



# Mechanical Engineering

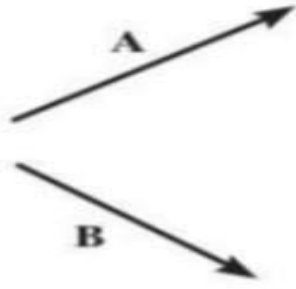
**ASST.LEC. Zahraa Hussein Jassim**

**Class: 1 st**

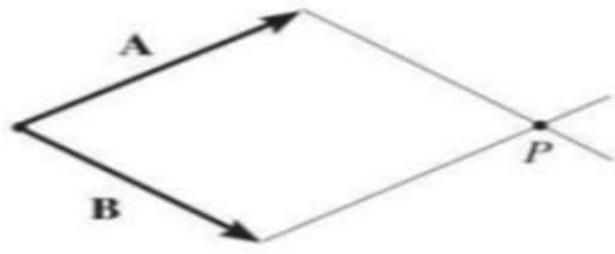
**2025 - 2026**

# Vector Addition of Forces

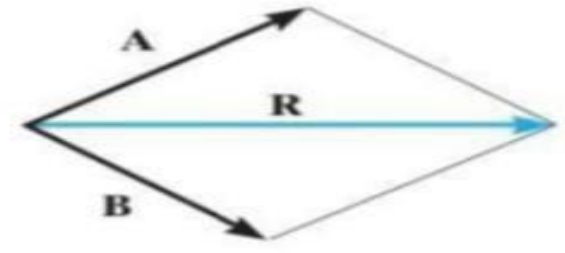
Experimental evidence has shown that a force is a vector quantity since it has a specified magnitude, direction, and sense and it adds according to the parallelogram law. Two common problems in statics involve either finding the resultant force, knowing its components, or resolving a known force into two components. We will now describe how each of these problems is solved using the parallelogram law.



(a)

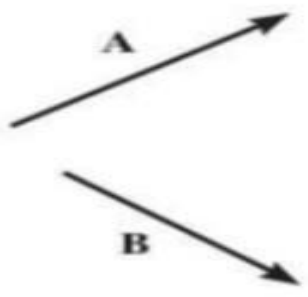


(b)

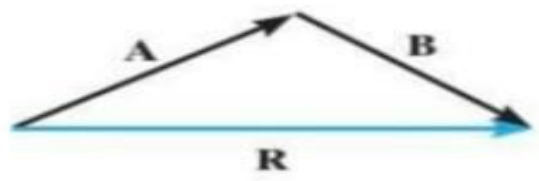


$R = A + B$   
Parallelogram law

(c)

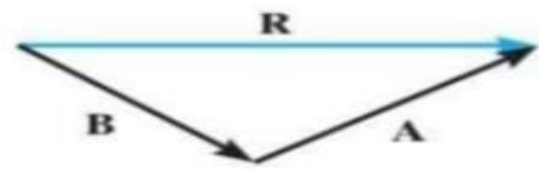


(a)



$R = A + B$   
Triangle rule

(b)



$R = B + A$   
Triangle rule

(c)

# Trigonometry

Redraw a half portion of the parallelogram to illustrate the triangular head-to-

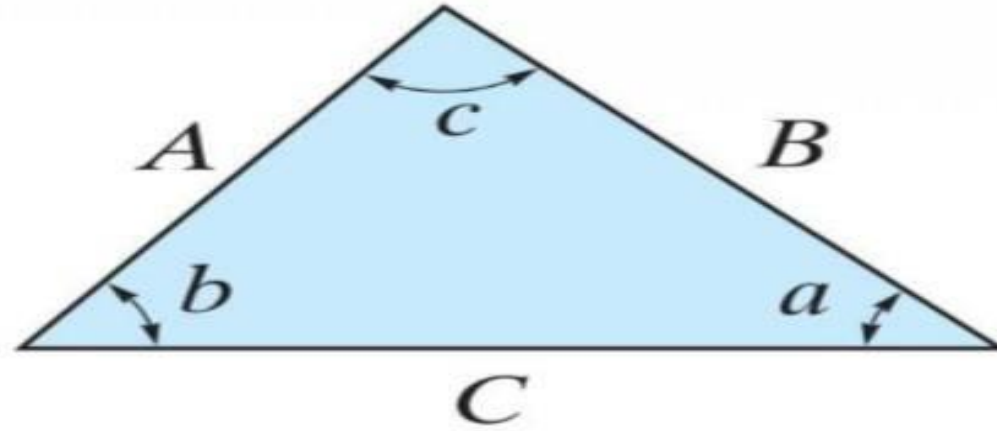
tail addition of the components.

