tools / Instruments with broad specification	Remarks
1	Different shaped sections of thin plywood (Lamina)	2 to 3		
2	Vertical stand	1		
3	Plumb Bob & Nain	1		
4	Drawing sheet and ruler	1		
5	String & Pencil	2		

16.7 Precaution

1. The load of the plumb bob should not be too heavy to pull down or remove the nail.
2. The plumb bob should not be swinging at the time the lines to drawn.
3. The nail should be firmly fix.
4. The plumb line should draw with straight ruler.

16.8 Procedure

(1) Take any irregular shape of thin plywood sheet (lamina) & paste blank drawing sheet on its Centre.

(2) Hang it on the vertical stand from any one corner with the help of string as shown in the Figure 1.

(3) Use plumb bob make a vertical line, according alignment of string on the drawing sheet.

(4) Again, hang this irregular shape of thin plywood sheet on the stand from other corner and mark a vertical line on the same drawing sheet.

(5) Repeat step-2 & 3 and make vertical lines on the drawing sheet for different hanging positions.

(6) Intersection of all these vertical lines on the drawing sheet will gives centroid of that lamina.

(7) Then find out centroid of that lamina theoretically and tabulate the results.

(8) By using regular shape of thin plywood sheet with removable disk/disks like as shown in Figure 2. We can calculate and verify shifting of centroid of the plain lamina also.

15.9 Observation Table and calculations

Sr. No.	Shape of Lamina	Observed Co-ordinates of Centroid (mm)		Theoretical Co-ordinates of Centroid (mm)	
		Y	X	Y	X
1					
2					
3					

16.10 Results and/or Interpretation

.....

16.11 Conclusions and/or Validation

.....

16.12 Practical related Questions

1. What precautions would you take to ensure best results?
2. If lamina shape is trapezium, how would be you determine it centroid?
3. Why do we have to draw several lines from different points?
4. How can you check that you have correctly found centre of gravity?

16.13 Disposal of Waste

Classify the waste materials to be throw in this experiment in the following bins:

Type of Waste	Bin	Details
Biodegradable waste	Green bin	
e-Waste	Black bin	
Plastic and metal waste	Blue bin	
Any Other		

P-2 : DIFFERENTIAL AXLE AND WHEEL

2.1 Practical Statement

To find mechanical advantage (MA), velocity ratio (VR) & efficiency and law of machine for differential axle and wheel.

2.2 Practical Significance

To establish the law of machine of the given differential axle & wheel.

2.3 Relevant Theory

[REFER TOPIC 5.2 & 5.3]

2.4 Practical Outcomes (PrO)

After completing the practical you will be able to :

PrO1 : Understand the Mechanical Advantage (MA), Velocity Ratio (VR) & Efficiency of machine.

PrO2 : Understand the law of machine $P = mW + C$

PrO3 : Interpret the analytical and graphical results.

2.5 Practical Setup

[REFER FIG. 5.3]

2.6 Resources Required

Sr. No.	Suggested Resources required Machines / Tools / Instruments with vital specification	Qty	Actual Resources required Machines / Tools / Instruments with broad specification	Remarks
1	Differential axle & wheel	1		
2	Set of weights like 1 kg, 2 kg, 3 kg	2		
3	Set of slotted weights 1 g, 2 g, 5 g, 10 g, 20 g, 50 g, 100 g, 200 g, 500 g.	4 to 6		
4	External Vernier capiler	1		
5	Steel foot rule & Wooden meter scale	1		
6	Nylon string	2		

2.7 Precaution

1. The weight should be place in the pan gently without any jerk or impact.
2. The distance moved by effort & load should be measured carefully.
3. Select proper scale for the graph.

2.8 Suggested Procedure

(1) First know the working system of given differential axle & wheel machine.

(2) Hang the appropriate quantities of Effort P on Wheel to lift the Load W on Axle as shown in figure. So we can measure the displacements *y* & *x* of Effort & Load respectively.

(3) We can obtain the Velocity Ratio = $\frac{y}{x}$ of given machine by measuring values of *y* & *x* as displacement of Effort and displacement of Load respectively.

(4) To get average value of VR repeats Step No.2&3 for further sets of readings (4 to 5).

(5) Now measure the diameter of Wheel (D) and diameter of big & small Axle (d_1 & d_2) to get theoretical VR = $\frac{D}{(d_1 - d_2)}$

(6) Draw a graph of lifted Load (W) on X-axis v/s applied Effort (P) on Y-axis & get the values of m and C graphically.

