PHYSICS 534

EXERCISE-14 Equilibrant Forces

ANSWERS
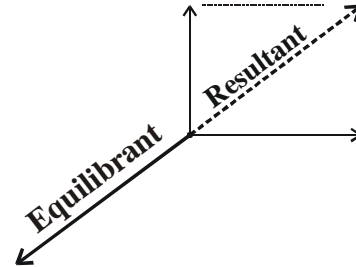
Johannes van der Waals was awarded the Nobel prize for physics in 1910 for his development of the fluid state equation.

van der Waals

The equilibrant force is that force which produces equilibrium. It is always equal to but opposite the resultant force. Thus, in order to determine the equilibrant force, you must first find the resultant force.

1. Explain the difference between a *resultant force* and an *equilibrant force*.

> **The resultant force is the sum of all the forces acting on a system. The equilibriant force is opposite and equal to the resultant force and causes a system to be in equilibrium.**
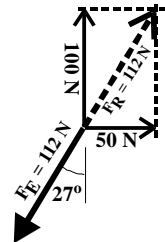
✎ **Note: Diagrams not drawn to scale.**

2. A 100 N force and a 50 N force act concurrently on point P. The 100-N force acts due North. The 50-N force acts due East. What is the *equilibrant* force? [112 N, S 27° W]
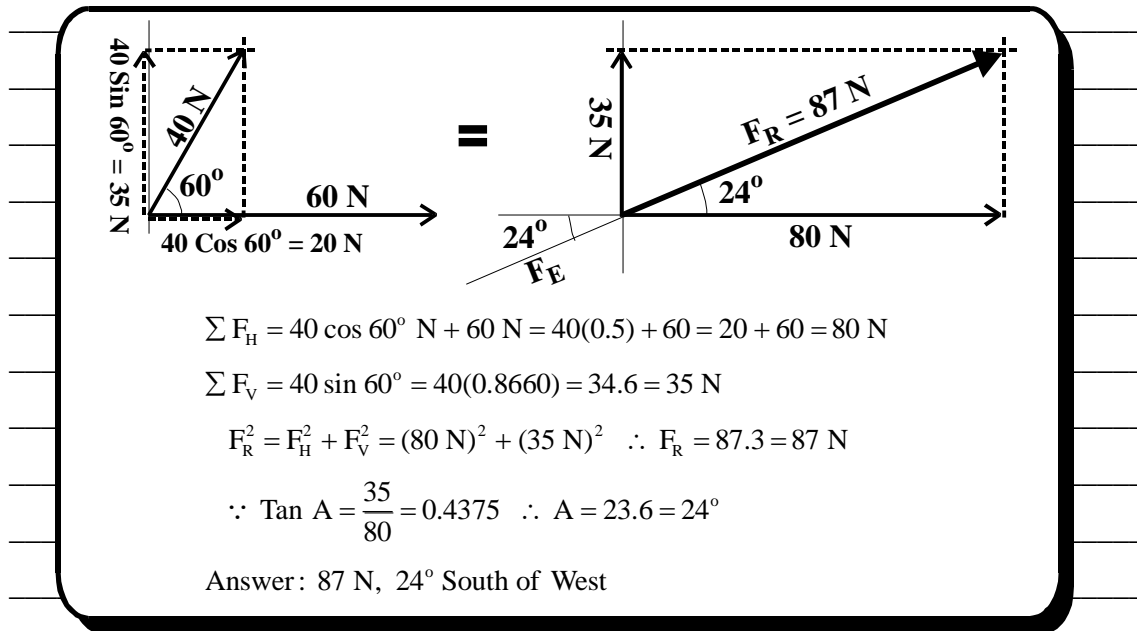
$$\because \ F_R^2 = (100 \text{ N})^2 + (50 \text{ N})^2 \quad \therefore \ F_R = 112 \text{ N}$$

