# PRACTICAL RECORD BOOK

## ENGINEERING MECHANICS LAB

(B.E. [illegible] SEMESTER)

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# EXPERIMENT NO.-1

## OBJECT :

To draw the following diagram for a Simple Screw Jack.

1. Load - effort diagram.
2. Load - ideal effort diagram.
3. Load - efficiency diagram.

Also determine the maximum efficiency and the law of machine.

## APPARATUS :

A Simple Screw Jack consists of a square thread screw engaged with nut. This nut is fixed to a base as shown in Fig. Some times nut is in the form of base itself. An effort wheel is attached with the screw at top. Screw is free to rotate in nut. As the screw rotates in nut, it moves up or down. The top surface of effort wheel works as load platform as shown in fig. A string is wrapped around the effort wheel and one end of the string attached to the effort pan.

## THEORY :

Screw Jack basically works on principle of wedge. As load is lifted through inclined plane; there is requirement of lesser effort as compared to direct lifting.

The velocity ratio V of any lifting machine is given by :

$$V = \frac{\text{Distance traveled by effort in a particular time interval}}{\text{Distance traveled by load in the same time interval}}$$

In case of Simple Screw Jack

$V = \pi d/p$

Where $d$ = diameter of effort wheel (mm)

$P$ = pitch of screw thread (mm)

The efficiency of machine ($\eta$) is given by

$\eta = W/(P_a.V)$

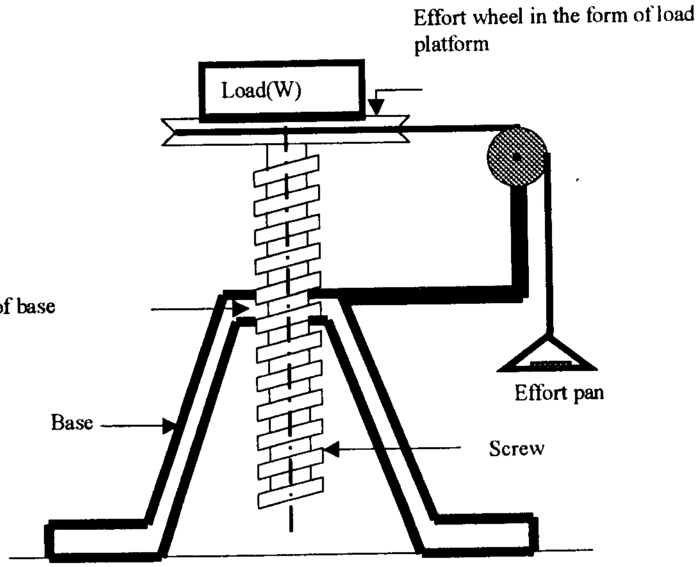
Where $W$ = Load lifted (Kg)

$P_a$ = Actual effort (Kg)

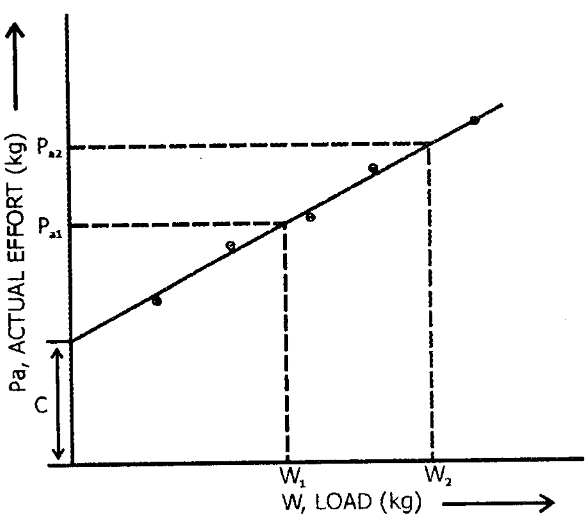
$V$ = Velocity ratio

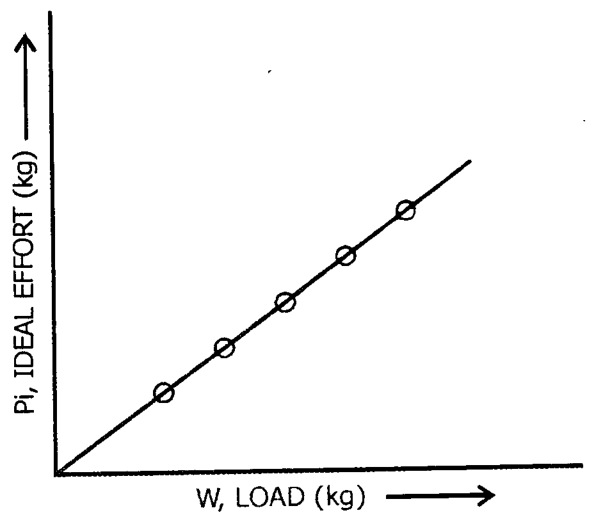
Mechanical Advantage is given by

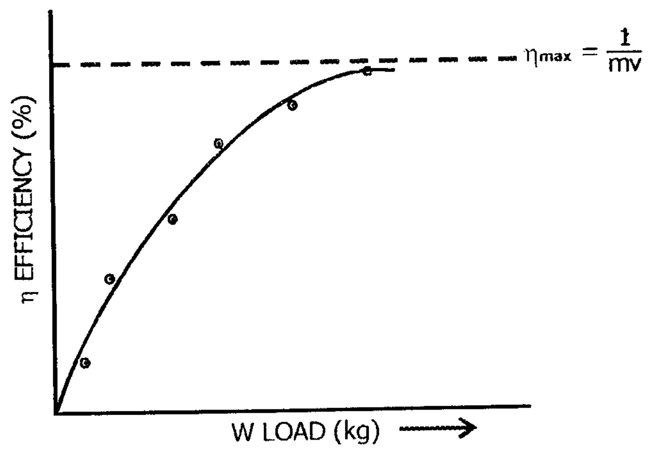
$$M.A. = \frac{W}{P_a}$$




Simple Screw jack



**PROCEDURE :**

1. Rotate the screw by five revolution and measure the axial upward or downward movement (x)
2. Determine the pitch of the screw thread i,e distance moved in one revolution $p = x/5$
3. Measure the circumference of the effort wheel.
4. Put some known weight on the load hanger and find out the corresponding effort required to lift the load by adding the weights on the effort pan.
5. Repeat the experiment for at least five values of load.
6. Draw the necessary graphs as shown in Fig.

**OBSERVATION AND CALCULATION :**

1. Circumference of effort wheel ($\pi d$)=
2. Hence the diameter of effort wheel (d) =
3. Weight of the moving parts, $W_m$ = 1000gm
4. Velocity ratio, $V = \pi d/P$ =
5. Effort for moving parts $P_m = W_m/V$ =

| S. No. | Load W (kg) | Effort P (kg) | Actual effort Pa=P-Pm (kg) | Ideal effort Pi=W/V (kg) | Efficiency $\eta=[W/(P_a.V)]$ X 100 (%) |
|---|---|---|---|---|---|
| | | | | | |

The law of machine relating the effort and load is a straight line and is expressed as $P_a = mW + C$

Where $P_a$ = Actual effort (gm)
W = load (gm)
C = Intercept on the effort axis (from the graph in gm)
m = Slope of the load Vs actual effort graph
= $(P_{a2} - P_{a1}) / (W_2 - W_1)$ (from graph)

$\eta_{max} = 1/mV$ =

**RESULTS :**

Graph between load – actual effort; load – ideal effort and load – efficiency are plotted as shown.

Velocity ratio = ——————————

The law machine $P_a$ = mW + C = ———— W+ ————

Maximum efficiency, $\eta_{max} = \frac{1 \times 100}{m \times v}$ = ———— %

**PRECAUTIONS :**

1. String should be flexible & inextensible.
2. Weight should be added gradually
3. Jack should be properly lubricated.

**DISCUSSIONS :**

1. Where this screw jack is used ?
2. What are the advantages of irreversible machine ?
3. What is the difference between simple and modified screw jack ?
4. Explain pitch and lead of screw ?

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# EXPERIMENT NO.-2

**OBJECT :**

To determine the stiffness of a helical compression spring and to plot the graph between load and deflection.

**THEORY :**

The stiffness of a spring is defined, as the load required for producing unit deflection within the elastic limit of the material of the spring. The load is found to be proportional to the deflection. The unit of stiffness of spring is N/m in SI system. The stiffness of spring is also called spring constant.

**PROCEDURE :**

1. The deflection of the given helical spring is measured by a vernier. Calculate the zero error and least count of the vernier scale.
2. Note the weight of the hanger.
3. Add some weight to the hanger and measure the deflection by vernier scale.
4. Go on adding more weights on the hanger and measure the defection every time.
5. Now reduce the weight one by one in the same order and again note the deflection.
6. Take at least five readings.
7. Draw the necessary graph as shown in Fig.