(7) Find Constants m and C analytically by putting any two observation in equation P = mW + C.

(8) Compare the values of m and C obtained by analytically and graphically.

2.9 Observation Table and calculations

(i) Diameter of Wheel = D = ... mm

(ii) Diameter of big & small Axle = d_1 = ... mm & d_2 = ... mm

Sr. No.	Load W in (N)	Effort P in (N)	Mech. Adv. MA = $\frac{W}{P}$	Displacement of		Practically VR = $\frac{Y}{X}$	Efficiency $\frac{MA}{VR}$	Constants for law of machine			
				Effort Y (mm)	Load X (mm)			Analytically		Graphically	
								m	C in (N)	m	C in (N)
1											
2											
3											
4											
5											

Sample Calculations:

(I) $MA = \frac{W}{P}$

(II) $VR = \frac{Y}{X}$

(III) Efficiency = $\frac{MA}{VR}$

(IV) Law of machine : (Analytical) $P = mW + C$

(V) Law of machine : (Graphical) $P = mW + C$

(VI) Theoretical Velocity ratio : $VR = \frac{2D}{(d_1 - d_2)}$

2.10 Results and/or Interpretation

.....

2.11 Conclusions and/or Validation:

.....

2.12 Practical related Questions

1. Discuss the reasons for difference between theoretical & practical value of VR.
2. Discuss the reasons for difference between analytical & graphical values for constants m & C from low of machine P= mW + C.

2.13 Disposal of Waste

Classify the waste materials to be throw in this experiment in the following bins:

Type of Waste	Bin	Details
Biodegradable waste	Green bin	
e-Waste	Black bin	
Plastic and metal waste	Blue bin	
Any Other		

P-3 : SIMPLE SCREW JACK

3.1 Practical Statement

To find mechanical advantage (MA), velocity ratio (VR) & efficiency and law of machine for simple screw jack.

3.2 Practical Significance

To establish the law of machine of a given Simple Screw Jack.

3.3 Relevant Theory

[REFER TOPIC 5.2 & 5.3]

3.4 Practical Outcomes (PrO)

PrO1 : Understand the Mechanical Advantage (MA), Velocity Ratio (VR) & Efficiency of machine.

PrO2 : Understand the law of machine $P = mW + C$.

PrO3 : Interpret the analytical and graphical results.

3.5 Practical Setup

[REFER FIG. 5.7]

3.6 Resources Required

Sr. No.	Suggested Resources required Machines / Tools / Instruments with vital specification	Qty	Actual Resources required Machines / Tools / Instruments with broad specification	Remarks
1	Scew jack Apparatus	1		
2	Set of weights like 1 kg, 2 kg, 3 kg	2		
3	Set of slotted weights 10 g, 20 g, 50 g, 100 g, 200 g, 500 g.	4 to 6		
4	External Vernier capiler	1		
5	Steel foot rule & Wooden meter scale	1		
6	Nylon string	1		

3.7 Precaution

(1) The weight should be place in the pan gently without any jerk or impact.

(2) The pitch of the screw jack should be measure very carefully.

(3) At least three readings should be carryout for each value of load.

3.8 Suggested Procedure

(1) First know the working system of given simple screw jack machine.

(2) To obtain Velocity Ratio (VR) of the given machine :

(i) Theoretical : measure the diameter of effort wheel /handle (D) and pitch (p) of the screw

(ii) Graphical : measure displacement of effort as y and as x for load.

(3) Put the different load W one by one on load drum and find required minimum effort P applying on effort wheel/ handle to raise each load and note them in observation table.

(4) Draw agraph of lifted Load (W) on X-axis v/s applied Effort (P) on Y-axis and get the values of m &C.

(5) Find Constants m & C analytically by putting any two observation in law of machine : $P = mW + C$.

(6) Compare the values of m & C obtained by analytically and graphically.

