### List of Experiments

<table>
<thead>
<tr>
<th>SR.NO</th>
<th>NAME OF THE EXPERIMENT</th>
<th>PAGE NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Study of Simple Machines</td>
<td></td>
</tr>
<tr>
<td>02</td>
<td>Simple Screw Jack</td>
<td></td>
</tr>
<tr>
<td>03</td>
<td>Differential Axle and Wheel</td>
<td></td>
</tr>
<tr>
<td>04</td>
<td>Moment of Inertia of a Fly Wheel</td>
<td></td>
</tr>
<tr>
<td>05</td>
<td>Lami’s Theorem</td>
<td></td>
</tr>
<tr>
<td>06</td>
<td>Parallel Force Table</td>
<td></td>
</tr>
<tr>
<td>07</td>
<td>Study of Forces in the Members of Jib Crane.</td>
<td></td>
</tr>
<tr>
<td>08</td>
<td>Comparison of Coefficient of Friction of Various Pairs of Surfaces &amp; Determination of Angle of Repose.</td>
<td></td>
</tr>
<tr>
<td>09</td>
<td>Parallelogram Law Of Forces</td>
<td></td>
</tr>
</tbody>
</table>

**Time Allotted for each Practical Session = 02 Hrs.**
Instruction for Conduction of Experiments

01. Take down the procedure of today’s experiment displayed on the notice board.

02. Collect the necessary instruments.

03. Follow all the instructions given by the teacher time to time.

04. Conduct the experiment and return all the equipments to the lab Incharge.

05. Show the result to the teacher.
EXPERIMENT NO 01
STUDY OF SIMPLE MACHINES

Aim: To study simple machines.

Machine:
It is a device by means of which a small effort applied at one part of it is transmitted to another to secure an advantage to lift a heavy load.

Load (W):
This is that part of resistance which machine has to overcome and which is of the use to the operator.

Effort (P):
This is the force necessary to work the machine so as to overcome the load and any other resistance against movement.

Mechanical advantage (M.A.):
This is the ratio of the load applied to the effort applied to the machine i.e.
M.A. = load applied / effort applied = W / P

Velocity Ratio (V.R.):
This is the ratio of the distance moved by the effort in any interval of time to the corresponding distance, moved by the load in the same interval of time.
V.R. = Distance moved by effort / Distance moved by load = Sp / Sw

Input of machine:
This is the total work done on the machine. This is the energy supplied to the machine. This is same as work done by the effort. The importance of machine is to lift the load and overcome the resistance. (Friction of the machine)

Resistance of machine:
This is the resistance against the movement of load. Resistance of the machine is mainly due to the friction between the moving parts of the machine.
**Output of machine:**
This is the useful work done.

**Efficiency of machine: (η):**
This is ratio of output of machine to the input. This is also same as the ratio of useful work done by the machine to the energy supplied to it.

Efficiency of machine = output of machine / input of machine

\[ \frac{\text{useful work done}}{\text{actual energy supplied}} = \frac{W \times Sw}{P \times Sp} = \frac{W/P}{Sp/Sw} = \frac{M.A.}{V.R.} \]

\[ \eta\% = (\frac{M.A.}{V.R.}) \times 100 \] i.e. efficiency in %.

**Ideal machine:**
This machine is absolutely free from the frictional resistance. Since no resistance are in the energy supplied equal to the useful work done i.e., for ideal machine,

Input = Output

\[ \frac{W}{P} = \frac{Sp}{Sw} \]

\[ P \times Sp = W \times Sw \]

\[ M.A. = V.R. \]

**Ideal Effort (Pi):**
For ideal machine V.R. = M.A. i.e. W/P = V.R.
Therefore \[ P = \frac{W}{V.R.} \]
Hence ideal effort is the ratio of load applied to the velocity ratio.

\[ Pi = \frac{W}{V.R.} \]

**Frictional Effort (Pf):**
Frictional effort = Actual effort – Ideal effort

\[ Pf = Pa - Pi \]
Law of machine:

The relation between the efforts required in the machine to lift a load is called as a law of machine. It can be expressed in the form of:

\[ P = mW + C \]

Where, \( P \) = Effort applied in ‘N’
\( W \) = Load applied in ‘N’
\( m \) = Slope of graph line (Graph of actual effort Vs Load)
\( C \) = Intercept of line on Y axis / Constant.