**OBSERVATIONS :**

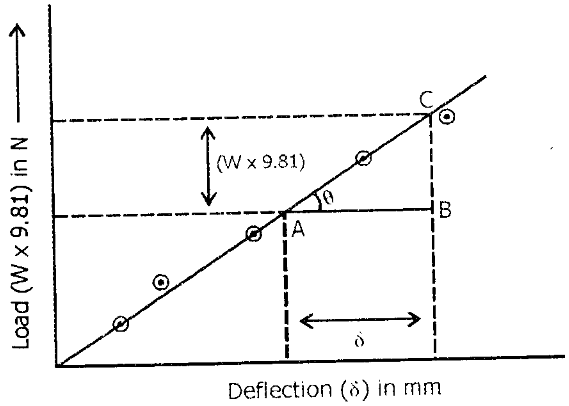
Least count of the vernier =

Weight of the hanger =

| S. No. | Load including hanger (kg) | Deflection of spring (mm) | Deflection of spring (mm) | Average deflection $\delta$ (mm) | Stiffness $(W \times 9.81) / \delta$ (N/mm) |
|---|---|---|---|---|---|
| | | Load Increasing | Load Decreasing | | |
| | | | | | |

**CALCULATION :**

1. Calculate the average deflection.
2. Calculate the stiffness by dividing the load W with average deflection δ for each reading.
3. Calculate the average stiffness of the spring.
4. Plot a graph between deflection δ and load W, taking them on X and Y-axis respectively.
5. Determine the average stiffness from the graph.
6. Compare the stiffness value obtained by calculation and that obtained by graph.




Graphical value of K = tanθ = $\frac{BC}{AB}$

**RESULT :**

The average value of the stiffness of the helical spring is :

By calculation =

By graph =

**DISCUSSION :**

1. Compare the two values of stiffness and point out the reasons for the difference ?
2. What are the various types of spring and where they are used ?
3. What is the significance of knowing the spring constant ?
4. How can you increase or decrease the stiffness of a spring ?
5. How will you determine the least count of the vernier scale provided ?

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# EXPERIMENT NO.-3

**OBJECT :**

Study of Simple Wheel and Axle and to draw the following diagram –

1. Load - effort diagram
2. Load - ideal effort diagram
3. Load - efficiency diagram

**APPARATUS :**

The apparatus consists of an axle of radius r and wheel of radius R. Two strings are wrapped around the wheel and axle in the opposite direction separately. One end of the wheel string is attached to an effort pan. One end of the axle string is attached to the load hanger.

**THEORY :**

In this lifting machine simple principle has been used to increase the velocity ratio. The velocity ratio V of any lifting machine is given by :

$$V = \frac{\text{Distance traveled by effort in a particular time interval}}{\text{Distance traveled by load in the same time interval}}$$

The velocity ratio of simple wheel and axle is given by :

$$V = R/r$$

Where R is a radius of effort wheel (mm)
r is the radius of load axle (mm)

The efficiency of machine at any load is given by

$$\eta = W/\ (P.V)$$

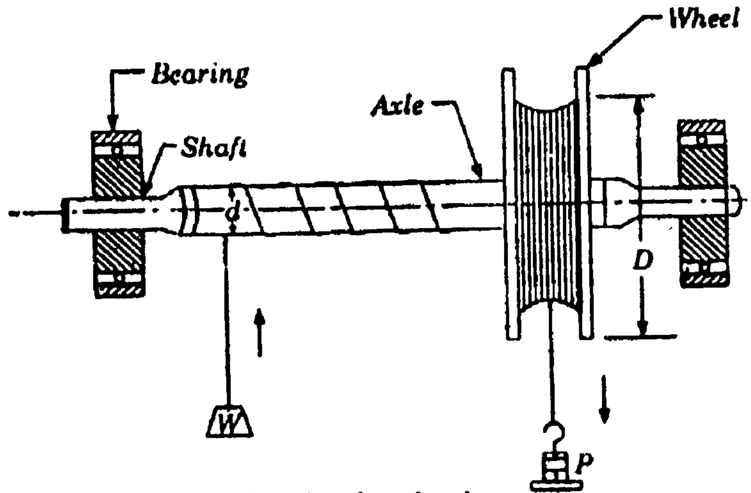
Where W is the load lifted (gm)
P is the effort required to lift the load (gm)

Mechanical advantage is given by

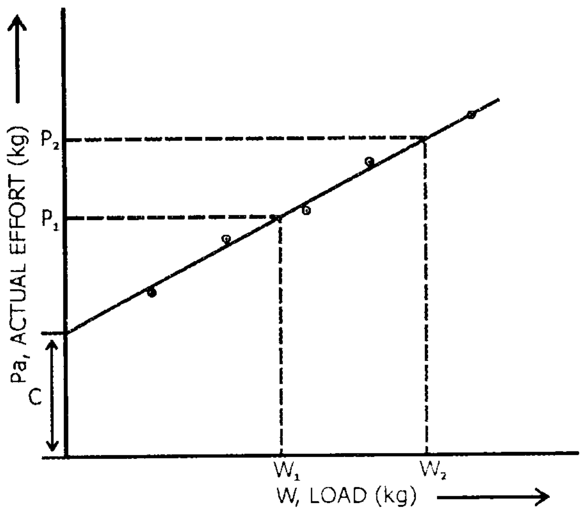
$$M.\ A. = W/P$$

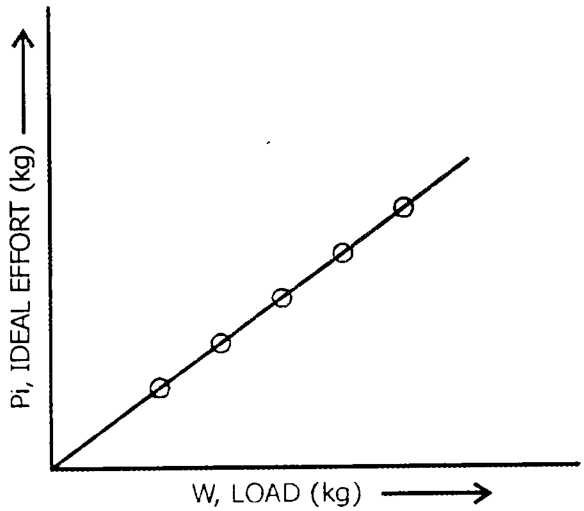
**PROCEDURE :**

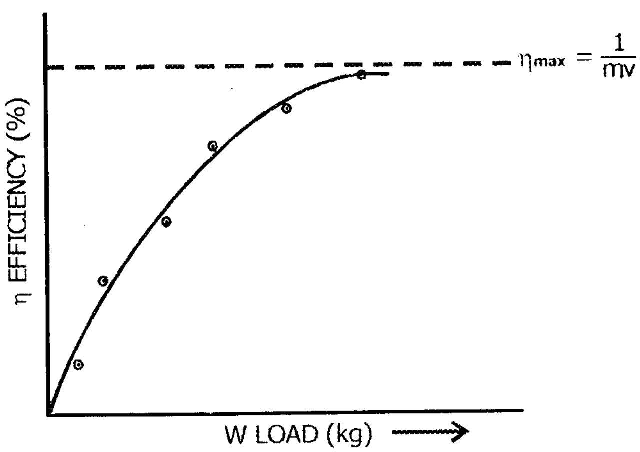
1. Measure and note down the circumference of the effort wheel and load axle.
2. Note down the weight of the pan and load hanger.
3. Put some known weight on the load hanger.




**Simple wheel and axle.**



4. Put some weight from the weight box on the pan attached to the effort wheel, add the weights on pan until the load starts moving up.
5. Note down the applied load and corresponding effort.
6. Repeat the experiment for different known weights. Take at least five readings.
7. Draw the necessary graphs as shown in Fig.

**OBSERVATION AND CALCULATION :**

Circumference of the effort wheel ($2\pi$ R) =

Therefore R = circumference /$2\pi$ =

Circumference of load axle ($2\pi$ r) =

Therefore r = circumference /$2\pi$ =

Weight of the load hanger =

Velocity ratio (V) = R / r =

The law of machine relating the effort and load is a straight line and is expressed as

$$P = mW + C$$

Where P = effort (gm)

W = load (gm)

C = Intercept on the effort axis (from the graph)

m = Slope of the load Vs actual effort line

= $(P_2 - P_1) / (W_2 - W_1)$ (from graph)

$\eta_{max} = 1/mV =$

| S. No. | Load including Hanger W (gm) | Effort P (gm) | Ideal effort Pi = W/V | Efficiency, $\eta = [W/(P \times V)] \times 100$ % | Mechanical Advantage = W/P |
|---|---|---|---|---|---|
| | | | | | |

**RESULTS :**

Velocity ratio = ______________________

The law machine P = mW + C = __________ W+ __________

Maximum efficiency, $\eta$ max = $\frac{1 \times 100}{mv}$ = __________ %

**PRECAUTIONS :**

1. Circumference should be measured very carefully.
2. The weight should be put gradually on effort pan.
3. The weights of hanger and pan should be taken into account.

**DISCUSSIONS :**

1. What is the advantage of increasing the velocity ratio ?
2. What do you understand by the law of machine ?

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# EXPERIMENT NO.-4

**OBJECT :**

To study the Single Purchase Winch Crab and to draw the following diagram.

1. Load - effort diagram
2. Load - ideal effort diagram
3. Load - efficiency diagram

Also state the law of machine and determine the maximum efficiency of the machine.

**APPARATUS :**

Single Purchase winch Crab consists of asset of gear and pinion. Gear is attached with load axle, where as pinion is attached with effort wheel. The whole assembly is supported on bearings. Two ropes are wrapped around the effort wheel and load axle in opposite direction separately. One end of effort wheel rope is attached to effort pan. One end of load axle rope is attached to load hanger.

**THEORY :**

The Single Purchase Winch crab is a simple lifting machine in which a large load W can be lifted by a small effort P. In this machine gear ratio and ratio of diameters of effort wheel to load axle is used for increasing the velocity ratio.

The velocity ratio V of any lifting machine is given by :

$$V = \frac{\text{Distance traveled by effort in a particular time interval}}{\text{Distance traveled by load in the same time interval}}$$

The velocity ratio V of Single Purchase Winch crab is given by

$$V = (Z_2 \times R) / (Z_1 \times r)$$

Where $Z_1$ and $Z_2$ are the Nos. of teeth on pinion and gear respectively. R is the radius of the effort wheel and r is radius of load axle.

