

COMPOSITION AND RESOLUTION OF FORCES

LAB MECH 10

From *Laboratory Manual of Elementary Physics*, Westminster College.

INTRODUCTION

Even though this experiment deals with forces, the methods used can be applied to any vector quantity. The resultant of two or more vectors can be determined graphically, i.e. by a scale drawing, by mathematical method, as well as by experiment with actual forces. In these cases both the magnitude and the direction of the resultant must be expressed for a complete solution.

Conventionally, the direction of any vector is taken as the angle between its direction and horizontal right direction which is considered as 0° . Thus in Fig. 1 the vector A might represent a force due to gravity on 30 gm at 0° and B, might be due to 40 gm at 90° . To find the combined effect of A and B, the vector B is added to A as shown in Fig. 2. The resultant is the vector R at an angle θ . The length of R may be measured to determine its magnitude and the angle θ measured to give its direction.

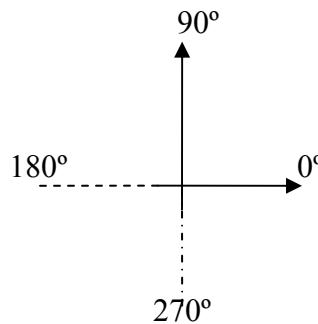


Figure 1

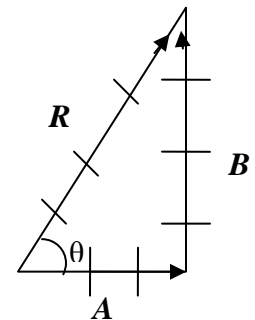


Figure 2

Mathematically, the resultant may be computed from the well known relation:

$$R^2 = A^2 + B^2 \quad (1)$$

And

$$\theta = \tan^{-1} B/A. \quad (2)$$

These expressions are true only if the angle between A and B is 90° . If the angle is not 90° , we may have something like Fig. 3 and Fig. 4 where the vectors C and D are added to obtain the resultant R. The mathematical solution can be obtained by use of the law of cosines, or better by the use of component vectors. If the vector D is resolved into two components D_x and D_y and vector C resolved into components C_x and C_y , as shown by the dashed lines in Fig. 3, then C_x and D_x can be added to obtain the x-component R_x and C_y and D_y can be added to obtain the y-component R_y . This is effectively shown in Fig. 4. That $R = \sqrt{R_x^2 + R_y^2}$, then

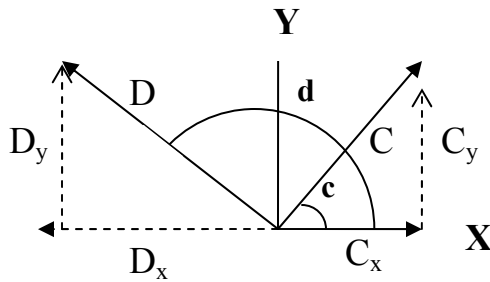


Figure 3

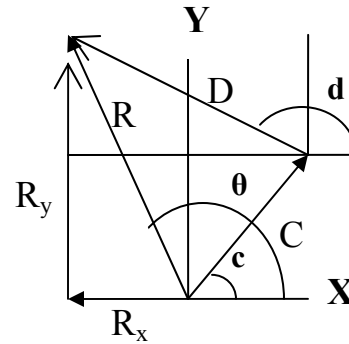


Figure 4

the magnitude of the resultant can now be obtained thus:

$$R^2 = (C_x + D_x)^2 + (C_y + D_y)^2; \quad C_x = C \cos c; \quad C_y = C \sin c; \quad D_x = -D \cos (180^\circ - d); \quad D_y = D \sin (180^\circ - d). \quad (3)$$

The direction θ of the resultant is given by $\theta = 180^\circ - \tan^{-1} (R_y/R_x)$. (4)

Experimentally, the resultant force of two or more forces can be obtained with a force table. It is set up with hanging masses of values corresponding to the forces given and appropriately directed. An additional “equilibrant” force is placed on the force table that balances the forces to be resolved. The resultant R is equal in magnitude and in opposite direction from the equilibrant.

If we have more than two vectors, we can extend the process as shown in Fig. 5 . In this figure vectors E, F, and G can be added to obtain R graphically.

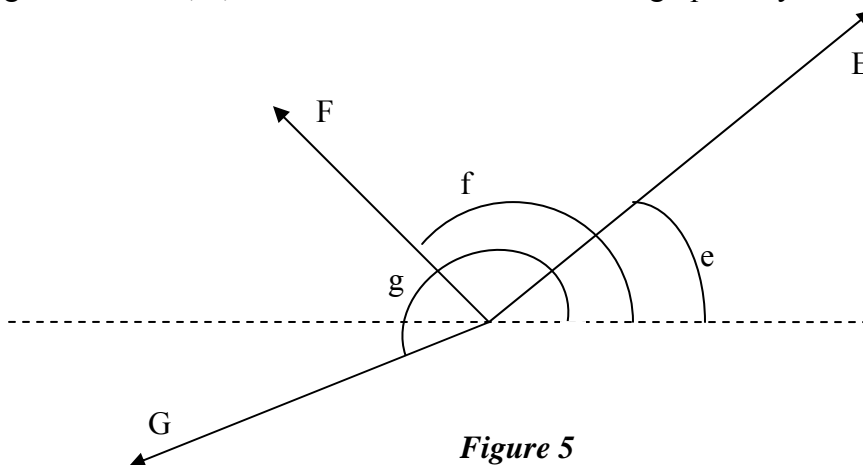


Figure 5

PURPOSE

The specific objective of this experiment is to determine the magnitude and direction of the resultant of two or more component forces. The experiment should provide some experience in the treatment of vector quantities.

MATERIALS

Force table with: ring, strings, weight hangers
Known masses
Ruler and protractor
Scientific calculator

PRELIMINARY QUESTIONS

1. For the sun to keep its rather constant size over eons of time with the strong gravitational mutual mass attraction, requires that...; Explain.
2. Explain that humans all around the circular earth all have the sense of standing upright.

PROCEDURE AND ANALYSIS

Obtain a problem card from the instructor. Although forces should be expressed in dynes or newtons, for this experiment we will use the forces in gram-weights (gm-wts) to save work in the computations. Using a suitable scale (such as 1 cm = 20 gm-wts), carefully draw the vector diagram for the problem as shown in Figs. 2 and or Fig. 4. Copy your problem on your data sheet and record the resultant obtained by this graphical method.

Now do the mathematical computations, considering values of the forces in (gm-wts), to obtain the resultant for the problem.

By use of the force table, experimentally determine the resultant R.

For the case of more than two forces, consider the three forces according to Fig. 5. With a ruler and protractor, draw approximately to scale a representative graphical solution showing the resultant with basic explanation.

Define: component; resultant; equilibrant. Discuss the comparative accuracy of the three methods used in the solution of the problem given on the card.