Reversibility of simple machine:

If load and effort are changed whether the machine works or not is called reversibility of machine.

If efficiency of machine is \( \geq 50\% \), machine is reversible.

If efficiency of machine is \( < 50\% \), machine is irreversible / self locking.

Questions:

1. What is machine?
2. What is Mechanical Advantage?
3. What is Velocity Ratio?
4. What is the unit of M.A.?
5. What is input & output of machine?
6. What is efficiency of machine?
7. M.A. = V.R., condition for which machine?
8. What is ideal effort?
9. What is frictional effort?
11. What is reversibility of machine? Explain with example.
12. If efficiency of machine \( < 50\% \), machine is.................
13. If efficiency of machine \( \geq 50\% \), machine is.............
EXPERIMENT NO 02

SIMPLE SCREW JACK

Aim: To study simple screw jack and find its V.R. and its various performances

Apparatus: Simple screw jack, thread, pan, weights etc…

Theory:

i) Parts of machine: Simple screw jack fitted with nut

ii) Working of machine: Screw jack fitted with a nut works on the principle similar to as that of an inclined plane. If screw is rotated by application of an effort applied at one end of pulley, load kept on load table will be lifted.

iii) Take care, whether the string is properly wound on the circular disc or not.

iv) Different loads are applied and corresponding efforts are recorded.

v) To keep the friction constant, readings are taken at particular point.

vi) Calculation for V.R. and efficiency is done.

Observations:

1. Diameter of load table: D
2. Pitch of Screw: p
3. Circumference of load table: πD
4. Velocity Ratio: \( \frac{S_p}{S_w} = \frac{\pi D}{p} \)

Observation Table:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Load (W) Newton</th>
<th>Effort (Pa) Newton</th>
<th>M.A. = W/Pa</th>
<th>( \eta% = \frac{\text{M.A.}}{\text{V.R.}} \times 100 )</th>
<th>Pi = W/V.R.</th>
<th>Pf = Pa-Pi</th>
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</tbody>
</table>
Result:

i. V.R. of machine: = Sp/Sw  
   Sp = Circumference of load table = πD  
   Sw = Pitch of screw = p  
   Therefore V.R. = Sp/Sw = πD/p

ii. Efficiency of machine = M.A. /V.R.

iii. Percentage of efficiency = (M.A./V.R.)*100

iv. As the efficiency of machine is less than 50%, it is irreversible.

v. Law of machine, Pa = mW+ C

Conclusion:

i. Efficiency of machine is less than 50%, the machine is irreversible.

ii. VR of machine remains constant.

iii. Efficiency of machine increases with load in the beginning and then remains constant.

iv. The graph line indicates a linear motion.

v. As load on machine increases, the effort required to lift also increases.

Questions:

1. What is pitch?
2. Why Sp= πD?
3. How you measure the pitch?
4. Explain machine is self locking?
5. As load on machine increases, the effort required to lift also increases or decreases?
6. How you measure the circumference of the load table?
7. On which principle screw jack works?
8. What is the nature of the graph of actual effort vs Load?
9. What is the nature of the graph of efficiency vs Load?
EXPERIMENT NO 03
DIFFERENTIAL AXLE AND WHEEL

Aim: To study the performance of differential axle and wheel and find its velocity ratio, efficiency and law of machine etc…

Apparatus: Differential axle and wheel consisting of effort wheel, larger axle, smaller axle, thread, pan, weights

Theory:

i. Parts of machine: Differential axle and wheel consisting of effort wheel, larger axle and smaller axle.

ii. Working of machine: The load axle is made up of two parts to the same shaft which is mounted on the shaft ball bearing in order to reduce the frictional resistance. The effort string is wound around the axle to which the effort pan is attached.

iii. Velocity Ratio: In one revolution of effort wheel, displacement of effort wheel is \( Sp = \pi D_1 \)
Distance travelled by load = \( \frac{\pi d_1 - \pi d_2}{2} \)
\( Sw = \frac{\pi d_1 - \pi d_2}{2} \)
Therefore  \( V.R. = \frac{Sp}{Sw} = \frac{\pi D_1}{(\pi d_1 - \pi d_2)/2} \)
\( = 2 \pi D_1 / (\pi d_1 - \pi d_2) \)