Efficiency $\eta = W / (P \times V)$

Where P is the effort required to lift the load W.

The ideal effort $P_i$ is calculated by

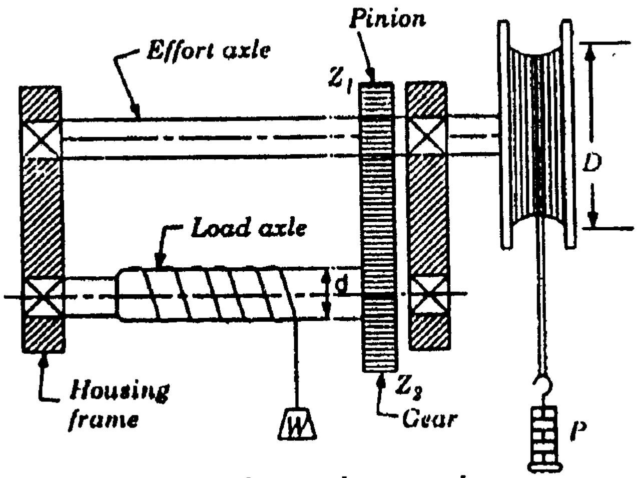
$$P_i = W / V$$

And the maximum efficiency is given by

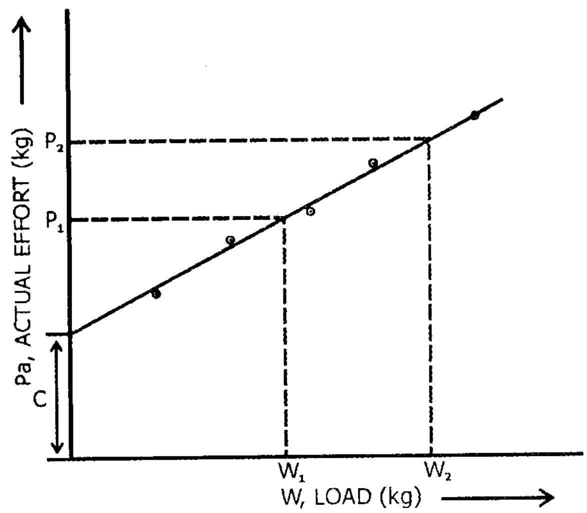
$$\eta_{max} = 1 / (m \times V)$$

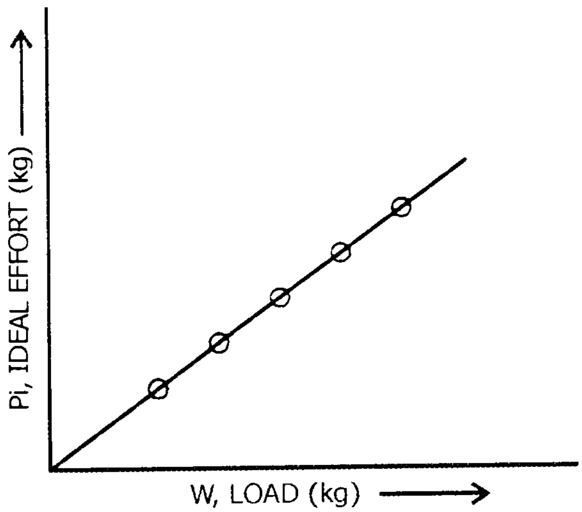
The law of machine is

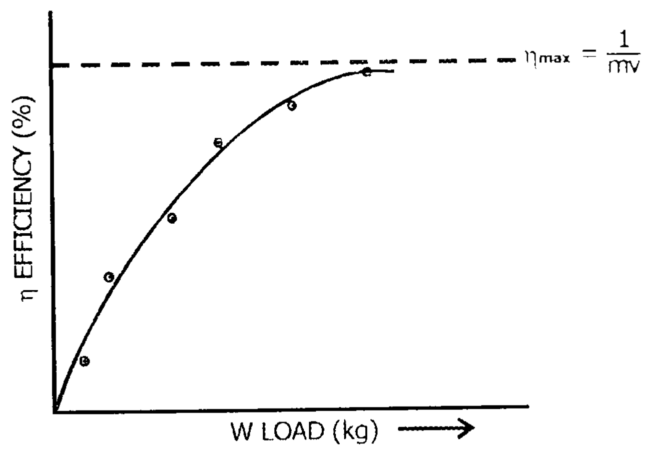
$$P = mW + C$$




**Single purchase crab.**



Where m is the slope of the load – effort line

C is the intercept of the load – effort line on Y – axis

**PROCEDURE :**

1. Count the No. of teeth on pinion $Z_1$
2. Count the No. of teeth on gear $Z_2$
3. Measure the circumference of the effort wheel.
4. Measure the circumference of the load axle.
5. Note the weight of the pan attached with the effort wheel string.
6. Note the weight of the hanger on the load axle string.
7. Put some known weight on the load hanger.
8. Put some weight from the weight box on the pan attached to the effort wheel; add the weights on pan until the load starts moving up.
9. Note down the value of the load and effort including hanger and pan.
10. Change the load and repeat the experiment. Take at least five readings.
11. Draw the necessary graphs as shown in Fig.

**OBSERVATION :**

1. No. of teeth on the pinion $Z_1$ = ――――――――――――
2. No. of teeth on the gear $Z_2$ = ――――――――――――
3. Circumference of the effort wheel ($2\pi R$) = ――――――――――――
4. Circumference of the Load axle ($2\pi r$) = ――――――――――――
5. Weight of the effort pan = ――――――――――――
6. Weight of the load hanger = ――――――――――――

| S. No. | Load including the hanger W (kg) | Effort including the hanger (kg) | Ideal effort Pi = W/V(kg) | Efficiency $\eta$ = [W/(PxV)] x 100 (%) | Mechanical Advantage =W/P |
|---|---|---|---|---|---|
| | | | | | |

**CALCULATION :**

1. Calculate the radius of the effort wheel.

   R = circumference / $2\pi$
2. Calculate the radius of load axle.

   r = circumference / $2\pi$
3. Calculate velocity ratio

   $V = (Z_2 \times R) / (Z_1 \times r)$
4. Calculate the ideal effort ($P_i$) and the efficiency for all the loads and complete the table.
5. From Fig Calculate the slope (m) of load- effort line, m =
6. Calculate the maximum efficiency $\eta_{max} = 1 / (m.V)$
7. Measure C from the load – effort diagram from Fig.
8. Write the law of machine P = mW + C

The law of machine relating the effort and load is a straight line and is expressed as

$$P = mW + C$$

Where P = effort (Kg)

W = load (Kg)

C = Intercept on the effort axis (from the graph)

m = Slope of the load Vs actual effort graph

$= (P_2 - P_1) / (W_2 - W_1)$ (from graph)

$\eta_{max} = 1/mV =$

**RESULT :**

Velocity ratio = ____________________

The law machine P = mW + C = __________ W+ __________

Maximum efficiency, $\eta_{max} = \frac{1}{mv} \times 100 =$ __________ %

**PRECAUTIONS :**

1. Put the weight on the pan carefully.
2. Increase the weight gradually.

**DISCUSSIONS :**

1. What is the use of law of machine ?
2. How will you reduce the effort required to lift a particular load ?
3. Define the following terms – Mechanical advantage, Velocity, ratio, ideal effort, ideal load and reversibility of machine ?

*****

# EXPERIMENT NO.-5

**OBJECT :**

To draw the following diagram for Wheel and Differential axle.

1. Load - effort diagram.
2. Load - ideal effort diagram
3. Load - efficiency diagram

Also find out the law of machine and its maximum efficiency.

**THEORY :**

In this lifting machine differential principle has been used to increase the velocity ratio.

The velocity ratio V of any lifting machine is given by :

$$V = \frac{\text{Distance traveled by effort in a particular time interval}}{\text{Distance traveled by load in the same time interval}}$$

The velocity ratio of differential wheel and axle is given by

$$V = 2R / (r_1 - r_2)$$

Where R is a radius of wheel

$r_1$ and $r_2$ are the radius of larger and smaller axle respectively

The efficiency of machine at any load is given by

$$\eta = W / (P.V)$$

Where W is the load lifted

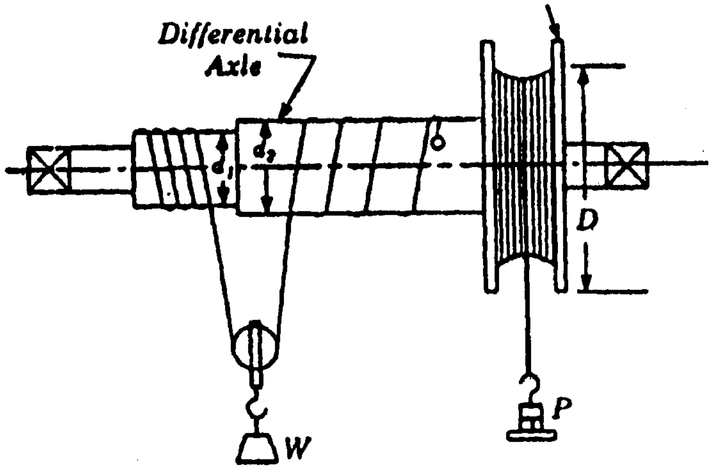
P is the effort required to lift the load.

