Experiment No. : 4

Title of Experiment : Verification of Parallelogram Law of Coplanar Forces

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Semester : 1

Academic Year : 2020 - 2021

| Punctuality | Reading & Understanding | Application | Total | Signature & Date |
|---|---|---|---|---|
| 02 | 04 | 04 | 10 | |
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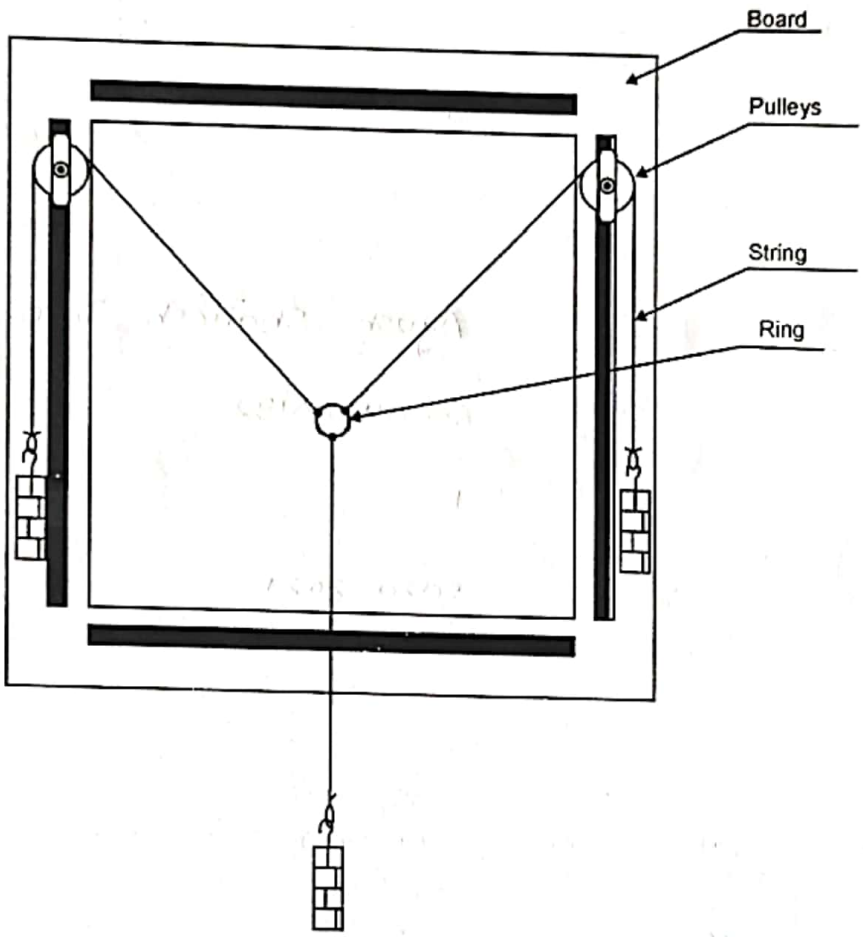
|---|---|
| *DJ19FEC104.01* | *Illustrate the effect of force and moment and apply the same along with the concept of equilibrium systems with the help of FBD.* |
| *DJ19FEC104.02* | *Demonstrate the understanding of Centroid and its significance and locate the same.* |
| *DJ19FEC104.03* | *Correlate real life application to specific type of friction and estimate required force to overcome friction.* |
| *DJ19FEC104.04* | *Establish relation between velocity and acceleration of a particle and analyze the motion by plotting the relation.* |
| *DJ19FEC104.05* | *Analyze general plane motion of rigid bodies using Instantaneous centre.* |
| *DJ19FEC104.06* | *Analyze particles in motion using force and acceleration, work-energy and impulse-momentum principles.* |

**Set-up Diagram**




**Parallelogram Law of Forces Apparatus**

**Experiment No:** 04 **Date:** 25/03/2021

**Title :** **Verification of Parallelogram Law of Coplanar Forces**

**Aim:** To verify the Parallelogram Law of Coplanar Forces for a concurrent force system.

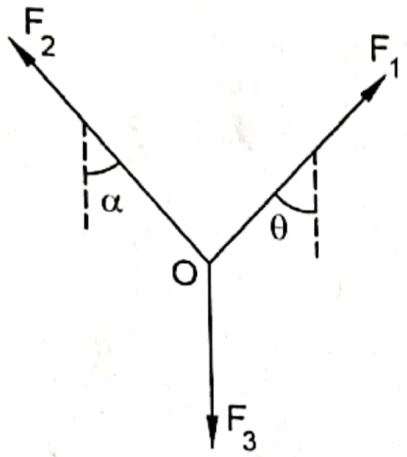
**Apparatus :**

Law of Polygon apparatus, angle measuring instrument, slotted weights of 50 gm each, weight hangers, metal ring 2 cm diameter, weighing balance, thin strong strings.