Procedure:

i. Check that string is wound properly on wheel A, B, and C.
ii. Different loads are applied and corresponding efforts are recorded.
iii. To keep friction constant readings are taken at particular point.
iv. From above observation V.R., M.A., and efficiency of machine are calculated.
Observations:

1. Circumference of Effort wheel: \( \pi D_1 \)
2. Circumference of bigger axle: \( \pi d_1 \)
3. Circumference of smaller axle: \( \pi d_2 \)
4. Distance travelled by effort: \( S_p = \pi D_1 \)
5. Distance travelled by load: \( S_w = (\pi d_1 - \pi d_2)/2 \)
6. Velocity Ratio = \( S_p/S_w = (\pi D_1) / ((\pi d_1 - \pi d_2)/2) = 2 \pi D_1 / (\pi d_1 - \pi d_2) \)

Observation Table:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Load (W) Newton</th>
<th>Effort (Pa) Newton</th>
<th>M.A. = W/Pa</th>
<th>( \eta % = \frac{M.A.}{V.R.} \times 100 )</th>
<th>Pi = W/V.R.</th>
<th>Pf = Pa-Pi</th>
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</table>

Result:

i. V.R. of machine =
ii. Efficiency of machine =
iii. Percentage of efficiency of machine =
iv. Law of machine is given as \( P = mW + C \)

Conclusion:

i. As the efficiency is greater than 50\%, machine is reversible.
ii. Velocity ratio remains constant.
iii. Effort of machine increases with load.
iv. Graph of effort against load is a straight line represents linear motion.
Questions:

1. What are different parts of machine?
2. Why velocity ratio remains constant?
3. Machine is reversible / irreversible?
4. How you calculate M.A.?
5. How P_i & P_f is calculated?
6. What is the nature of the graph of Ideal effort vs Load?
7. What is the nature of the graph of Mechanical advantage vs Load?
**EXPERIMENT NO.04**  
**MOMENT OF INERTIA OF FLYWHEEL**

**Aim:** To find moment of inertia of flywheel

**Apparatus:** Flywheel mounted on axle and supported by bearing, pan, weights, and stop watch.

**Theory:**

Moment of Inertia is the property of the body by virtue of which it resists the change in the state of its angular motion about any axis. It depends upon the mass of the body and the distance with respect to axis of rotation.

For falling mass,

Initial velocity \( v = 0 \)

Height of fall \( h \)

\( a = \frac{2h}{t^2} \)

Resultant force \( = T - mg \)

\(-F = T - mg\)

\(-ma = T - mg\)

\( T = m(g-a) \)

Moment ‘\( M' = Ia \)

\( T*r = I \frac{a}{r} \) (since \( a = r\alpha \))

\( I = Tr^2/a \)

\( I = m \frac{(g - a)}{a} r^2 \)
Procedure:

Attach a long thread about 1.8 m length to the axle of flywheel and end of thread is attached to the axle while the pan is attached to the outer end of the thread. Weight should be added so that pan must be in suitable line on the wheel by which we can calculate no. of revolutions of the wheel. Wrap the thread on the axle and measure the height of the pan from the ground level, and then add the weights in the pan and take readings of time required for pan to touch the ground. This time is calculated by using the stop watch as soon as weight starts moving down. Take different weights and corresponding time and complete the observation table.

Observation table:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Mass (m) kg</th>
<th>Time (t) sec</th>
<th>Acceleration (a) (a = 2h/t^2), m/s^2</th>
<th>Tension (T) (T = m (g – a)) Kg.m/s^2</th>
<th>M.I. = ((T*r^2) / a), Kg m^2</th>
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</tbody>
</table>

Result: Moment of Inertia of fly wheel is --------------- Kg m^2.

Questions:

1. What is moment of inertia?
2. How you calculate acceleration?
3. What is the height of fall?
4. How you calculate tension?
5. How you calculate MI?
6. What is the unit of MI?
EXPERIMENT NO. 5  
LAMI’S THEOREM

Aim: To study Lami’s theorem using universal force table apparatus.