**APPARATUS :**

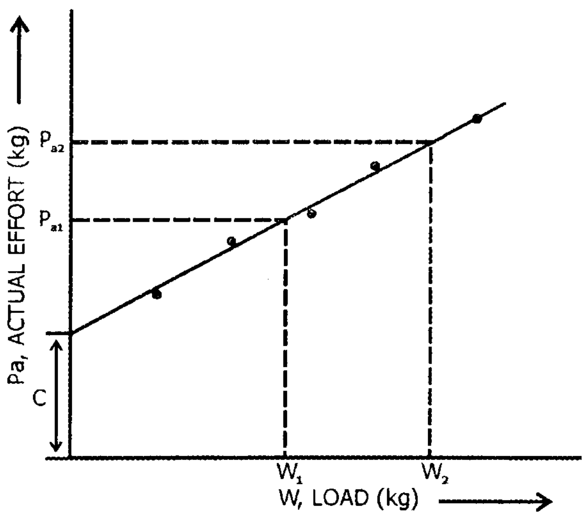
The apparatus consists of an axle of two redii, larger radius $r_1$ and smaller $r_2$. At the one end of the axle an effort wheel is attached. This assembly is supported on bearings. The load lifting rope is so wrapped around the differential axle that while it wraps around the larger axle it unwraps at the same time from the smaller axle, then the load is being raised. The effort P is applied through wheel of radius R.

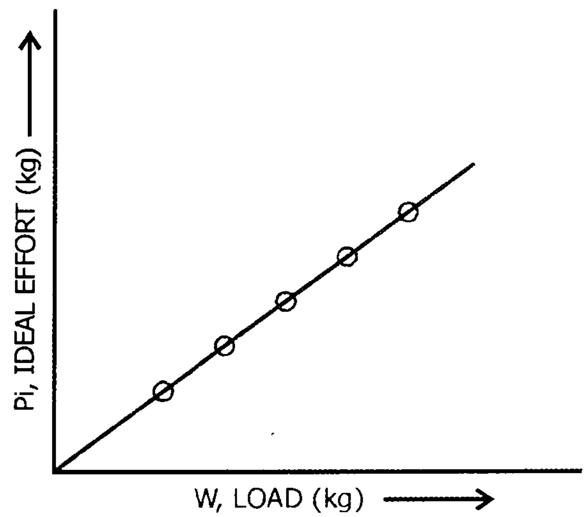
**PROCDURE :**

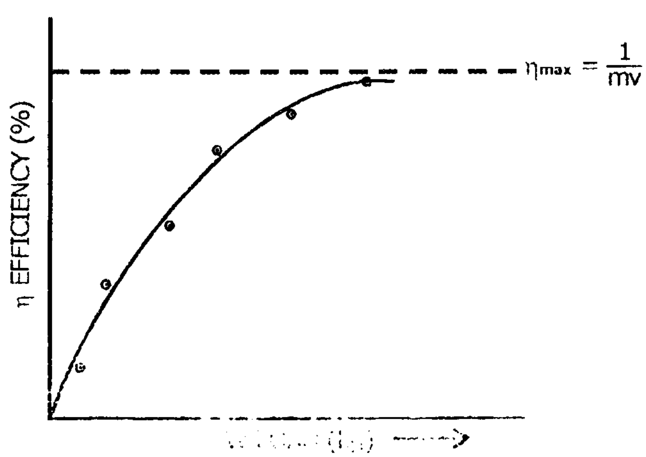
1. Measure and note down the circumference of the effort wheel, larger axle and smaller axle.
2. Weight and note down the weight of the snatch box.
3. Put some known weight on the hook attached with the snatch box.




**Wheel and differential axle.**



4. Put some weight from the weight box on the pan attached to the effort wheel; add the weights on pan until the load starts moving up.
5. Note down the applied load and corresponding effort.
6. Repeat the experiment for different known weights, at least five times.
7. Draw the necessary graphs as shown in Fig.

**OBSERVATION AND CALCULATION :**

1. Circumference of the effort wheel ($2\pi R$) = ______________________
   Therefore R = circumference /$2\pi$ = ______________________
2. Circumference of larger axle ($2\pi r_1$ )= ______________________
   Therefore $r_1$ = circumference /$2\pi$ = ______________________
3. Circumference of smaller axle ($2\pi r_2$) = ______________________
   Therefore $r_2$ = circumference /$2\pi$ = ______________________
4. Weight of the snatch block (Machine load) $W_m$ = ______________________
5. Machine load effort $P_m = W_m/V$ = ______________________
6. Slope of load effort diagram m = ______________________

The law of machine relating the effort and load is a straight line and is expressed as

$$P_a = mW + C$$

Where $P_a$ = Actual effort (Kg)
$W$ = load (Kg)
$C$ = Intercept on the effort axis (from the graph)
$m$ = Slope of the load Vs actual effort graph
$= (P_{a2} - P_{a1}) / (W_2 - W_1)$ (from graph)

$\eta_{max} = 1/mV =$

| S. No. | Load including Hanger W (gm) | Effort P (gm) | Actual effort Pa = P-Pm (gm) | Ideal effort Pi = W/V (gm) | Efficiency, η = [W x (Pa x V)] x 100% | Mechanical Advantage = W/P |
|---|---|---|---|---|---|---|
| | | | | | | |

**RESULTS :**

Velocity ratio = ____________________

The law machine $P_a$ = mW + C = __________ W+ __________

Maximum efficiency $\eta_{max}$ = $\frac{1}{m.v}$ x 100 = __________ %

**PRECAUTIONS :**

1. Circumference should be measured very carefully.
2. The weight should be put gradually on effort pan.
3. The weights of hanger and pan should be taken into account.

**DISCUSSIONS :**

1. How differential principle increases the velocity ratio ?
2. What is the advantage of increasing the velocity ratio ?
3. What do you understand by the law of machine ?

*****

# EXPERIMENT NO.-6

**OBJECT :**

To study the Double Purchase Winch Crab and to draw the following diagrams.

1. Load – effort diagram.
2. Load – ideal effort diagram.
3. Load – efficiency diagram

Also state the law of machine and determine the maximum efficiency of the machine.

**APPARATUS :**

Double purchase winch crab consists of two pairs of gear and pinion. These two pairs of gear and pinion enhance the velocity ratio considerably. This is used to lift loads by large reduction in effort. Load axle is attached with gear of second set. Effort wheel is attached with pinion of first set. Whole assembly is supported on bearings.

**THEORY :**

Double purchase winch crab is a lifting machine, which is a modification in the single purchase winch crab to increase the velocity ratio by adding one more pair of gear and pinion.

The velocity ratio V of any lifting machine is given by :

$$V = \frac{\text{Distance traveled by effort in a particular time interval}}{\text{Distance traveled by load in the same time interval}}$$

The V.R. of Double Purchase Winch Crab is given by;

$$V = (Z_2 / Z_1) \times (Z_4 / Z_3) \times (R/r)$$

Where,

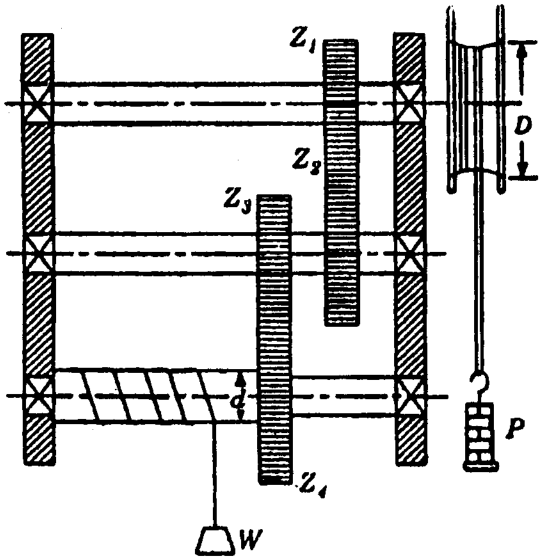
$Z_2$ and $Z_4$ are the numbers of teeth on gears 2 and 4 respectively.
$Z_1$ and $Z_3$ are the numbers of teeth on pinion 1 and 3 respectively.
R and r are the radius of effort wheel & load axle respectively,