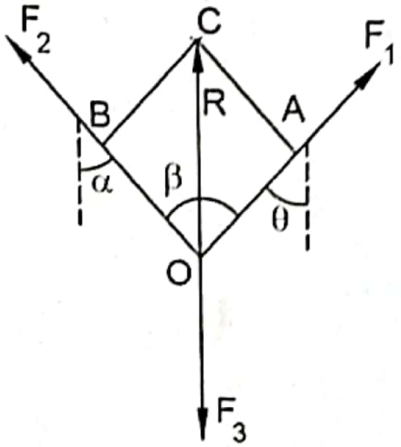
**Theory :**

'Parallelogram law of forces' states that, if a particle is acted by the two forces represented in magnitude and direction by the two sides of a parallelogram drawn from a point then the **resultant** is completely represented by the diagonal passing through the same point.

In this experiment we will verify the law.




Free Body Diagram




Force Polygon

**Observation Table:**

| SR NO. | $F_1$ (N) | $F_2$ (N) | $F_3$ (N) | θ (deg.) | α (deg.) | R (N) by Analytical | R (N) by Graphical |
|---|---|---|---|---|---|---|---|
| 1 | 2.48 | 2.3 | 3.58 | 44° | 45° | 3.42 | 3.40 |
| 2 | 2.02 | 2.3 | 3.12 | 45° | 42° | 3.14 | 3.15 |
| 3 | 2.02 | 2.76 | 4.00 | 40 | 30° | 3.94 | 3.95 |

**Procedure:**

**A. Measurements**

1. Tie three strings on the rim of a 2 cm diameter metallic ring.
2. Suspend the ring in a vertical plane by passing two of these strings over the two pulleys fixed at the two corners of the apparatus. Attach weight hangers at the end of these strings.
3. Insert slotted weights in these three suspended hangers. The metallic ring would move and occupy a new equilibrium position. The weights in hangers 1 to 3 represent the forces $F_1$, $F_2$, and $F_3$ respectively.
4. Measure the angles made with the vertical by strings 1 to 2 by the angle measuring instrument. Call these angles as $\theta$ and $\alpha$ respectively. The third string holding $F_3$ remains vertical.
5. Construct a space diagram by drawing all forces $F_1$, $F_2$ and $F_3$ at their true orientation and location as shown.
6. cut OA = $F_1$ and OB = $F_2$ in suitable scale. From A draw AC' parallel to OB and BC' parallel to OA. R represents the resultant of force $F_1$ and $F_2$. As the system is in equilibrium it must be equal to $F_3$.

   Note that R and $F_3$ are in opposite direction.

**Analytical Method**

Measure angle $\beta$ and by using resultant formula, calculate R

$$R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\beta}$$

1) $R = \sqrt{2.48^2 + 2.3^2 + 2\times2.48\times2.3\times\cos89} = 3.42\,N$

2) $R = \sqrt{2.02^2 + 2.3^2 + 2\times2.02\times2.3\times\cos87} = 3.14\,N$

3) $R = \sqrt{2.02^2 + 2.76^2 + 2\times2.02\times2.76\times\cos70} = 3.94\,N$

**Result:**

The parallelograms for the three sets of observations were drawn and resultant represented by the diagonal is same as the third force $F_3$. Hence the Parallelogram Law of Coplanar Forces is verified.

**Precautions**

1. The metal ring should be of a small diameter, less than 2 cm, so that a concurrent system is formed and its own weight becomes negligible.
2. Use thin and strong strings.
3. Oil the pulleys at their pins to make them close to being frictionless.
4. Hold the angle measuring instrument very close and parallel to the inclined strings. Note that the angle measuring instrument always gives the angle with the vertical.

