EXPERIMENT NO. 1

VERIFICATION OF TRIANGLE LAW & PARALLELOGRAM LAW OF FORCES

1. OBJECTIVE

To verify triangle and parallelogram law of forces with the help of Gravesand's apparatus

2. Apparatus Required

Gravesand's apparatus, paper sheet, weight, thread, pans, set square, pencil, drawing pin etc.

3. Theory

The "triangle law of force" states that if three coplanar forces acting on a particle can be represented in magnitude and direction by the three sides of the triangle taken in order, the force will be in equilibrium.

This law can also be stated as: If two forces acting on a particle represented in magnitude and direction by the two sides of the triangle taken in order then their resultant will be given by the third side of the triangle taken in opposite direction. "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.

4. PROCEDURE

Refer to fig. 1.1

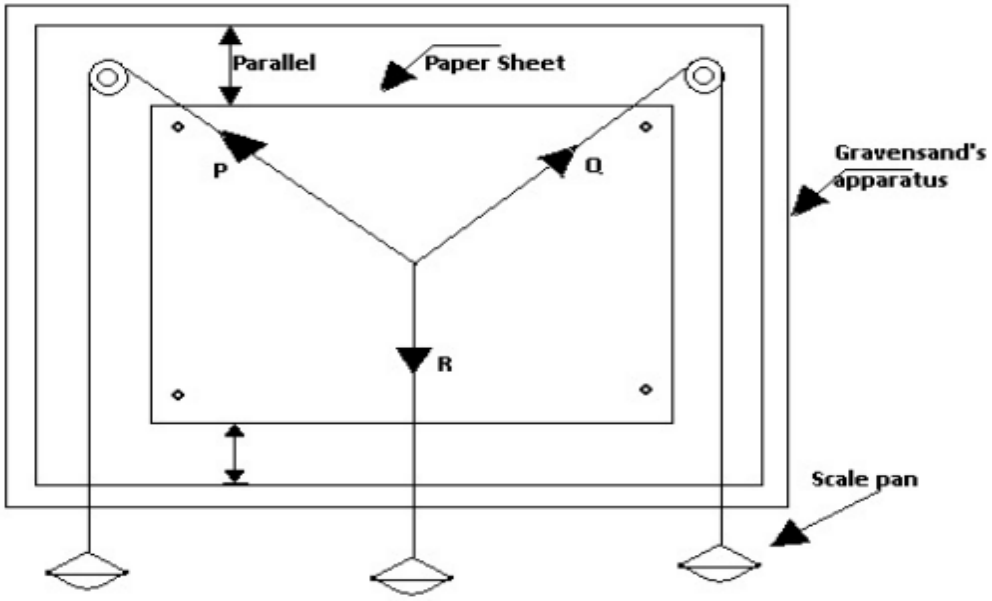


Fig. 1.1

A. Fix the paper sheet with drawing pin on the board set in a vertical plane such that it should be parallel to the edge of board.

B. Pass one thread over the pulleys carrying a pan at its each end. Take a second thread and tie its one end at the middle of the first thread and tie a pan at its other end.

C. Add weights in the pan in such a manner that the small knot comes approximately in the centre.

D. Displace slightly the pans from their position of equilibrium and note if they come to their original position of rest. This will ensure the free movement of the pulleys.

E. Mark lines of forces represented by thread without disturbing the equilibrium of the system and write the magnitude of forces i.e. Pan Weight + Added Weight.

F. Remove the paper from the board and produce the line to meet at O.

G. Use Bow's notation to name the force P, Q, R as AB, BC, and CA.

H. Select a suitable scale and draw the line ab parallel to force P and cut it equal to the magnitude of P. From b draw the line bc parallel to force Q and cut it equal to the magnitude of Q (Fig. 1.2). Calculate the magnitude of ca i.e., R1 which will be equal to the third force R which proves the triangle law of forces.

If R1 differs from original magnitude of R, the percentage error is found as follows:

