EXPERIMENT NO. 4
PARALLELOGRAM LAW OF VECTORS

Aim: To Verify parallelogram law and find the weight of a given body.

Apparatus: Parallelogram Law of Forces apparatus (Gravesand's apparatus), two hangers with slotted weights, a body (a wooden block) whose weight is to be determined, thin strong thread, white drawing paper sheet, drawing pins, mirror strip , sharp pencil , half meter scale, set squares, protractor.

Diagram :

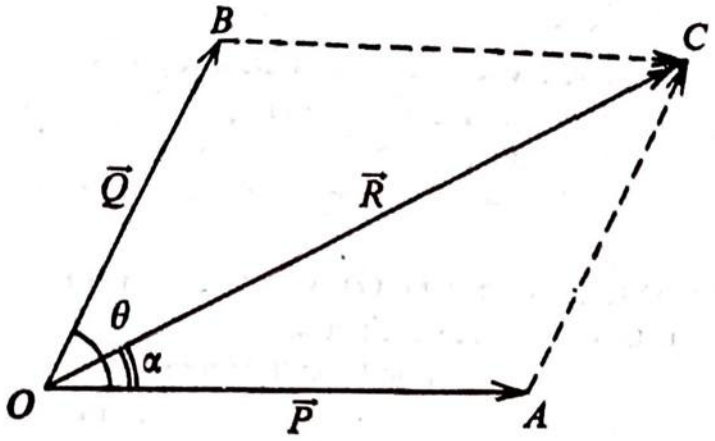
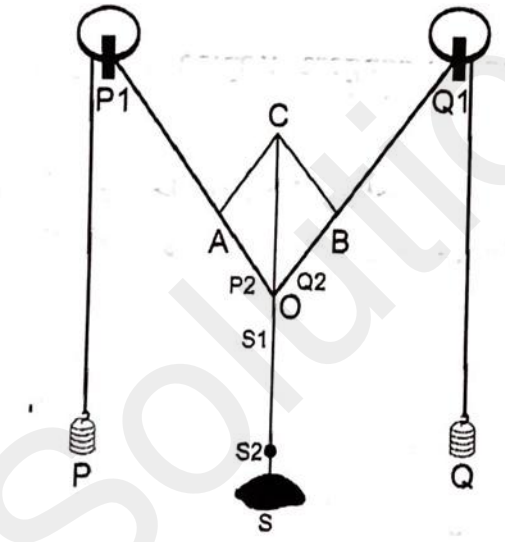
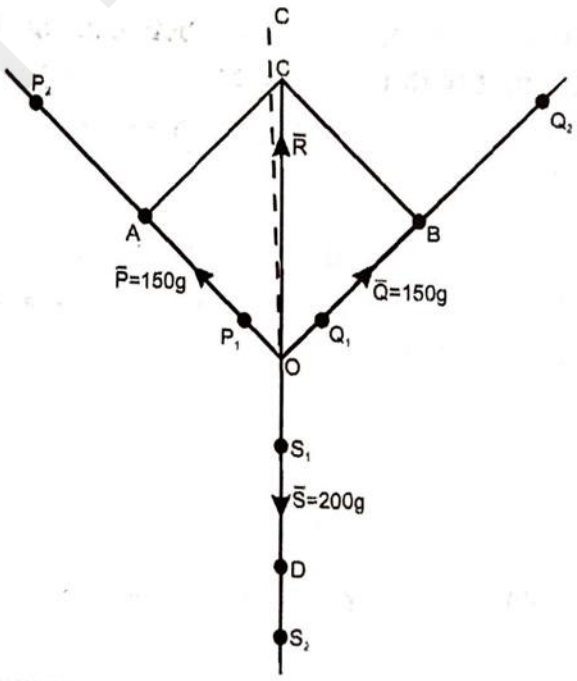


Fig 4.1 Parallelogram of forces

Fig. 4.2 Actual set up of parallelogram law of forces





Determination of weight of a wooden block

Fig. 4.3 Determination of weight of a wooden block

Formula :

1. $R = \sqrt{P^2 + Q^2 + 2PQ\cos\Theta}$, $\Theta < 90^0$
2. $R = \sqrt{P^2 + Q^2 - 2PQ\sin\theta_1}$, $\Theta > 90^0$ $\Theta = 90 + \Theta_1$
3. $R = \sqrt{P^2 + Q^2}$, $\Theta = 90^0$

Where R is resultant vector, P and Q are two vectors, and Θ is the angle between P and Q vectors.

Procedure:

1. Fix the wooden board in a vertical position as shown in figure. Clamp the pulleys on the wooden board. Fix the white paper on the drawing board with the help of drawing pins.
2. Pass a long string over the pulleys and a hanger at each end. Tie another string at the centre of the first string. Tie a hanger to the free end of this string as shown in figure.
3. Add suitable weights to the hangers so that the system is in equilibrium and the common point O is near the centre of the board.
4. Note the forces P, Q and S from diagram it can be seen that $p = w_1$,$Q = w_2$ and $S = w_3$ where w denotes the numerical value or magnitude of the total weight in each case .
5. Hold the plane mirror on the paper behind the string. Mark two points on the paper at the ends of the mirror such that string and its image in the plane mirror coincide. The line joining the points gives the line of action of the corresponding forces (P,Q or Q).Determine the lines of action of all three forces in this manner .
6. Remove the white paper from the board. Draw the lines through the points and produce them to meet at the common point O.
7. With a suitable scale(for e.g. Let 20 g = 1 cm) mark the points A and B such that the lengths OA and OB represent the magnitude of the forces P and Q respectively.
8. Complete the parallelogram OACB . Draw the diagonal OC . Measure the length OC and determine the magnitude of R using the scale chosen.
9. Measure the angle AOB (Θ) between the forces P and Q . Calculate R using the formula. Compare it with the value obtained by calculation .
10. Take two readings by changing the weights added to the hangers. Replace w_3 by the object (unknown) whose weight is to be found. Adjust w_1 and w_2 such that the system is in equilibrium and the common point O is near the centre of the board.
11. For unknown weight, following the earlier procedure complete the parallelogram. Find the weight of the body by measuring the length of the diagonal passing through the point O and using the scale chosen.

