3B SCIENTIFIC® PHYSICS

Force Table 1000694

Instruction sheet

10/13 ALF

1 Base
2 Weight holder with slotted weights
3 Clamps with pulleys
4 Centre rod
5 Mount for cords
6 Work disc

1. Description

The force table serves to prove that force is a vector quantity. It is also used for quantitative investigation of how forces combine and resolve.

The force table consists of a circular work disc on a stable base with a dual angle scale. Weights are attached to three pulleys with securing clamps. The three sets of brass weights consist of 2x 5 g, 2x 10 g, 2x 20 g and 2x 50 g weights and weight holders weighing 50 g.

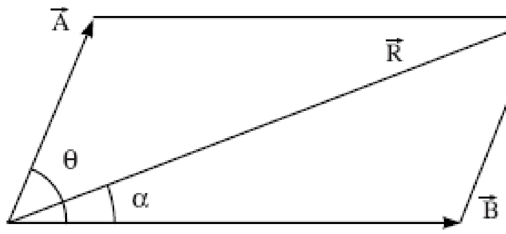
2. Technical data

Dimensions:	300 mm x 390 mm dia. approx.
Scale:	0 to 360° with 1° resolution
Weight:	3 kg approx.

3. Principle

Forces are vector quantities. This means that the resultant of two forces working at a single point is not simply the sum of the forces but is dependent on the direction in which the forces act. The resultant of two forces acting at the same point in a single plane is defined as that force which, acting alone in the same plane, would have the same effect as the combination of the two forces. A force of equal magnitude to the resultant but acting in the opposite direction therefore maintains the body in equilibrium. The resultant can be obtained by analysis or by graphical means using various laws (parallelogram of forces, triangle of forces, polygon of forces).

A parallelogram of forces represents two forces acting simultaneously on a body as two adjacent sides of a parallelogram. The magnitude and direction of their resultant is then given by the diagonal originating from the same point.



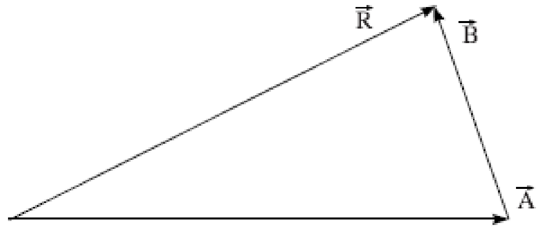
This theorem can be expressed mathematically as follows: When two forces $\vec{A}$ and $\vec{B}$ acting on a body with an angle θ between them, the resultant $\vec{R}$ is given by:

$$R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$$

If α is the angle between the resultant and force $\vec{A}$ then:

$$\tan\alpha = \frac{B\sin\theta}{A + B\cos\theta}$$

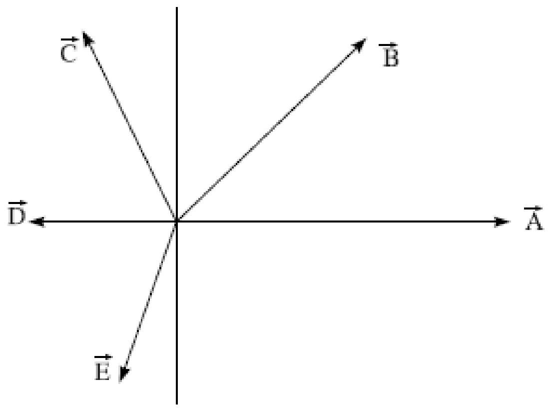
With the law of the triangle of forces, two forces acting simultaneously on a body are represented in terms of magnitude and direction by two following sides of a triangle. The magnitude and direction of the resultant is then given by following the third side of the triangle in the opposite direction.

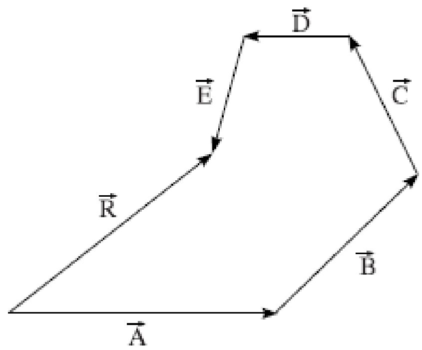


$$\vec{A} + \vec{B} = \vec{R}$$

From this it can be determined that a body is in equilibrium if three forces are acting upon it, which can be represented by the three sides of a triangle.

If more than two forces act on a body at once, the law of the polygon of forces is used. This represents several forces acting at the same point as following sides of a polygon where one side remains open. As for the triangle, following the side that closes the polygon in the opposite direction gives the resultant force.





$$\vec{A} + \vec{B} + \vec{C} + \vec{D} + \vec{E} = \vec{R}$$

Therefore a body is in equilibrium when several forces act upon it that can be represented as a closed polygon. The vector sum of the individual forces is equal to zero and so is the resultant force. On closer observation, this law can be seen to be a simple extension of the law of the triangle of forces. The force table is suitable for demonstrating vector addition and equilibrium of forces and for confirming the graphic and analytical methods. The equilibrium between two or three forces can be demonstrated and the magnitude and direction of each force easily determined.

4. Operation

4.1 Equipment Setup

- Place the base on an even surface.
- Screw the centre rod vertically into the base.
- Press the work disc with force onto the centre rod.
- Place the washer onto the central bore and screw in the mount for cords.
- Attach the pulleys with clamps at the positions on the work disc marked 0°, 120° and 240°.
- Place the ring above the mount in the centre of the work disc.
- Run the cords over the pulleys, suspend the weight holders and attach the slotted weights.
- The ring should be in a state of equilibrium.

4.2 Sample experiment: Vector Addition

- Set up the force table as above.
- Add a 20 g mass to one weight holder and a 50 g mass to another at 0° and 120°.
- By adding weights to a third weight holder and selecting a suitable angle it is possible to establish equilibrium. To check the equilibrium, lift the ring and let it drop. If it falls back to the centre, equilibrium has been attained. If not, then further adjustments are necessary.
- Calculate the magnitude and direction of the forces required to attain equilibrium. Compare the values obtained in the experiment to those determined by the theory.
- Draw the forces to scale showing their magnitude and direction to confirm the law of the triangle of forces.
- Repeat the experiment with different masses and angles.