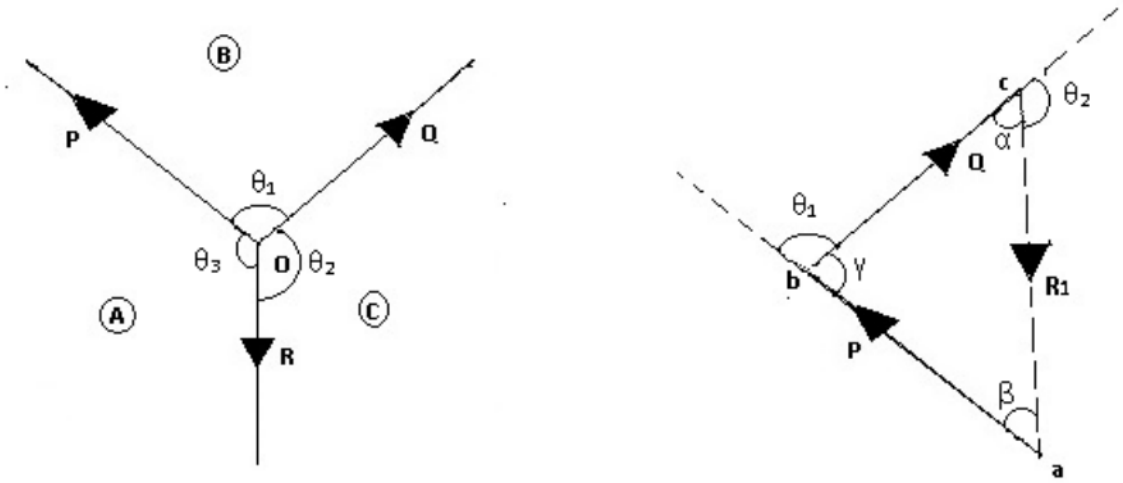
Percentage error $=(R-R1)/R* 100$

1.1 TRIANGLE LAW OF FORCES

Graphical Method

Fig. 1.2(b), draw ab parallel to force P in suitable scale with the use of set square and then from b draw bc parallel to force Q. The closing side of triangle represents the force R1 which should be equal to force R.

Note, the difference in R1 and R shows the graphical error.



(a) Space diagram (b) Vector diagram

Analytical Method

Measure angles α, β and γ and by using Lami's theorem check the following relation

$$\frac{P}{Sin\ \alpha} = \frac{Q}{Sin\ \beta} = \frac{R2}{Sin\ \gamma}$$

1.2 PARALLELOGRAM LAW OF FORCES

Graphical Method

Fig. 1.3, cut OA=P and OB=Q in suitable scale. From A draw AC' parallel to OB and BC' parallel to OA.

R1 represents the resultant of force P and Q. As the system is in equilibrium it must be equal to R.

Note that R and R1 are in opposite direction.

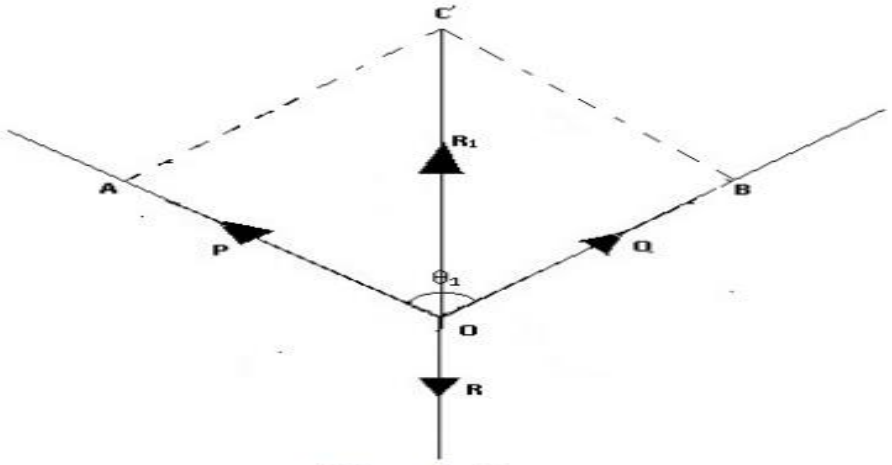


Fig. 1.3

Analytical Method

Measure angles θ_1 and by using resultant formula, calculate R_1

$$R_2=\sqrt{(P^2+Q^2+2\ PQ\ \text{cosine}\ \theta_1)}$$

5. OBSERVATION

Scale .....N: .....mm

Law	Total Weight of pan P	Total Weight of pan Q	Total Weight of pan R	Calculate Resultant	%age error =
Triangle Law					Graphical $\frac{R-R1}{R}*100$
					Analytical $\frac{R-R2}{R}*100$
Parallelogram Law					Graphical $\frac{R-R1}{R}*100$
					Analytical $\frac{R-R2}{R}*100$

6. PRECAUTIONS

A. Pans/weights should not touch the vertical board

B. There should be only one central knot on the thread which should be small

C. While calculating the total force in each case the weight of the pan should be added to the weight put into the pan

D. Make sure that all the pans are at rest when the lines of action of forces are marked

E. All the pulleys should be free from friction