From this triangle, the magnitude of the resultant force can be determined using the

law of cosines, and its direction is determined from the law of sines.

The magnitudes

of two force components are determined from the law of sines



Cosine law:

$$C = \sqrt{A^2 + B^2 - 2AB \cos c}$$

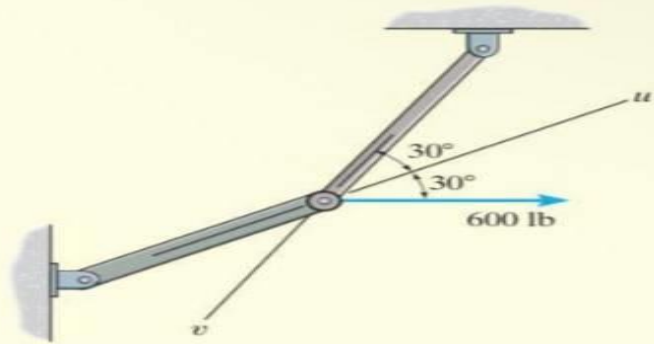
Sine law:

$$\frac{A}{\sin a} = \frac{B}{\sin b} = \frac{C}{\sin c}$$

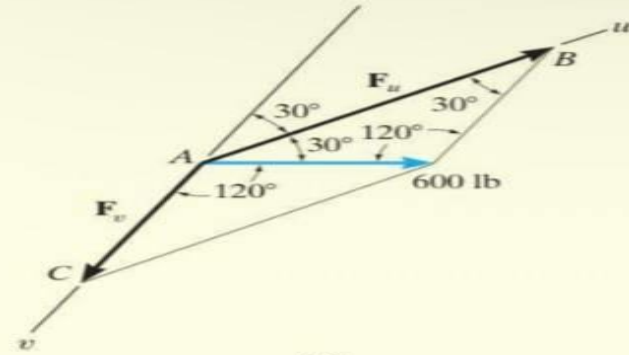
# Example 1

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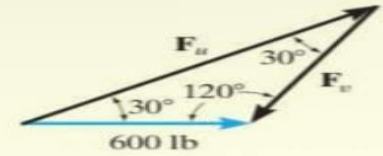
- Resolve the horizontal 600-lb force in Fig, into components acting along the  $u$  and
- $v$  axes and determine the magnitudes of these components.



(a)



(b)



(c)

$$\frac{F_u}{\sin 120^\circ} = \frac{600 \text{ lb}}{\sin 30^\circ}$$

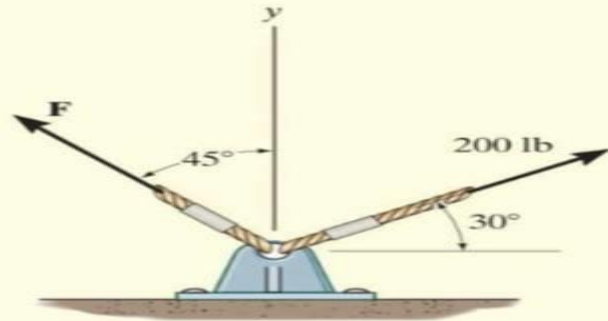
$$F_u = 1039 \text{ lb}$$

$$\frac{F_v}{\sin 30^\circ} = \frac{600 \text{ lb}}{\sin 30^\circ}$$

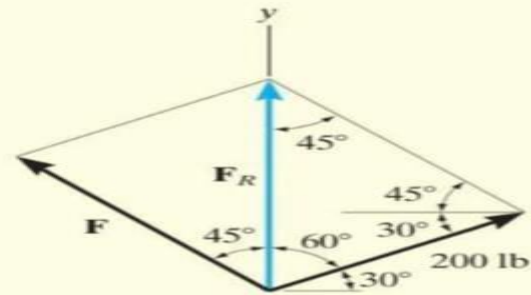
$$F_v = 600 \text{ lb}$$

## Example 2

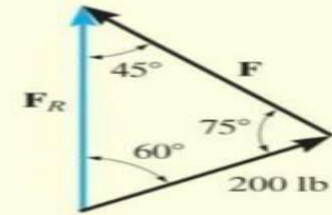
- Determine the magnitude of the component force  $F$  in Fig and the magnitude of the
- resultant force  $F_R$  if  $F_R$  is directed along the positive  $y$  axis.