3.9 Observation Table and calculations

(i) Diameter of effort wheel/ handle (D) = ... mm

(ii) Pitch of the screw jack = p = ... mm

Sr. No.	Load W in (N)	Effort P in (N)	Mech. Adv. $MA = \frac{W}{P}$	Displacement of		Practically $VR = \frac{Y}{X}$	Efficiency $\frac{MA}{VR}$	Constants for law of machine			
				Effort Y (mm)	Load X (mm)			Analytically		Graphically	
								m	C in (N)	m	C in (N)
1											
2											
3											
4											
5											

Sample Calculations :

(I) $MA = \frac{W}{P}$

(II) $VR = \frac{Y}{X}$

(III) Efficiency = $\frac{MA}{VR}$

(IV) Law of machine : (Analytical) $P = mW + C$

(V) Law of machine : (Graphical) $P = mW + C$

(VI) Theoretical Velocity Ratio = $VR = \frac{\pi D}{p}$

3.10 Results and/or Interpretation

.....

3.11 Conclusions and/or Validation

.....

3.12 Practical related Questions

1. What is pitch? How you measure it?
2. How you measure the circumference of the load drum?
3. Screw jack on which principal works?

3.13 Disposal of Waste

Classify the waste materials to be throw in this experiment in the following bins:

Type of Waste	Bin	Details
Biodegradable waste	Green bin	
e-Waste	Black bin	
Plastic and metal waste	Blue bin	
Any Other		

P-4 : WORM & WORM WHEEL

4.1 Practical Statement

Derive law of machine for worm & worm wheel.

4.2 Practical Significance

To determine the Mechanical Advantage, Velocity Ratio & efficiency and law of machine of a given worm & worm wheel.

4.3 Relevant Theory

[REFER TOPIC 5.2 & 5.3]

4.4 Practical Outcomes (PrO)

PrO1 : Understand the Mechanical Advantage (MA), Velocity Ratio (VR) & Efficiency of machine.

PrO2 : Understand the law of machine $P = mW + C$

PrO3 : Interpret the analytical and graphical results.

4.5 Practical Setup

[REFER FIG. 5.4]

4.6 Resources Required

Sr. No.	Suggested Resources required Machines / Tools / Instruments with vital specification	Qty	Actual Resources required Machines / Tools / Instruments with broad specification	Remarks
1	Worm & worm wheel	1		
2	Set of weights like 1 kg, 2 kg, 3 kg	2		
3	Set of slotted weights 1 g, 2 g, 5 g, 10 g, 20 g, 50 g, 100 g, 200 g, 500 g.	4 to 6		
4	External Vernier capiler	1		
5	Steel foot rule & Wooden meter scale	1		
6	Nylon string	2		

4.7 Precaution

1. The weight should be place in the pan gently without any jerk or impact.
2. The distance moved by effort & load should be measured carefully.
3. Select proper scale for the graph.

4.8 Suggested Procedure

(1) First know the working system of given worm & worm wheel machine.

(2) Hang the appropriate quantities of Effort P on Wheel / handleto lift the Load W on load drum. So we can measure the displacements y & x of Effort & Load respectively.

(3) We can obtain the Velocity Ratio = $\frac{y}{x}$ of given machine by measuring values of y & x as displacement of Effort and displacement of Load respectively.

(4) To get average value of VR repeats Step No. 2 & 3 for further sets of readings (4 to 5).

(5) Now measure the diameter of Wheel / handle (D), Radius of load drum (r), T = no. of teeth on worm wheel and n = no. of worm thread (single, double etc.), then theoretical VR = $\frac{RT}{r}$ or VR = $\frac{RT}{nr}$.

(6) Draw a graph of lifted Load (W) on X-axis v/s applied Effort (P) on Y-axis & get the values of m & C graphically.

(7) Find Constants m and C analytically by putting any two observation in equation P = mW + C.

(8) Compare the values of m and C obtained by analytically and graphically.

4.9 Observation Table and calculations

(i) Diameter of Wheel / handle = D = ... mm

(ii) Radius of load drum = r ..... mm

(iii) No. of teeth on worm wheel = T = ...

(iv) No. of worm thread = n = ...

Sr. No.	Load W in (N)	Effort P in (N)	Mech. Adv. MA = $\frac{W}{P}$	Displacement of		Practically VR = $\frac{Y}{X}$	Efficiency $\frac{MA}{VR}$	Constants for law of machine			
				Effort Y (mm)	Load X (mm)			Analytically		Graphically	
								m	C in (N)	m	C in (N)
1											
2											
3											
4											
5											

Sample Calculations :

(I) MA = $\frac{W}{P}$

(II) VR = $\frac{Y}{X}$

(III) Efficiency = $\frac{MA}{VR}$

(IV) Law of machine : (Analytical) $P = mW + C$

(V) Law of machine : (Graphical) $P = mW + C$

(VI) Theoretical Velocity Ratio = VR = $\frac{RT}{nr}$

4.10 Results and/or Interpretation

.....