The efficiency of the machine is given by

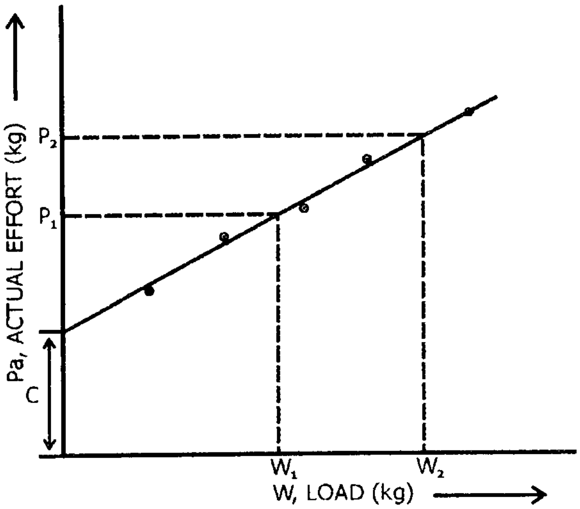
$$\eta = W / (P \times V)$$

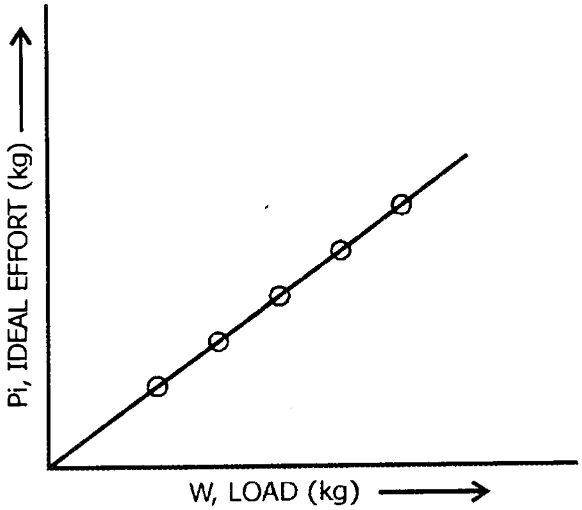
**PROCEDURE :**

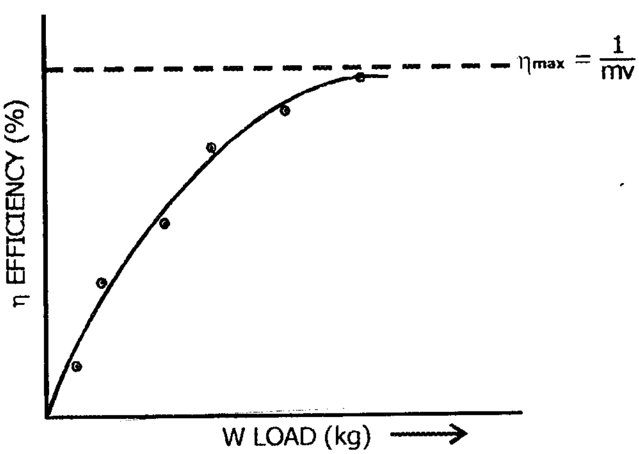
1. Count the number of teeth on gears 2 & 4 and pinion 1 & 3.
2. Measure the circumference of load axle and effort wheel.
3. Put some known weight on the load hanger.
4. Determine the effort at effort pan so that load starts moving up.



Double purchase crab.



5. Repeat the experiment for various loads, at least five times.
6. Draw the necessary graphs as shown in Fig.

**OBSERVATION AND CALCULATION :**

Number of teeth on pinion, $Z_1$ = ______________________

Number of teeth on gear, $Z_2$ = ______________________

Number of teeth on pinion, $Z_3$ = ______________________

Number of teeth on gear, $Z_4$ = ______________________

Circumference of load axle $(2\pi r)$ = ______________________

$r$ = ______________________

Circumference of effort wheel $(2\pi R)$ = ______________________

$R$ = ______________________

Plot the required graphs and calculate slope of load effort line m = ________

The law of machine relating the effort and load is a straight line and is expressed as

$$P = mW + C$$

Where
P = effort (Kg)
W = load (Kg)
C = Intercept on the effort axis (from the graph)
m = Slope of the load Vs actual effort graph
= $(P_2 - P_1) / (W_2 - W_1)$ (from graph)

$\eta_{max} = 1/mV =$

| S. No. | Load including hanger W (Kg) | Effort including pan P (Kg) | Ideal Effort $P_i$ | Efficiency $\eta = [W/(P.V.)] \times 100$ (%) | Mechanical Advantage = W/P |
|---|---|---|---|---|---|
| | | | | | |

**RESULTS :**

Velocity ratio =

The law machine P = mW + C = ———— W+ ————

Maximum efficiency, $\eta_{max}$ = $\frac{1}{mv}$ x 100 = ————————%

**PRECAUTIONS :**

1. Count the no. of teeth carefully.
2. Put the load and effort gradually.
3. Measure the circumference of load axle and effort wheel carefully.

**DISCUSSIONS :**

1. In what way higher velocity ratio helps ?
2. Why efficiency is increasing with load ?
3. What is the use of law of machine ?

*****

## EXPERIMENT NO.-7

**OBJECT :**

To verify the law of polygon of forces.

**THEORY :**

If a number of coplanar forces acting at a point are in equilibrium, then sides of a polygon taken in an order can represent them.

**APPARATUS :**

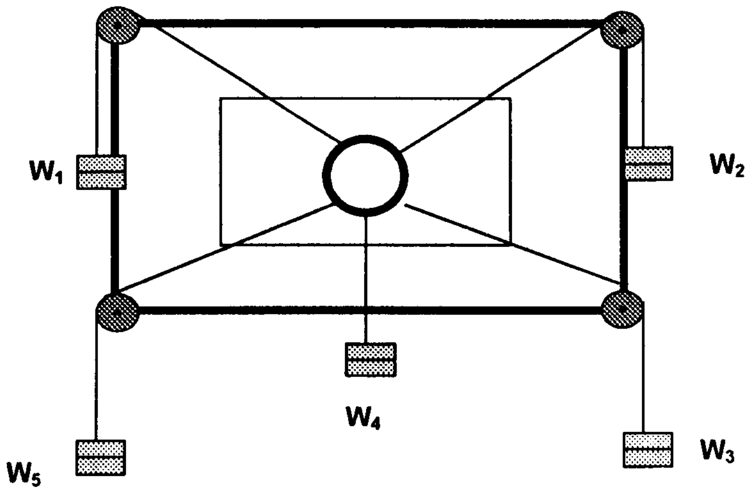
The apparatus used for the experiment is called vertical forces table. The force table is fixed on the wall and it has four frictionless pulleys on its four corners. Four strings passes through these frictionless pulley. One end of this string is attached to weights and the other end is tied to a single ring. One more string is there whose one end is attached to a weight and other end is attached directly with the ring.

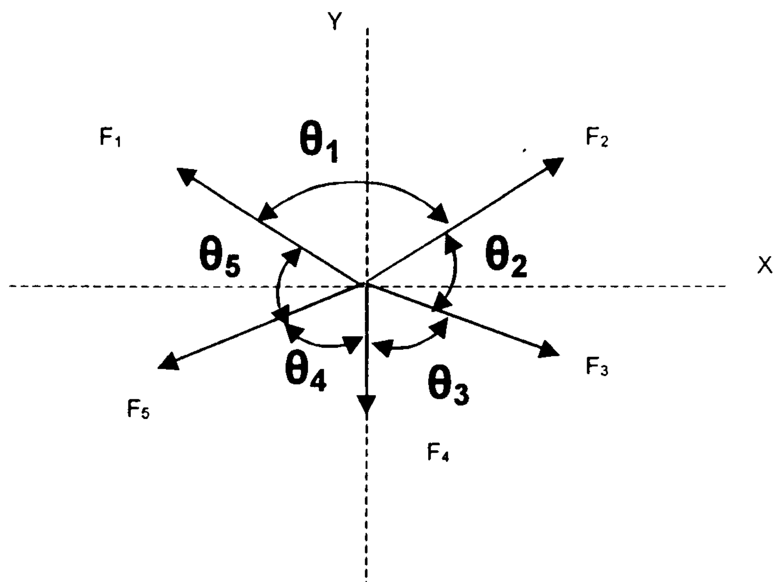
**PROCEDURE :**

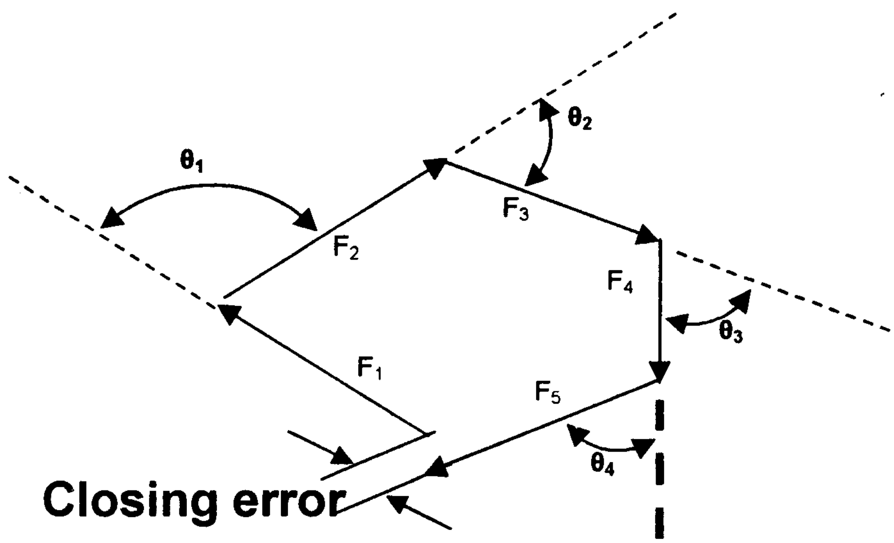
1. Pin up a plain paper on vertical board (forces table).
2. Put some known weights on load hangers.
3. Mark the center of ring and line of action of forces.
4. Extract the paper from board and measure the angle of line of action of forces.
5. Repeat the experiment for different set of forces, at least five times.
6. Draw the polygon for each case taking the forces in a single order, with suitable scale.
7. Measure the closing error for each case.

**OBSERVATION & CALCULATION :**

| Reading | Set | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Force F1<br>Magnitude ...... (In gm)<br>Angular position | | | | | |
| Force F2<br>Magnitude = ...... (In gm)<br>Angular position = | | | | | |
| Force F3<br>Magnitude = ...... (In gm)<br>Angular position = | | | | | |


W1
W2
W4
W5
W3


Y
X
F1
F2
F3
F4
F5
θ1
θ2
θ3
θ4
θ5


θ1
θ2
θ3
θ4
F1
F2
F3
F4
F5
Closing error

| Reading | Set | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Force F4<br>Magnitude = ..... (In gm)<br>Angular Position = | | | | | |
| Force F5<br>Magnitude = ..... (In gm)<br>Angular Position= | | | | | |
| Closing error in gms | | | | | |

**RESULT :**

Law of polygon of forces is verified and corresponding closing errors are shown in table.

**PRECAUTION :**

1. Mark the center of ring and line of actions of forces carefully.
2. Put the weights on hangers gradually.
3. Pulleys should be approximately frictionless.