Apparatus: Universal force table, detachable pulley, ring with three strings, weight hanger, slotted weights and spirit level.

Theory: If three coplanar forces acting at a point are in equilibrium then each force is directly proportional to the sine of the angle included between the other two forces.

By using simple weights, pulleys & strings placed around a circular table, several forces can be applied to an object located in the centre of the table in such a way that the forces exactly cancel each other, leaving the objects in equilibrium (the object will appear to be at rest). Force table and Newton’s First Law is used to study the components at the force vector.

Procedure:

1. Place the Universal Force Table on firm platform.
2. Make the circular disc in horizontal position with the help of boot screws.
3. Check the horizontal position of circular disc by spirit level.
4. Clamp the three detachable pulleys to the circular disc at three different positions.
5. Keep the ring at the centre of disc and pass the other ends of each string over the three pulleys.
6. Hang three hangers to these ends of strings passing over the pulleys.
7. Put slotted weights to each hanger so as to make pivot and ring concentric with each other.
8. Note the sum of slotted weights in each hanger and weight of hanger as three forces F1, F2, F3.
9. Measure the angles included between the two adjacent pulleys and note them as θ1, θ2, θ3 as per figure no. (2)
10. Record these observations in table.
11. Repeat step (7) by changing one or two pulleys position and take two sets of observation.
**Observation Table:**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Forces in ‘N’ (Wt. in hanger + Wt. of hanger)</th>
<th>Included angles between two forces in “degrees”</th>
<th>Ratio of force and angle between other two forces</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F1</td>
<td>F2</td>
<td>F3</td>
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</tbody>
</table>

**Result:**

The ratios obtained are:

1. \( \frac{F1}{\sin \theta_1} = \)
2. \( \frac{F2}{\sin \theta_2} = \)
3. \( \frac{F3}{\sin \theta_3} = \)

**Conclusion:**

The ratios obtained for each reading are…………..(same / nearly same/not same)

**Questions:**

1. What are apparatus required for carrying out experiment?
2. What is Lami’s theorem?
Experiment No. 6
EQUILIBRIUM OF PARALLEL FORCES

Aim:
To study Equilibrium of parallel forces – simply supported beam reactions.

Apparatus:
Beam reaction apparatus, hooks & weights with hangers.

Objectives:
a) To understand facts & concepts of parallel forces in equilibrium & support reactions.
b) To find unknown force using equilibrium of parallel forces.

Figure:
Theory:

When system of parallel forces act on body & keeps the body in equilibrium then algebraic sum of forces is equals to zero & sum of moment of forces (active & reactive) about any point in plane of forces is equals to zero.

Procedure:

1. Organize the physical setup of experiment study it.
2. Measure span of beam.
3. Note down initial reading (reactive forces) at support A & B.
4. Apply loads P1, P2, P3 (active forces) at different positions & measure the distances d1, d2, d3, respectively from support A & note it.
5. Take final readings of reactive forces at supports A & B after loading & note down in observation table.
6. Calculate analytically support reaction at support A & B.
7. Compare the support reactions at supports A & B calculated by analytical method with support reactions calculated by deducting initial readings from final readings at each support.
8. Repeat the procedure for four sets of loadings.
9. Apply unknown weight & final support reactions.
10. Calculate unknown weight by applying conditions of equilibrium.

**Observation:**

a) Span of AB = L = …………………mm

b) Initial readings at support A =…………………N

c) Initial readings at support B =…………………N

**Observation table:**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Loads in N</th>
<th>Distances of load from support A</th>
<th>Support reactions</th>
<th>Support reactions by analytical method</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P1</td>
<td>P2</td>
<td>P3 D1 D2 D3</td>
<td>At A</td>
<td>At B</td>
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<td>Final reading</td>
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</table>
Calculations for support reactions by analytical & unknown force:

Result:

Unknown Force = ----------------- N

Conclusion:
Experiment No.07

Aim:
STUDY OF FORCES IN THE MEMBERS OF JIB CRANE.

Apparatus:
Apparatus of jib crane, hook, weights, scale, string.

Objectives:
a) To understand facts & concepts of mechanism of jib crane & nature of forces in members of jib crane.
b) To find the relationship between forces in the members of jib crane & lengths of members of jib crane.