4.11 Conclusions and/or Validation

.....

4.12 Practical related Questions

1. What do you understand by constant "C" in the Law of simple lifting machine?
2. List the reasons why differ the values of analytical velocity ratio and practical velocity ratio.
3. Write the formulas of velocity ratio of simple lifting machines,which are available in the laboratory.

4.13 Disposal of Waste

Classify the waste materials to be throw in this experiment in the following bins:

Type of Waste	Bin	Details
Biodegradable waste	Green bin	
e-Waste	Black bin	
Plastic and metal waste	Blue bin	
Any Other		

P-5 : SINGLE PURCHASE CRAB WINCH

5.1 Practical Statement

Derive law of machine for single purchase crab winch.

5.2 Practical Significance

To determine the Mechanical Advantage, Velocity Ratio & efficiency and law of machine of a given single purchase crab winch.

5.3 Relevant Theory

[REFER TOPIC 5.2 & 5.3]

5.4 Practical Outcomes (PrO)

PrO1 : Understand the Mechanical Advantage (MA), Velocity Ratio (VR) & Efficiency of machine.
PrO2 : Understand the law of machine P = mW + C
PrO3 : Interpret the analytical and graphical results.

5.5 Practical Setup

[REFER FIG. 5.5]

5.6 Resources Required

Sr. No.	Suggested Resources required Machines / Tools / Instruments with vital specification	Qty	Actual Resources required Machines / Tools / Instruments with broad specification	Remarks
1	Single purchase crab winch	1		
2	Set of weights like 1 kg, 2 kg, 3 kg	2		
3	Set of slotted weights 1 g, 2 g, 5 g, 10 g, 20 g, 50 g, 100 g, 200 g, 500 g.	4 to 6		
4	External Vernier capiler	1		
5	Steel foot rule & Wooden meter scale	1		
6	Nylon string	2		

5.7 Precaution

1. The weight should be place in the pan gently without any jerk or impact.
2. The distance moved by effort & load should be measured carefully.
3. Select proper scale for the graph.

5.8 Suggested Procedure

(1) First know the working system of given single purchase crab winch machine.
(2) Hang the appropriate quantities of Effort P on Wheelto lift the Load W on load drum as shown in figure. So we can measure the displacements y & x of Effort & Load respectively.
(3) We can obtain the Velocity Ratio = $\frac{y}{x}$ of given machine by measuring values of y & x as displacement of Effort and displacement of Load respectively.
(4) To get average value of VR repeats Step No. 2 & 3 for further setsof readings (4 to 5).

(5) Now measure the Length of handle or Radius of effort wheel (L) &Radius of load drum (r) and count No. of teeth on spur wheel (main gear) (T_1) & No. of teeth on pinion wheel (T_2) to get theoretical VR = $\left(\frac{L}{r}\right) \times \left(\frac{T_1}{T_2}\right)$

(6) Draw a graph of lifted Load (W) on X-axis v/s applied Effort (P) on Y-axis & get the values of m and C graphically.

(7) Find Constants m and C analytically by putting any two observation in equation P = mW + C.

(8) Compare the values of m and C obtained by analytically and graphically.

5.9 Observation Table and calculations

(i) Length of handle or Radius of effort wheel = L = ... mm

(ii) Radius of load drum = r = ... mm

(iii) No. of teeth on spur wheel (main gear) = T_1 = ...

(iv) No. of teeth on pinion wheel = T_2 = ...

Sr. No.	Load W in (N)	Effort P in (N)	Mech. Adv. $MA = \frac{W}{P}$	Displacement of		Practically $VR = \frac{Y}{X}$	Efficiency $\frac{MA}{VR}$	Constants for law of machine			
				Effort Y (mm)	Load X (mm)			Analytically		Graphically	
								m	C in (N)	m	C in (N)
1											
2											
3											
4											
5											

Sample Calculations :

(I) $MA = \frac{W}{P}$

(II) $VR = \frac{Y}{X}$

(III) Efficiency = $\frac{MA}{VR}$

(IV) Law of machine : (Analytical) P = mW + C

(V) Law of machine : (Graphical) P = mW + C

(VI) Theoretical Velocity Ratio = VR = $\left(\frac{L}{r}\right) \times \left(\frac{T_1}{T_2}\right)$

5.10 Results and/or Interpretation

.....