**DISCUSSIONS :**

1. Why polygons are not closed when the force system are in equilibrium ?
2. What is the law of parallelogram of forces ?
3. What does the closing error indicates ?
4. What is the law of triangle of forces ?

*****

# EXPERIMENT NO.-8

**OBJECT :**

To study the Jib Crane and to determine the forces in the member of Jib Crane.

**THEORY :**

According to the law of triangle of forces, a point will be in equilibrium under the action of three forces if

1. Forces are concurrent and coplanar.
2. These three forces can be represented in magnitude and direction by three sides of a triangle taken in order.

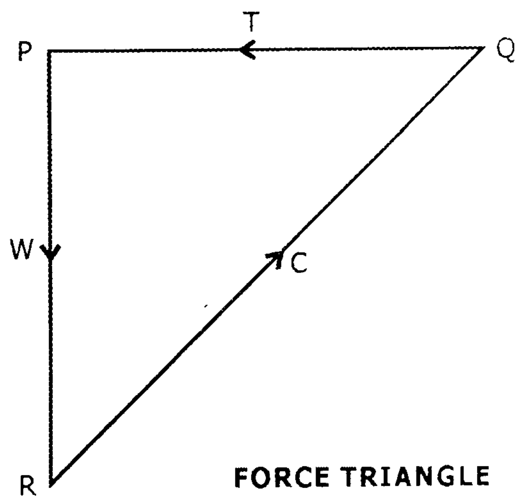
As per the sine rule of triangles or triangle law of forces.

$$\frac{T}{PQ} = \frac{C}{RQ} = \frac{W}{PR}$$

Therefore

$$T = \frac{PQ}{PR} \times w$$

$$C = \frac{RQ}{PR} \times w$$




FORCE TRIANGLE

**PROCEDURE :**

1. Fix the chain PQ to the hook of the vertical member.
2. Put some weight on hanger.
3. Measure length PR, RQ and PQ.
4. Note the readings of the spring balance T and C.
5. Change the weights on hanger and again note the value of T and C, PR, RQ &PQ.
6. Change the distance PR and repeat the experiment for two times more.

**OBSERVATIONS :**

1. Zero error of spring balance in chain =
2. Zero error of spring balance in beam =

| S. No. | W (kg) | PR (cm) | PQ (cm) | RQ (cm) | Tension T (kg) | Compre-ssion C (kg) | Graphical value of T (kg)=(PQ/PR) x w | Graphical value of C(kg)= (RQ/PR) x W | Differ-ence in T (kg) | Differ-ence in C (kg) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.<br>2.<br>3. | | | | | | | | | | |
| 1.<br>2.<br>3. | | | | | | | | | | |
| 1.<br>2.<br>3. | | | | | | | | | | |

Draw the free body diagram of point Q and force triangle for the various of W and measure T and C. Compare the graphical values of T and C with the experimental value and find out the difference.

**RESULTS :**

Law of triangle of forces is verified and corresponding errors are shown in table.

**PRECAUTIONS :**

1. Zero error of spring balance should be subtracted from the corresponding value of compression and tension.
2. Whole apparatus should be stationary and the weight hanger should not swing.

**DISCUSSIONS :**

1. What is the maximum value of difference between the graphical and experimental value of T and C and what would be the main reasons for this high error ?

*****

## EXPERIMENT NO.-9

**OBJECT :**

To verify the law of lever, in case of simple lever.

**APPARATUS :**

Simple lever, weight hanger and a scale.

**THEORY :**

Lever is a simple machine. It is a straight or bent rod pivoted in between and is used to obtain the mechanical advantage. Lever AC has fulcrum at B. The effort P is applied at C and load is lifted at end A. In case of simple lever, we have

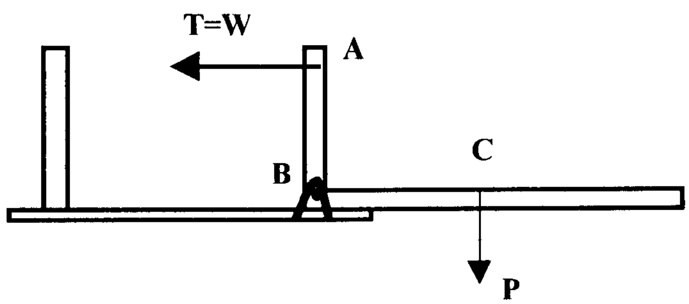
$$P \times BC = W \times AB$$

Or

$$W/P = BC/AB$$

**PROCEDURE :**

1. Note down the zero error of spring balance.
2. Set the position of hook and measure AB and BC.
3. Put the weight on the hanger and note down the corresponding reading of spring balance.
4. Repeat the experiment for other loads.
5. Change the position of the hanger and repeat the experiment.




**ABC IS A LEVEL WITH PULCRUM AT B**

**OBSERVATION :**

Zero error of spring balance =

Distance AB =

| S. No. | Weight including hanger P (gm) | Reading of spring balance W (gm) | Distance BC (cm) | Ratio (W/p) (q) | Ratio BC/AB(p) | % error ((p-q)/p) x 100 |
|---|---|---|---|---|---|---|
| | | | | | | |

**RESULT :**

Law of lever is verified and corresponding errors are shown in table.

**PRECAUTIONS :**

1. Hinge should be properly lubricated.
2. Heavy weight should be used.
3. Reading should be taken just after putting the weight.

**DISCUSSIONS :**

1. What is bell crank lever ?
2. Give the examples of simple lever in use ?

*****

# EXPERIMENT NO.-10

**OBJECT :**

To determine the support reactions of the simply supported beam, subjected to concentrated loads.

**APPARATUS :**

It consists of beam simply supported at the ends on two spring balances. The beam has two hooks, which can be moved along the beam. Through these 2 hooks loads can be applied to the beam. Springs measure the support reactions.

**THEORY :**

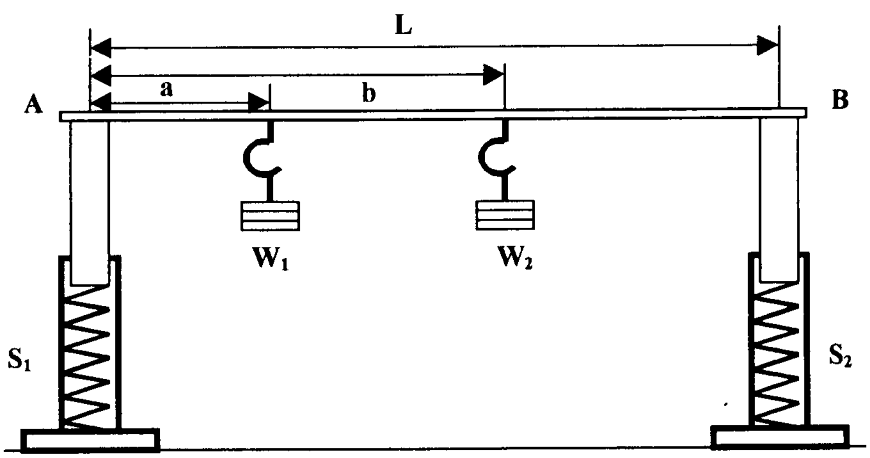
A simply supported beam is that which is supported by a hinge at one end and by a roller at the other end. Referring to the Fig.

$R_A + R_B = W_1 + W_2 =$ ——————————— (1)

Taking moments about the hinged joint A, we have,

$R_B = (W_1 \times a + W_2 \times b) / L$ ——————————— (2)

Calculating value of $R_B$ from equation 2 and substituting in equation 1, both the reactions are known.




**PROCEDURE :**

1. Take the initial readings of spring balances $S_1$ and $S_2$.
2. Measure the length of the beam.
3. Put some known weights on the load hangers attached to the hook.
4. Measure distance 'a' & 'b'.
5. Change the distance 'a' & 'b'
6. Repeat the experiment. Take at least seven readings.

## OBSERVATION & CALCULATION :

Length of the beam, L =

Initial reading of spring balances, $S_1$ = ____________

$S_2$ = ____________

| S. No. | Load $W_1$ | Load $W_2$ | Distance | | Readings of Spring Balance | |
|---|---|---|---|---|---|---|
| | | | a | b | $S_1$ | $S_2$ |
| | | | | | | |

| S. No. | By calculation Reaction $R_B = (W_1 X A + W_2 X B)/L$ | Exp. Value of Reaction $R_B = S_2 - I.R.$ | By calculation Reaction $R_A = W_1 + W_2 - R_B$ | Exp. Value of Reaction $R_A = S_1 - I.R.$ |
|---|---|---|---|---|
| | | | | |

## RESULT :

Compare the experimental and analytical values of support reactions and find out the percent error.

## PRECAUTIONS :

1. The weight should not be hanged with jerk.
2. The reading should be measured from the mid point of the weight.

## DISCUSSIONS :

1. Draw the bending moment and shear force diagram of any one reading ?
2. What are the support reactions in case of cantilever beam ?

*****

# EXPERIMENT NO.-11

**OBJECT :**

For Pulley block draw the following diagram.

1. Load effort diagram
2. Load ideal effort diagram
3. Load efficiency diagram

Determine the law of machine and the maximum efficiency.

**APPARATUS :**

It consists of two stacks of pulleys, upper and lower stack. A string passes over all the pulleys. One end of the string is attached to the lower stack, and the other end is attached to the effort pan Fig.

**THEORY :**

Pulley block is one of the simple machines. Its velocity ratio is equal to the number of pulleys. It is known as second system of pulleys.

**PROCEDURE :**

1. Attach the load hanger to the lower pulley.
2. Put some known weight on the hanger and determine the effort required at effort pan when the load starts moving up.
3. Repeat the experiment for various loads.
4. Take at least 5 set of readings.