$$\because \ \text{Tan } A = \frac{50}{100} = 0.5 \quad \therefore \ A = 27°$$
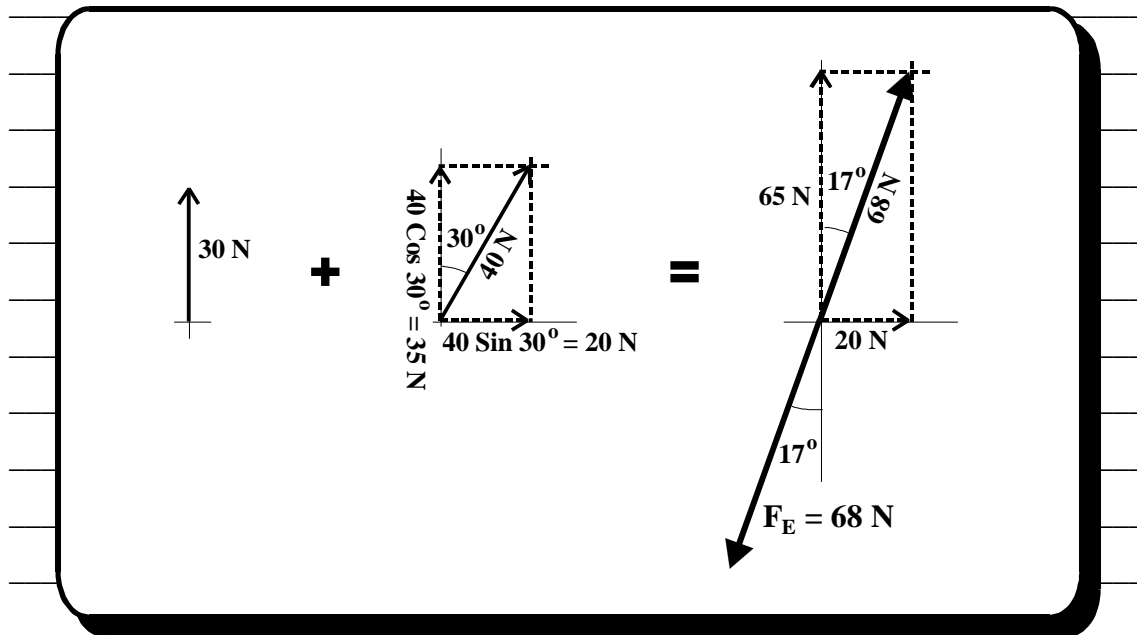
Answer : $F_E = 112 \text{ N}, \ S \ 27° \ W$

3. A force of 40 N and a force of 60 N act concurrently on a point P. The 60-N force acts in the direction of due East. The 40-N force acts in the direction 60° North of East. What is the magnitude and direction of the equilibrant force? [87 N, W 24° S]

$$\Sigma F_H = 40 \cos 60^{\circ}\ N + 60\ N = 40(0.5) + 60 = 20 + 60 = 80\ N$$

$$\Sigma F_V = 40 \sin 60^{\circ} = 40(0.8660) = 34.6 = 35\ N$$

$$F_R^2 = F_H^2 + F_V^2 = (80\ N)^2 + (35\ N)^2 \quad \therefore\ F_R = 87.3 = 87\ N$$

$$\because\ \text{Tan A} = \frac{35}{80} = 0.4375 \quad \therefore\ A = 23.6 = 24^{\circ}$$

Answer: 87 N, 24° South of West

4. An airplane flies at 150 km/h and heads 30° South of East. A 50 km/h wind blows in the direction 25° West of South. What is the resultant velocity? [162 km/h, E 48° S]
What is the equilibrant velocity? [162 km/h, W 48° N]