5.11 Conclusions and/or Validation

.....

5.12 Practical related Questions

1. Define Ideal Simple Lifting Machine.
2. What will be the effect on efficiency, if effort loss in friction reduced?

5.13 Disposal of Waste

Classify the waste materials to be throw in this experiment in the following bins:

Type of Waste	Bin	Details
Biodegradable waste	Green bin	
e-Waste	Black bin	
Plastic and metal waste	Blue bin	
Any Other		

P-6 : DOUBLE PURCHASE CRAB WINCH

6.1 Practical Statement

Derive law of machine for double purchase crab winch.

6.2 Practical Significance

To determine the Mechanical Advantage, Velocity Ratio & efficiency and law of machine of a given double purchase crab winch.

6.3 Relevant Theory

[REFER TOPIC 5.2 & 5.3]

6.4 Practical Outcomes (PrO)

PrO1 : Understand the Mechanical Advantage (MA), Velocity Ratio (VR) & Efficiency of machine.
PrO2 : Understand the law of machine P = mW + C
PrO3 : Interpret the analytical and graphical results.

6.5 Practical Setup

[REFER FIG. 5.6]

6.6 Resources Required

Sr. No.	Suggested Resources required Machines / Tools / Instruments with vital specification	Qty	Actual Resources required Machines / Tools / Instruments with broad specification	Remarks
1	Double purchase crab winch	1		
2	Set of weights like 1 kg, 2 kg, 3 kg	2		
3	Set of slotted weights 1 g, 2 g, 5 g, 10 g, 20 g, 50 g, 100 g, 200 g, 500 g.	4 to 6		
4	External Vernier capiler	1		
5	Steel foot rule & Wooden meter scale	1		
6	Nylon string	2		

6.7 Precaution

1. The weight should be place in the pan gently without any jerk or impact.
2. The distance moved by effort & load should be measured carefully.
3. Select proper scale for the graph.

6.8 Suggested Procedure

(1) First know the working system of given double purchase crab winch machine.
(2) Hang the appropriate quantities of Effort P on Wheel to lift the Load W on load drum as shown in figure. So we can measure the displacements y & x of Effort & Load respectively.
(3) We can obtain the Velocity Ratio = $\frac{y}{x}$ of given machine by measuring values of y & x as displacement of Effort and displacement of Load respectively.
(4) To get average value of VR repeats Step No. 2 & 3 for further setsof readings (4 to 5).
(5) Now measure the Length of handle or Radius of effort wheel (L) & Radius of load drum (r) and count No. of teeth on spur wheel (main gear) (T_1 & T3) & No. of teeth on pinion wheel (T_2 & T_4) to get theoretical VR = $\left(\frac{L}{r}\right) \times \left(\frac{T_1 \times T_3}{T_2 \times T_4}\right)$
(6) Draw a graph of lifted Load (W) on X-axis v/s applied Effort (P) on Y-axis & get the values of m and C graphically.
(7) Find Constants m and C analytically by putting any two observation in equation P = mW + C.
(8) Compare the values of m and C obtained by analytically and graphically.

6.9 Observation Table and calculations

(i) Length of handle or Radius of effort wheel = L = ... mm

(ii) Radius of load drum = r = ... mm

(iii) No. of teeth on spur wheel (main gear) = T_1 & T_3 = ...& .....

(iv) No. of teeth on pinion wheel = T_2 &T_4 = ... & .....

Sr. No.	Load W in (N)	Effort P in (N)	Mech. Adv. $MA = \frac{W}{P}$	Displacement of		Practically $VR = \frac{Y}{X}$	Efficiency $\frac{MA}{VR}$	Constants for law of machine			
				Effort Y (mm)	Load X (mm)			Analytically		Graphically	
								m	C in (N)	m	C in (N)
1											
2											
3											
4											
5											

Sample Calculations :

(I) $MA = \frac{W}{P}$

(II) $VR = \frac{Y}{X}$

(III) Efficiency = $\frac{MA}{VR}$

(IV) Law of machine : (Analytical) $P = mW + C$

(V) Law of machine : (Graphical) $P = mW + C$

(VI) Theoretical Velocity Ratio = $VR = \left(\frac{L}{r}\right) \times \left(\frac{T_1 \times T_3}{T_2 \times T_4}\right)$

6.10 Results and/or Interpretation

.....