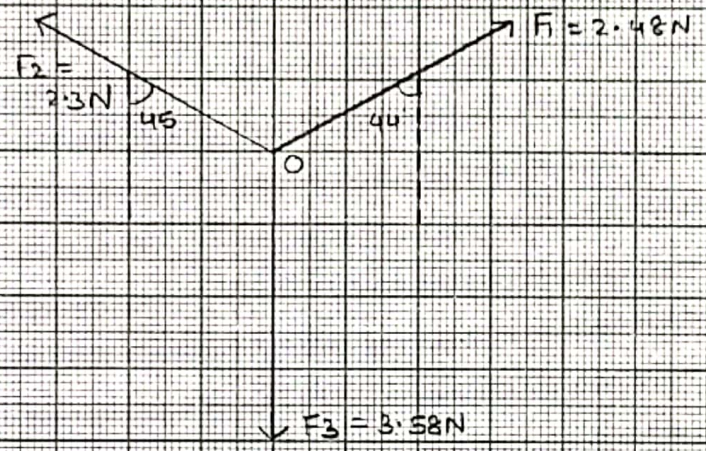
Case 1)



Scale

1N = 2cm

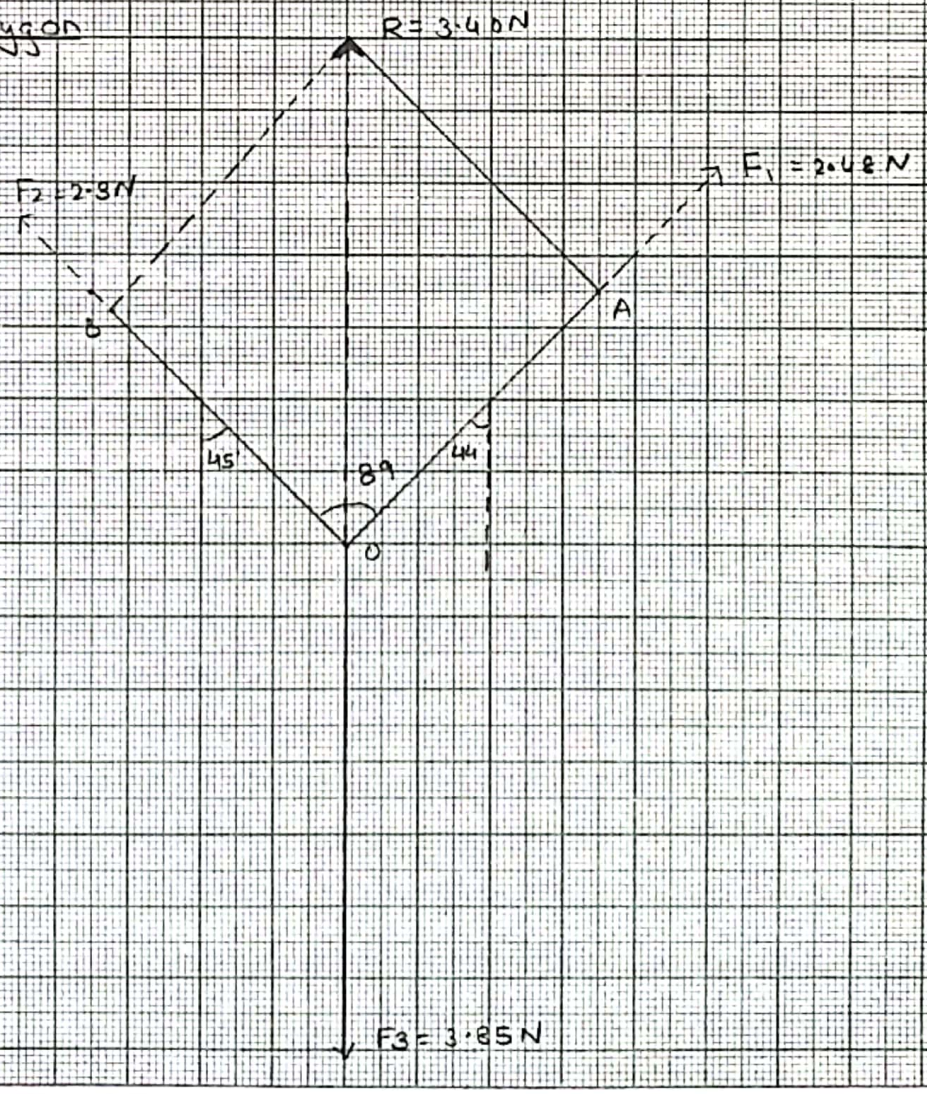
Force Body Polygon







Force Polygon

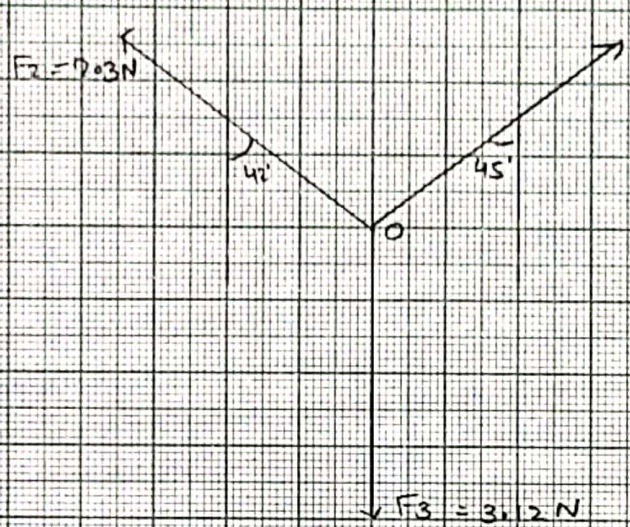


Case 2)