$$\text{Tan A} = \frac{120}{109} = 1.1009 \qquad \therefore\ A = 47.8 = 48^{\circ}$$
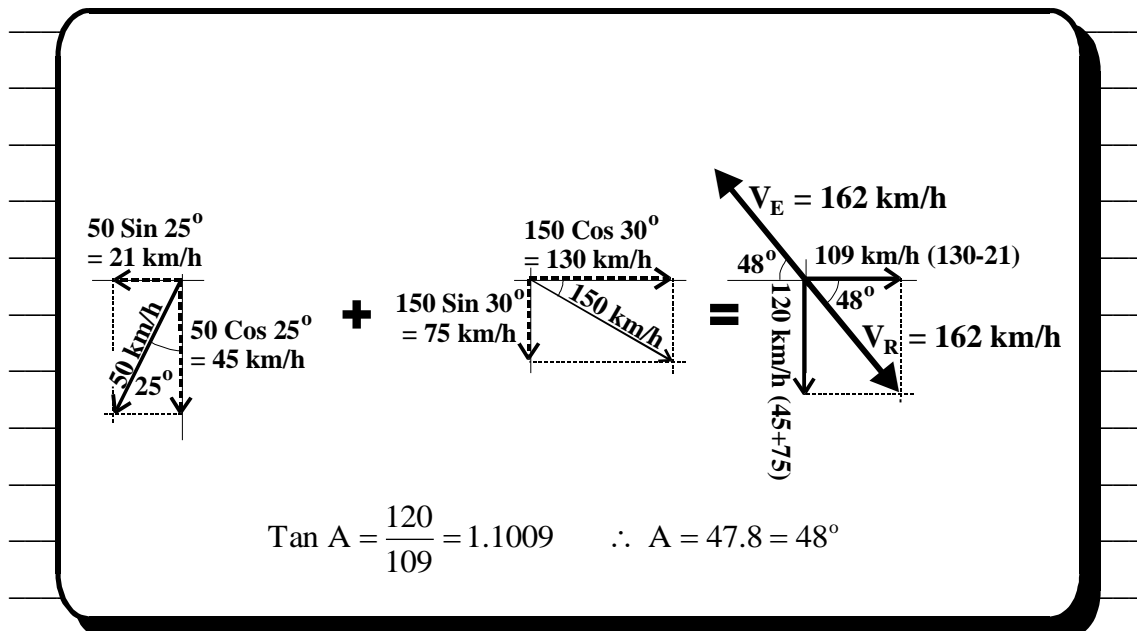
5. A 30 N force acting due North and a 40 N force acting 30° East of North act concurrently on point P. What is the magnitude and direction of a third force that places these two forces in equilibrium?   [68 N, S 17° W]

30 N   **+**   40 Cos 30° = 35 N 30° **40 N**   40 Sin 30° = 20 N   **=**   65 N 17° 68 N   20 N 17° F_E = 68 N

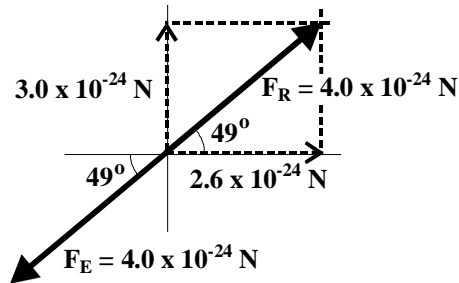**6.** A jet travels 40° North of East for a distance of 300 km. How far North and how far East does the jet travel?   [193 km North] [230 km East]