Observations:

I. To find the actual weight of the unknown mass, R unknown.

1. Least count of spring balance = ... g.

2. Zero error of spring balance = ... g.

3. Weight of unknown body by spring balance, R= unknown = ... g.

II. To verify parallelogram law of vectors

Obs. no.	P (w_1) gwt	Q (w_2) gwt	Angle between P and Q θ^0	Resultant R (gwt)		
				Observed (w_3)	From the diagram	Calculated using the formula
1	700	70	94	100	96	93·48
2	100	100	120	100	90	
3	120	120	130	100	100	

III. To find the weight of the unknown mass using parallelogram law of vectors Scale.

Obs. no	P (w_1) gwt	Q (w_2) gwt	Angle between P and Q. θ^0	R by measurement from the diagram (diagonal × scale) gwt	R by calculation using the formula gwt
1	100	160	120	= 105	160 gw
2	70	70	90	1107	99 w
3					

Calculation : $R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$, for $\theta \angle 90^0$

1. $R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$

$= \sqrt{(10)^2 + (10)^2 + 2 \times 100 \times \sin 30}$

$= \sqrt{100 + 100 + 200 \times \frac{1}{2}}$

$= \sqrt{200 + 100}$

$= 30^2 = 30 \times 30 = 900$ gm

2. $R = \sqrt{P^2 + Q^2 - 2PQ\sin\theta_1}$, for $\theta > 90^0$

$R = \sqrt{P^2 + Q^2 - 2PQ\sin\theta}$

$= \sqrt{(10)^2 + (10)^2 - 2 \times 100 \times \sin 30}$

$= \sqrt{100 + 100 - 200 \times \frac{1}{2}}$

$= \sqrt{200 - 100}$ $= 10^2 = 10 \times 10 = 100$ gm.

3.

1. Mean value of unknown weight R (using diagonal) = ---100--- gwt.
2. Mean value of unknown weight, R (using angle Θ) = ---100--- gwt.

Result :

The unknown weight of given body = ----------100---------- gwt.

The result shows the error is within limits of the experiment error.

Precautions:

Use frictionless pulleys. Hanger and pulley should not touch the board. Sufficient length of string is preferred.

Additional Experiment you can do:

1. If scale pan or spring balance is available in laboratory student can compare weight of unknown object with calculated weight of unknown weight.
2. To determine the direction of resultant vector R as follows:
   Measure the angle AOC (α) between P and R. 'α' gives the direction of resultant vector.

Multiple-choice Questions

1. In the experiment, on finding the weight of a given body by the parallelogram law of vectors, the student needs to use :

   a) Three pulleys and two weights in all
   b) Two pulleys and two weights in all
   c) Two pulleys and three weights in all
   d) Three pulleys and two weights in all

2. In above diagram if P = 5gwt, Q =7gwt, Θ = 45⁰, then α = ...

   a.) 26.40 with direction of P
   b) 26.40 with direction of Q
   c) 450 with direction of P
   d) 18.30 with direction of P

Questions

1. What are the main sources of error in the experiment using Gravesand's apparatus ?

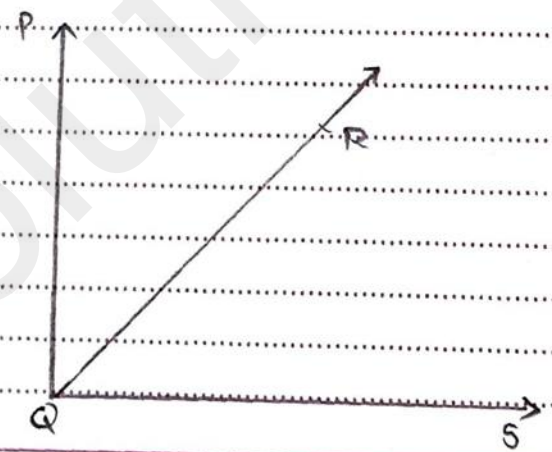
The following can be the main sours of error while conducting an experiment with grave and experiment.

① Pressure af fraction in a pully
② Weight tried to thereads

A part from these two main sources of erros. There can be be also occurs on error in marking the points in the experiment. The fraction, problem in pulley can be reduced or corrected by oiling the pullys.

2. State the law of Parallelogram of forces?

The law of Parallelogram of force state that if two vectors acting on a particle at the same time se reprensent in magnitude and direction by two adjacent sides of a parallelogram drawn from point. their resultant vectors in represented in magnitude and direction by the digonal of the parallelogram draw from the same point.



Remark and sign of teacher: .....