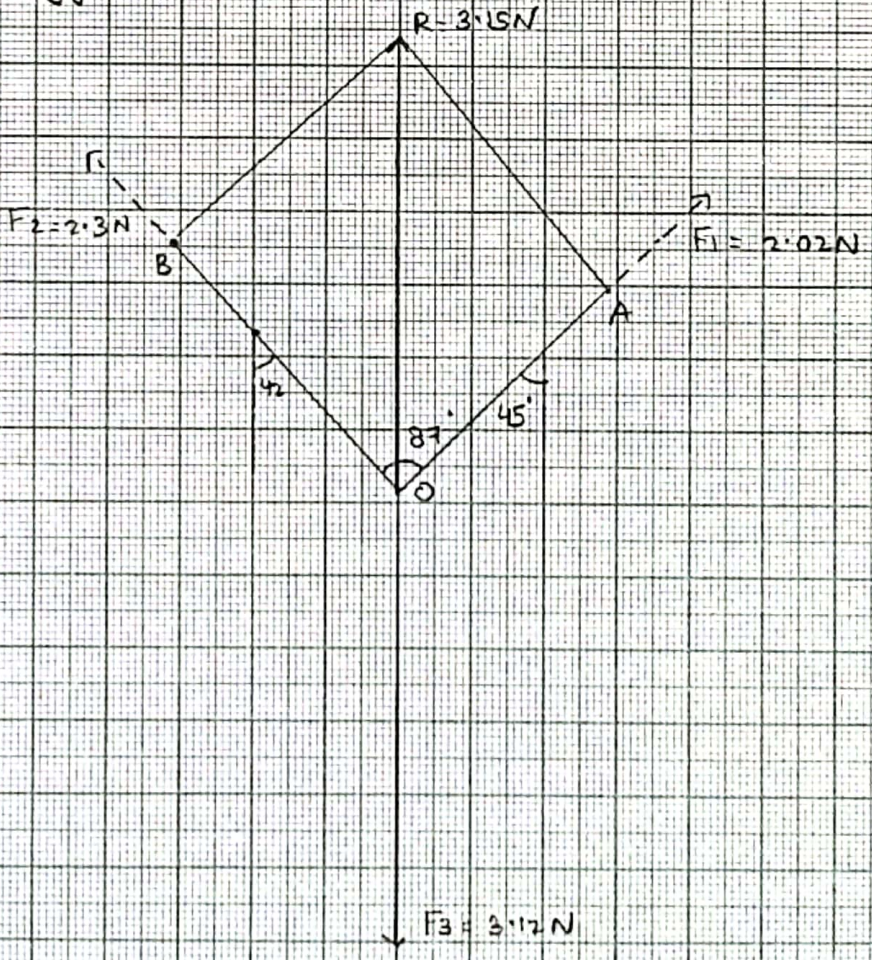


Scale
1N = 2cm

Free Body Diagram




Force Polygon

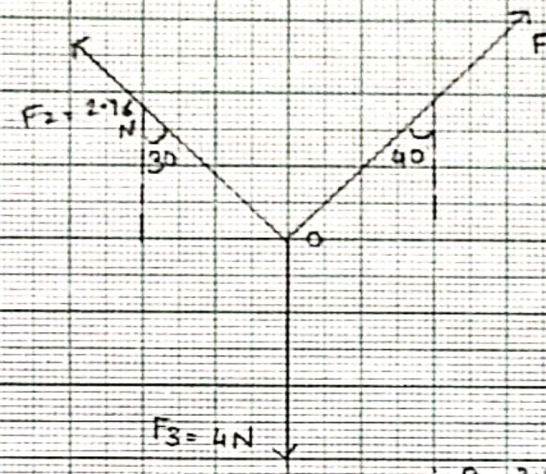


Case 3



Scale
1N = 2cm

Free Body Polygon




Force Polygon