Layout:
Theory:

Triangle law of forces:
If three coplanar concurrent forces are in equilibrium be represented in magnitude & direction by three sides of triangle taken in order then the first point of the first force coincides with the last point of last force i. e. force triangle is closed.
Jib crane is used to lift heavy loads. When it lifts load then jib member is subjected to compression & tie member is subjected to tension.

Procedure:

1. Organise the physical set up of experiment & study it. Adjust the position of clamp on vertical post.
2. Observe the initial readings in jib & tie & note them.
3. Apply load (W), say 10N.
4. Observe the final readings in tie & jib. Also measure the lengths of tie, post & jib in loaded condition & note them.
5. Tabulate your observations.
6. Calculate forces in jib & tie by substracting the initial readings from final readings.
7. Construct the scaled triangle for lengths of members of jib crane.
8. Considering the vertical side of triangle as the applied load (W) then find forces in jib & tie by measuring the lengths of corresponding sides of triangle & multiplying it by scale.
9. Repeat the procedure from 5.2 to 5.8 for two more values of W for same position of clamp.
10. Change position of clamp & repeat the steps from 5.2 to 5.9.

Observations:

Initial readings of jib = -------------- N

Initial readings of tie = -------------- N
Observation Table
### Observation Table:

<table>
<thead>
<tr>
<th>Position Of clamp</th>
<th>Vertical Load (W) N</th>
<th>Observed forces N</th>
<th>Calculated forces N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Jib</td>
<td>Tie</td>
</tr>
<tr>
<td></td>
<td>Final reading</td>
<td>Force in jib</td>
<td>Final reading</td>
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</table>

### Calculations:

- a) Force triangle closes / remains open.
- b) Nature of forces in jib & crane.
- c) Relationship between forces in members & their lengths.

### Result:

a) Force triangle closes / remains open.

b) Nature of forces in jib & crane.

c) Relationship between forces in members & their lengths.
Conclusion:
1. Magnitude of observed forces and calculated forces are ____________
   (equal/ nearly equal/ not equal)
   • Ideal conclusion is magnitude of observed force = magnitude of calculated force
2. The difference in the above two forces is because of ____________________
   (error of manipulation/ instrument error/ error of observation)
Experiment No. 8

Aim:
comparison of coefficient of friction of various pairs of surfaces & determination of angle of repose.

Objectives:
   a) To understand facts & concepts of development of frictional force with respect to applied external force causing motion or tends to cause the motion.
   b) To find coefficient of friction of various pairs of surfaces
   c) To find angle of repose

Apparatus:
Adjustable horizontal plane (surface) with the pulley at one end, wooden boxes with different bottom surfaces, hanger with thread, weight & bubble tube.

Layout:

![Diagram](image-url)
Theory:
Frictional force: The force which is always opposite to motion & acts tangentially at two surfaces of contact.

Types of friction:
1) Static friction: The friction exists between two surfaces at rest is called as static friction.
2) Dynamic friction: The friction exists between two surfaces in motion is called as dynamic friction.
3) Rolling friction: When one body rolls over another body then friction exists between them is called as rolling friction.

Co-efficient of friction (\(\mu\)): Ratio of frictional force to normal reactions is always constant & is called as coefficient of friction.

Laws of static friction:
1) Frictional force is always opposite to motion & acts tangentially to the two surfaces in contact.
2) Frictional force is directly proportional to normal reaction; the ratio of frictional force to normal reaction is called as coefficient of friction.
3) Frictional force depends on nature of surfaces in contact.
4) Frictional force does not depend upon amount of surface in contact.

Angle of repose:
When the body is in limiting equilibrium then angle made by inclined surface with horizontal is called as angle of repose.

Uses of friction:
1) It reduces the efficiency.
2) One can easily walk on a rough surface than on a very smooth surface.
3) A vehicle moving on road surface can be stopped suddenly by applying breaks when the sufficient friction is developed.
4) The type of vehicle are made up of certain special designs due to which sufficient friction can be developed between the tyres & the road surface so that accidents due to sleeping are avoided.