Distance North = 300 Sin 40° = 193 km   300 km 40° Distance South = 300 Cos 40° = 230 km
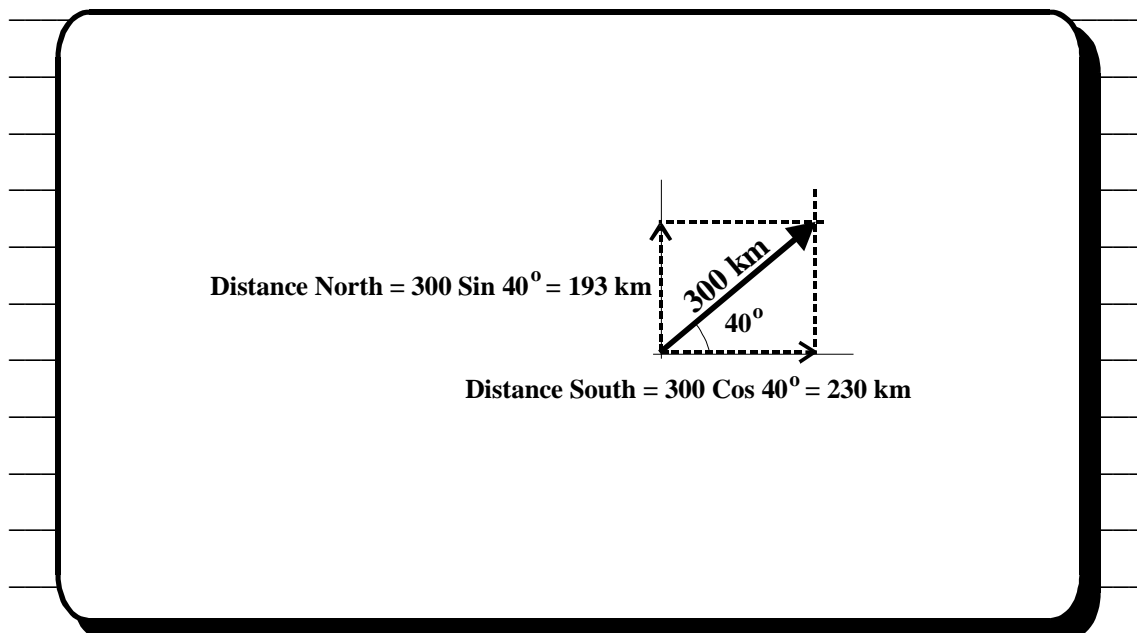
7. An electron in the picture tube of a television set is subjected to a magnetic force of 2.6×10^{-24} N acting horizontally and an electric force of 3.0×10^{-24} N acting vertically. What is the magnitude of the resulting force acting on the electron?   [4.0×10^{-24} N] What is the equilibriant force?   [4.0×10^{-24} N, $49°$ S of W]

$$F_R^2 = F_H^2 + F_V^2 = (2.6 \times 10^{-24})^2 + (3.0 \times 10^{-24})^2 \;\; \therefore \;\; F_R = 4.0 \times 10^{-24} \text{ N}$$

$$\text{Tan A} = \frac{3.0 \times 10^{-24}}{2.6 \times 10^{-24}} = 1.1538 \quad \therefore \;\; A = 49°$$

3.0 x 10^{-24} N

F_R = 4.0 x 10^{-24} N

49°

49°

2.6 x 10^{-24} N

F_E = 4.0 x 10^{-24} N

Answer: 4.0×10^{-24} N, $49°$ South of West

8. A heavy box is pulled across a wooden floor with a rope. The rope forms an angle of $60°$ with the floor. A tension of 80 N is maintained on the rope. What force pulls the box horizontally along the floor?   [40 N in the direction of its motion] What horizontal force would place the box at rest?   [40 N opposite its motion]

80 N

60°

$F_H = F_R = 80 \text{ Cos } 60° = 40 \text{ N}$ $F_E = 40 \text{ N}$
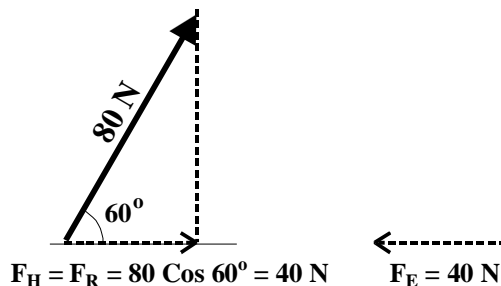
9. Two kids pull at opposite ends of a cord each with a force of 75 N.

a) What is the resultant force? **Zero (0)**

b) What is the tension in the cord? **75 N**

10. Determine the equilibriant of the three forces acting on an object as indicated in the diagram. [41.4 N North]

100 N

100 N

100 N

35°

100 N

Find the vertical components of these two diagonal forces.

The horizontal components of these diagonals cancel each other.

135°

135°

90°

100 N

100 N

45°

45°

←100 Cos 45° = 70.7 N

—100 Cos 45° = 70.7 N

F_R = 2(70.7 N) South - 100 N North = 41.4 N South

Answer: F_E = 41.4 N North

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