6.11 Conclusions and/or Validation

.....

6.12 Practical related Questions

1. What is advantage of double purchase crab winch over single purchase crab winch?
2. Why the nos. of teeth are more on spur wheel then on pinion wheel?
3. How you can increase VR of double purchase crab winch?

6.13 Disposal of Waste

Classify the waste materials to be throw in this experiment in the following bins:

Type of Waste	Bin	Details
Biodegradable waste	Green bin	
e-Waste	Black bin	
Plastic and metal waste	Blue bin	
Any Other		

P-7 : WESTON DIFFERENTIAL PULLEY BLOCK

7.1 Practical Statement

Derive law of machine for Weston's differential pulley block.

7.2 Practical Significance

To determine the Mechanical Advantage, Velocity Ratio & efficiency and law of machine of a given weston's differential pulley block.

7.3 Relevant Theory

[REFER TOPIC 5.2 & 5.3]

7.4 Practical Outcomes (PrO)

PrO1 : Understand the Mechanical Advantage (MA), Velocity Ratio (VR) & Efficiency of machine.

PrO2 : Understand the law of machine P = mW + C

PrO3 : Interpret the analytical and graphical results.

7.5 Practical Setup

[REFER FIG.5.8]

7.6 Resources Required

Sr. No.	Suggested Resources required Machines / Tools / Instruments with vital specification	Qty	Actual Resources required Machines / Tools / Instruments with broad specification	Remarks
1	Weston's differential pulley block	1		
2	Set of weights like 1 kg, 2 kg, 3 kg	2		
3	Set of slotted weights 1 g, 2 g, 5 g, 10 g, 20 g, 50 g, 100 g, 200 g, 500 g.	4 to 6		
4	External Vernier capiler	1		
5	Steel foot rule & Wooden meter scale	1		
6	Nylon string	2		

7.7 Precaution

1. The weight should be place in the pan gently without any jerk or impact.
2. The distance moved by effort & load should be measured carefully.
3. Select proper scale for the graph.

7.8 Suggested Procedure

(1) First know the working system of given weston's differential pulley block machine.

(2) Hang the appropriate quantities of Effort P on Wheel / handle to lift the Load W on load drum as shown in figure. So we can measure the displacements y & x of Effort & Load respectively.

(3) We can obtain the Velocity Ratio = $\frac{y}{x}$ of given machine by measuring values of y & x as displacement of Effort and displacement of Load respectively.

(4) To get average value of VR repeats Step No. 2 & 3 for further sets of readings (4 to 5).

(5) Now measure Diameter of bigger pulley (D) and Diameter of smaller pulley (d) to get theoretical VR = $\frac{2D}{D-d}$.

(6) Draw a graph of lifted Load (W) on X-axis v/s applied Effort (P) on Y-axis & get the values of m and C graphically.

(7) Find Constants m and C analytically by putting any two observation in equation P = mW + C.

(8) Compare the values of m and C obtained by analytically and graphically.

7.9 Observation Table and calculations

(i) Diameter of bigger pulley = D = ... mm

(ii) Diameter of smaller pulley = d = ... mm

Sr. No.	Load W in (N)	Effort P in (N)	Mech. Adv. $MA = \frac{W}{P}$	Displacement of		Practically $VR = \frac{Y}{X}$	Efficiency $\frac{MA}{VR}$	Constants for law of machine			
				Effort Y (mm)	Load X (mm)			Analytically		Graphically	
								m	C in (N)	m	C in (N)
1											
2											
3											
4											
5											

Sample Calculations :

(I) $MA = \frac{W}{P}$

(II) $VR = \frac{Y}{X}$

(III) Efficiency = $\frac{MA}{VR}$

(IV) Law of machine : (Analytical) $P = mW + C$

(V) Law of machine : (Graphical) $P = mW + C$

(VI) Theoretical Velocity Ratio = $VR = \frac{2D}{D-d}$

7.10 Results and/or Interpretation

.....

7.11 Conclusions and/or Validation

.....

7.12 Practical related Questions

1. Explain reversible and non-reversible machine.
2. Compare weston's differential pulley block with differential axle & wheel.

7.13 Disposal of Waste

Classify the waste materials to be throw in this experiment in the following bins:

Type of Waste	Bin	Details
Biodegradable waste	Green bin	
e-Waste	Black bin	
Plastic and metal waste	Blue bin	
Any Other		