**OBSERVATION & CALCULATION :**

Weight of effort pan =

Velocity ratio = No. of pulleys =

Plot the required diagrams and calculate slope of load effort line, m = ________

The law of machine relating the effort and load is a straight line and is expressed as

$P = mW + C$

Where $P$ = effort

$W$ = load

$C$ = Intercept on the effort axis (from the graph)

$m$ = Slope of the load Vs actual effort graph

= $(P_2 - P_1) / (W_2 - W_1)$ (from graph)

$\eta_{max} = 1/mV =$

| S. No. | Load W (kg) | Effort P (kg) | Mechanical Advantage = W/P | Ideal effort Pi = W/V(kg) | Efficiency $\eta = [W/(Pa.V)] \times 100\%$ |
|---|---|---|---|---|---|
| | | | | | |

**RESULT :**

Velocity ratio =

The law machine P = mW + C = ———— W+ ————

Maximum efficiency, $\eta_{max}$ = $\frac{1}{mv} \times 100$ = ———— %

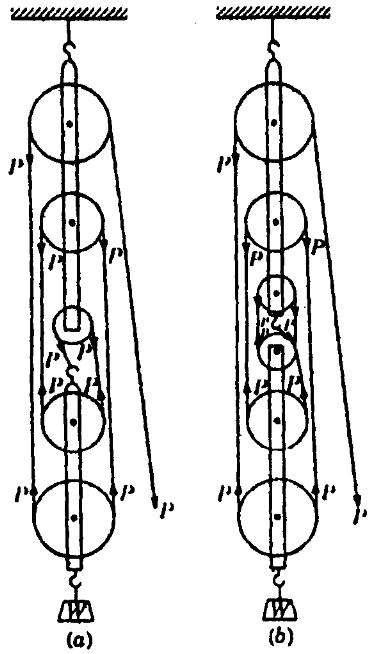
**PRECAUTIONS :**

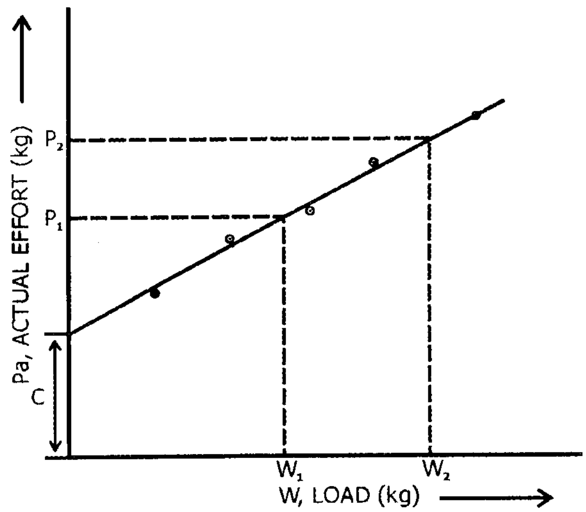
1. Effort pan and load hanger should be kept stationary.
2. Observation must be done very carefully.

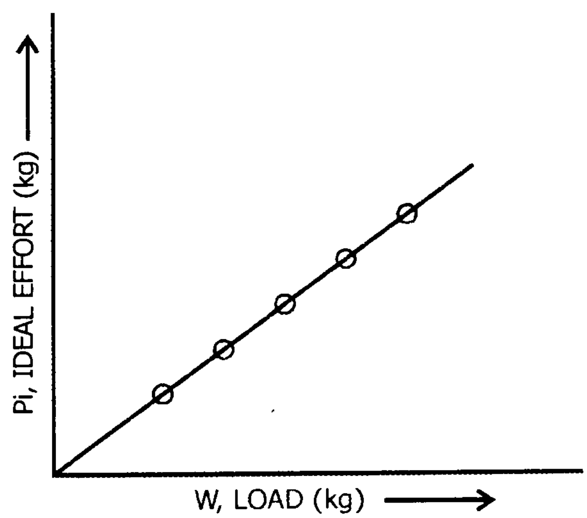
**DISCUSSIONS :**

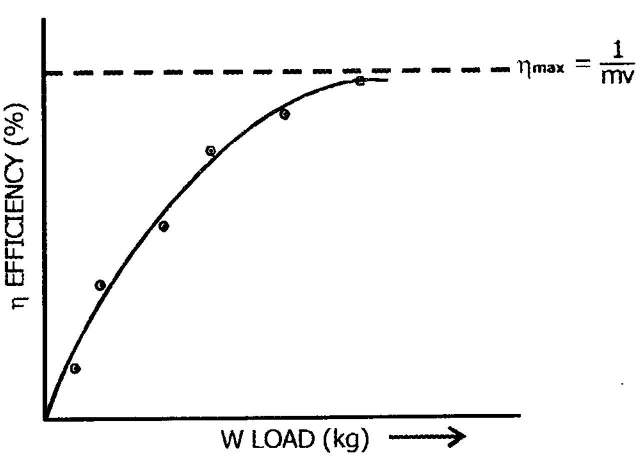
1. Give the examples where you have seen pulley block as lifting machine?
2. Why effort required for smaller loads are more?
3. Prove that the velocity ratio of existing pulley block is three?

*****


P
P
P
P
P
W
(a)
(b)


Pa, ACTUAL EFFORT (kg)
P2
P1
C
W1
W2
W, LOAD (kg)


Pi, IDEAL EFFORT (kg)
W, LOAD (kg)


η EFFICIENCY (%)
ηmax = 1/mv
W LOAD (kg)

# EXPERIMENT NO.-12

**OBJECT :**

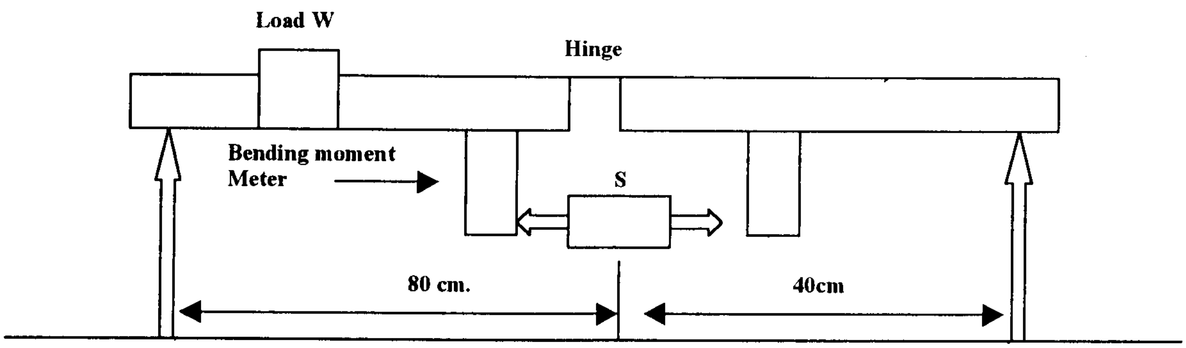
To draw the variation of bending moment at a section in a simply supported beam under moving load.

**THEORY :**

If a simply supported beam is subjected to concentrated loads then max. bending moment occurs at the section where the load is applied. When the load moves on a simply supported beam then the bending moment varies at given section and would be maximum when the moving load is at the section under consideration.

**APPARATUS :**

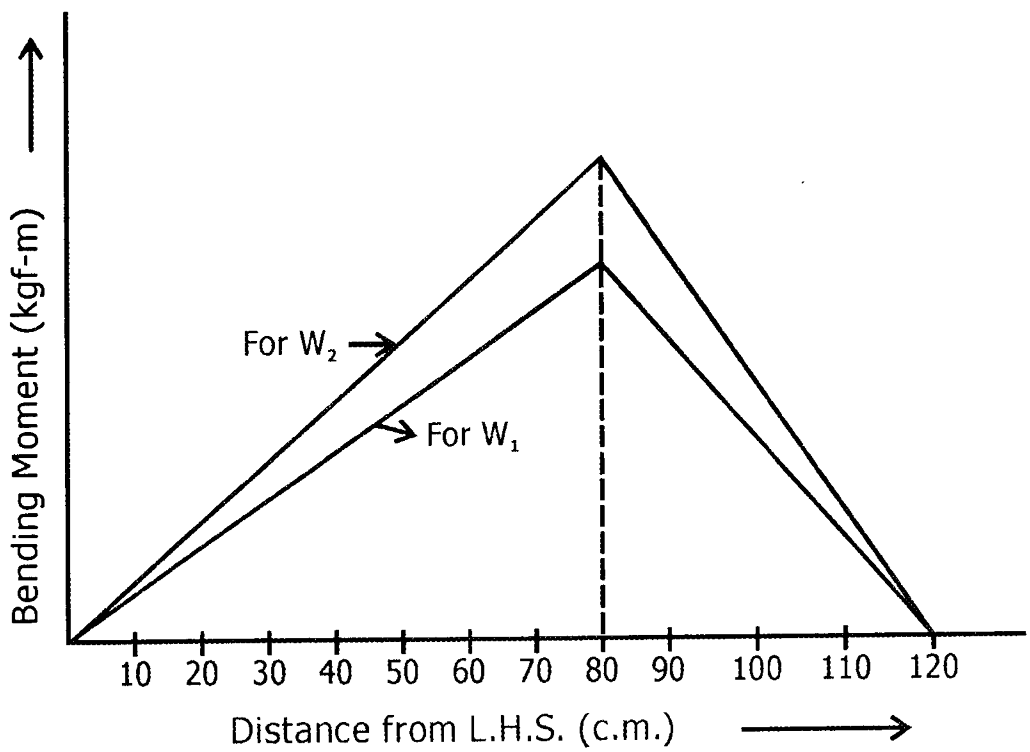
It consists of a long beam with a hinge in between. Two small rods are fixed to the beam at equal distance from the hinge. A spring balance is placed between the two rods at _______ c.m. below the hinged joint. The hinged joint, the rods and spring balance together form a bending moment meter which measures the bending moment at hinged section and it is equal to the one third of the spring balance reading in kg. f.m.