Procedure:
A) Study of frictional force:
1. Organize the physical set up of experiment with plane in horizontal position. (\(\theta=0\))
2. Predict that as you go on applying force by adding weights in pan \(P\); the frictional resistance developed restricts the motion of box.
   \(P = \text{weight of pan} + \text{weight in pan}\)
3. Predict that at particular value of \(P\), the box just starts moving.
4. Observe the weights in pan \(P\) & corresponding position of box (steady / just starts moving / moves faster)
5. Tabulate.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Weights in pan (P) in N</th>
<th>State of box</th>
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6. Infer: Frictional force developed increases till the box just starts moving. Maximum frictional force is developed at point of motion of box.

B) Study the relation between frictional force & area of contact:
1. Organize the physical set up of experiment.
2. Predict that as you change the area in contact of same body of same weight, the limiting (total) value of friction will remain unchanged.
3. Observe:
   a) Place the rectangular wooden body on given plane with larger surface area in contact.
   b) Go on increasing the weights in pan till body just starts moving.
   c) Place the same body on same plane with smaller surface area in contact.
   d) Observe the weights in pan till body just starts moving.

4. Table:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Area in contact with plane</th>
<th>Weights in pan</th>
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Conclusion:

1. Average value of co-efficient of friction between wooden surfaces is________ (less than/ greater than/ equal to) average value of wood and
2. Magnitude of slope of the graph plotted between load and effort for different surfaces is _____________( less than / greater than/equal to/ nearly equal to) observed magnitude for the same surfaces.
Experiment No. 9

Aim: To verify the parallelogram law of forces.

APPARATUS:
Iron nickelled slotted weight box, Paper sheet, Four frictionless pulleys, Thread, Drawing pins, Mirror strip, Gravesend apparatus, Set squares, Pencil, Pans

LAYOUT:
OBJECTIVE:

To verify the parallelogram of forces.

(Triangle, Parallelogram, Polygon and lamis theorem)

THEORY:

Law of parallelogram of forces states that “if two force, acting simultaneously on a particle, be represented in magnitude and direction by the two adjacent sides of a parallelogram then their resultant may be represented in magnitude and direction by the diagonal of the parallelogram, which passes through their point of intersection”
Mathematically, resultant force, \( R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta} \) where, P and Q are the force, where whose resultant is required to be found out and \( \theta \) is the angle between the forces P and Q.

**PROCEDURE:**

1. Set the board in vertical plane and fix the paper sheet with drawing pins.
2. Pass a thread over two pulleys.
3. Take a second thread and tie the middle of this thread to the middle of first thread.
4. Pass the ends of the second thread over the other set of two pulleys.
5. Take a third thread and tie its one end to the point of the first two threads.
6. Attach pan to the free ends of the thread as shown in figure.
7. Place the weight in the pans in such a manner that the knot comes approximately in the centre of the paper.
8. Take the mirror strip and place it under the threads turn by turn and mark the points by keeping the eye, the thread and its image in the same line without disturbing the system.
9. Mark the lines of force and write down the magnitude of forces.
10. Remove the paper from the board and produce the lines to meet at a point O.
11. Select a suitable scale and draw the vector diagram by moving in one direction (i.e. clockwise or anticlockwise). Draw ab parallel to AB and cut it equal to force p, draw bc parallel to BC and cut it equal to force Q, draw cd parallel to CD and cut it equal to force R, draw de parallel to DE and cut it equal to force S. Vector ae will be the resultant force T1 taken in opposite direction and should be equal to force T which proves the law of polygon of force. If forces. If ae is not equal to then percentage error is found as follows.
   a. Percentage error = \( \frac{T - T_1}{T} \times 100 \)

**OBSERVATION TABLE:**

<table>
<thead>
<tr>
<th>SR. NO.</th>
<th>Force (Total weight of part)</th>
<th>Calculated Resultant T1</th>
<th>Percentage Error</th>
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<tbody>
<tr>
<td>P</td>
<td>Q</td>
<td>R</td>
<td>S</td>
</tr>
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</table>
RESULTS AND DISCUSSION:

PRECAUTION:

- Pans weights should not touch the board.
- There should be only one central knot on the thread which should be small.
- Make sure that all pans are at rest when the lines of action of force are marked.
- All the pulleys should be free from friction.
- While calculating the total force in each the weight of the pan should be added to the weight put into the pan.