**PROCEDURE :**

1. Support the beam as shown in the figure.
2. Keep the known load at a distance of 10cm. From the left support and record the spring balance reading.
3. Shift the load by 10cm to the right and note down the spring balance reading.
4. Repeat the experiment till the load reaches the right support.
5. Repeat the whole experiment for other weights.
6. Take at least ten set of observation for each weight.

Plot a graph between the bending moment and the distance from the left support.



Bending Moment (kgf-m)
For $W_2$
For $W_1$
10
20
30
40
50
60
70
80
90
100
110
120
Distance from L.H.S. (c.m.)

**OBSERVATION :**

Load on the beam =

Initial reading of spring balance, (I. r) =

| S. No. | Distance of the load from L.H.S.(c.m.) | Spring balance reading S (kgf) For Load W=1 Kg | Spring Balance reading S (kgf) For Load W= 2Kg | Bending moment =1/3 (s-IR) (kgf-m) For Load W=1 Kg | Bending moment = 1/3 (S-IR) (kgf-m) For Load W= 2Kg |
|---|---|---|---|---|---|
| | | | | | |

**RESULT :**

The variation of the bending moment at a given section of a simply supported beam is linear and is maximum when the load is kept at the section under consideration (hinged section).

**DISCUSSION :**

1. Define the terms bending moment and shear force and their utility ?
2. What is the cantilever beam, over hanging beam, continuous beam, simply supported beam and rigidly fixed beam ?
3. Explain bending moment diagram for a beam ?
4. Draw the bending moment diagram for a simply supported beam subjected to concentrated load at the center ?
5. What do you understand by the term "point of contra flexure" ? Explain with reason if it exists in cantilever or in simply supported beam ?

*****

# EXPERIMENT NO.-13

**OBJECT :**

To find the co-efficient of static friction between the following block and wooden plane.

1. Aluminum block
2. Wooden block
3. Block with Glass surface.

**THEORY :**

Let two surfaces are in contact. Some one attempt to move surface with respect to the other, then tangential force called friction force develop between the contact surfaces which opposes the motion of one body with the other. In the limiting condition this frictional force bears a constant ratio with the normal reaction. This constant ratio is termed as coefficient of friction. The coefficient of friction is independent of the extent of areas of the contact surfaces but depends upon the materials and the nature (roughness or smoothness) of the surfaces in the contact.

**APPARATUS :**

The apparatus consists of a wooden plane, which is hinged at end and supported near to the other end. A frictionless pulley is attached at the free end. The wooden plane is kept on the inclined position with the help of the support. The angle of inclination can be varied and can be read on the scale provided.

**PROCEDURE :**

1. Weight and note down the weight of each block in grams.
2. Adjust the inclination of wooden plane at an angle say $15^0$ with horizontal and note down the angle.
3. Put the block (Aluminum block) on the inclined plane.
4. Attach one end of the given string to the block kept on the inclined plane and other end to the pan.
5. Put some weights from the weight box in the pan and knock it slightly, continue adding weights in the pan until the block is in the condition of impending motion. (i.e. block just about to start) up the plane.
6. Note down the weights on the pan.
7. Adjust the inclination of plane to $20^0$ and $25^0$.
8. Repeat the above experiment for Glass and Wooden block.

**OBSERVATION :**

Weight of the pan =

| S. No. | Material of the block | Angle of inclination | Weight of the block W (gm) | Tangential force including weight of pan (gm) | Coefficient of friction μ | Average μ |
|---|---|---|---|---|---|---|
| 1.<br>2.<br>3. | Aluminum | $15^0$<br>$20^0$<br>$25^0$ | | | | |
| 1.<br>2.<br>3. | Wood | $15^0$<br>$20^0$<br>$25^0$ | | | | |
| 1.<br>2.<br>3. | Glass | $15^0$<br>$20^0$<br>$25^0$ | | | | |

**CALCULATIONS :**

$\mu = (P\text{-}W\sin\theta)/\ (W\cos\theta)$

**RESULT :**

1. μ Between Aluminum and wood = ______________________.
2. μ Between wood and glass = ___________________________.
3. μ Between wood and wood =___________________________.

**PRECAUTIONS :**

1. The weight should be added in the pan until the block is just about to start.

**DISCUSSIONS :**

1. What is the difference between static and dynamic friction ?
2. Define angle of friction and angle of repose ?
3. Why the coefficient of kinetic friction is is less than the coefficient of static friction.
4. State the law of friction ?
5. Compare the experimental value of m with its standard value for all the case cases ?

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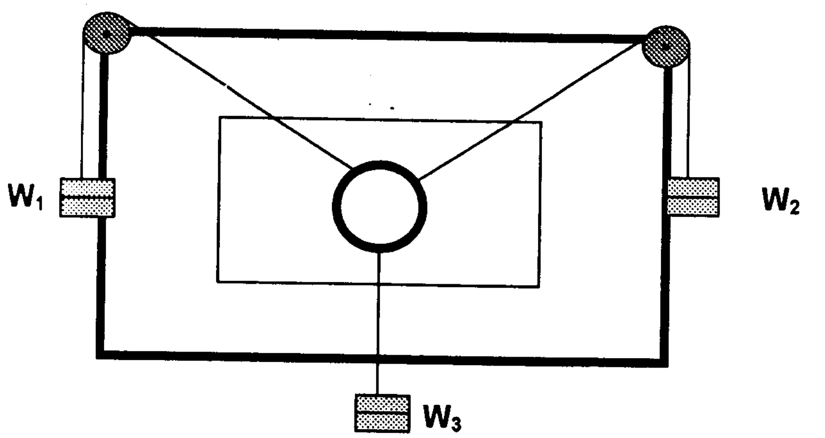
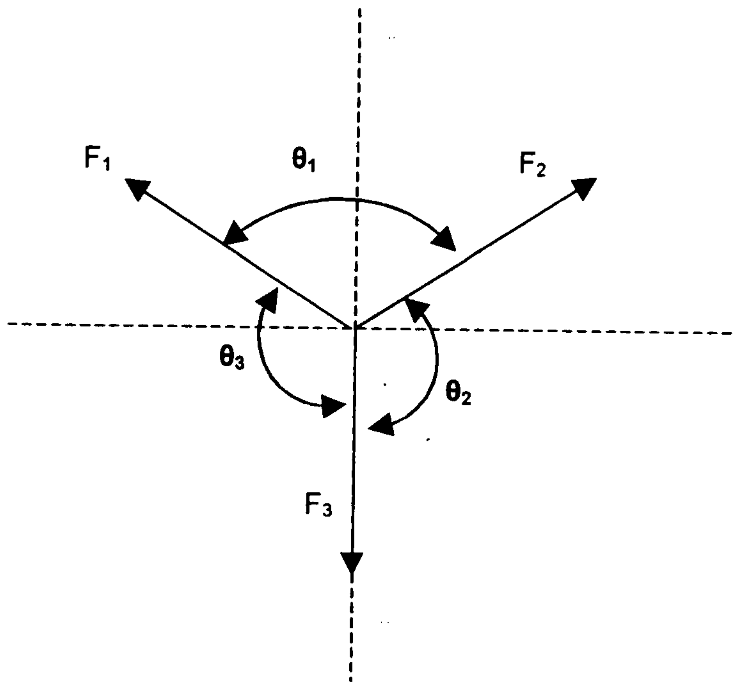
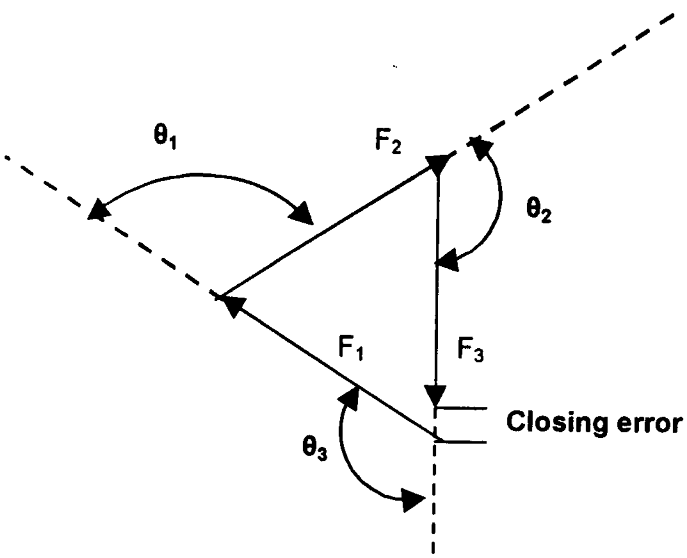

W₁
W₂
W₃


F₁
θ₁
F₂
θ₃
θ₂
F₃


θ₁
F₂
θ₂
F₁
F₃
Closing error
θ₃

**RESULT :**

Law of triangle of forces is verified and corresponding errors are shown in table.

**PRECAUTIONS :**

1. Mark the center of ring and line of actions of forces carefully.
2. Put the weights on hangers gradually.
3. Pulleys should be approximately frictionless.

**DISCUSSION :**

1. Why triangle is not closed even forces are in equilibrium ?
2. What are other laws of forces ?
3. What does closing error indicates ?

*****