(a)



(b)



(c)

$$\frac{F}{\sin 60^\circ} = \frac{200 \text{ lb}}{\sin 45^\circ}$$

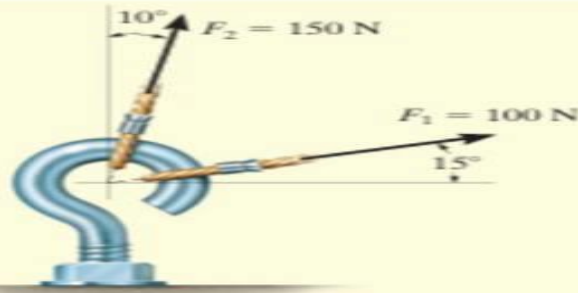
$$F = 245 \text{ lb}$$

$$\frac{F_R}{\sin 75^\circ} = \frac{200 \text{ lb}}{\sin 45^\circ}$$

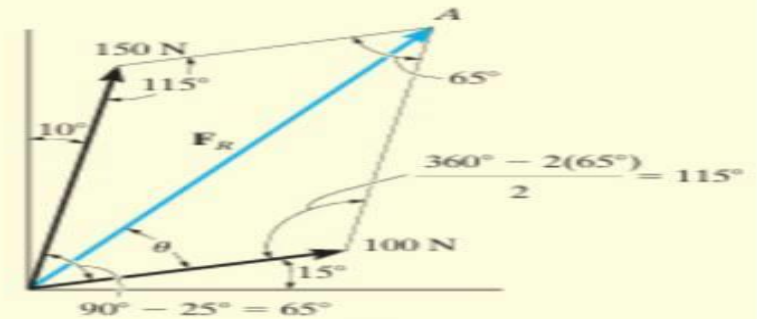
$$F_R = 273 \text{ lb}$$

## Example 3

- The screw eye in Fig. 2–11 a is subjected to two forces,  $F_1$  and  $F_2$ . Determine the
- magnitude and direction of the resultant force.



(a)



(b)

**SOLUTION**

**Parallelogram Law.** The parallelogram is formed by drawing a line from the head of  $F_1$  that is parallel to  $F_2$ , and another line from the head of  $F_2$  that is parallel to  $F_1$ . The resultant force  $F_R$  extends to where these lines intersect at point  $A$ , Fig. 2-11b. The two unknowns are the magnitude of  $F_R$  and the angle  $\theta$  (theta).

**Trigonometry.** From the parallelogram, the vector triangle is constructed, Fig. 2-11c. Using the law of cosines

$$\begin{aligned}
 F_R &= \sqrt{(100 \text{ N})^2 + (150 \text{ N})^2 - 2(100 \text{ N})(150 \text{ N}) \cos 115^\circ} \\
 &= \sqrt{10\,000 + 22\,500 - 30\,000(-0.4226)} = 212.6 \text{ N} \\
 &= 213 \text{ N}
 \end{aligned}$$

*Ans*

Applying the law of sines to determine  $\theta$ ,

$$\begin{aligned}
 \frac{150 \text{ N}}{\sin \theta} &= \frac{212.6 \text{ N}}{\sin 115^\circ} & \sin \theta &= \frac{150 \text{ N}}{212.6 \text{ N}} (\sin 115^\circ) \\
 & & \theta &= 39.8^\circ
 \end{aligned}$$

Thus, the direction  $\phi$  (phi) of  $F_R$ , measured from the horizontal, is

$$\phi = 39.8^\circ + 15.0^\circ = 54.8^\circ \quad \textit{Ans}$$

**NOTE:** The results seem reasonable, since Fig. 2-11b shows  $F_R$  to have a magnitude larger than its components and a direction that is between them.

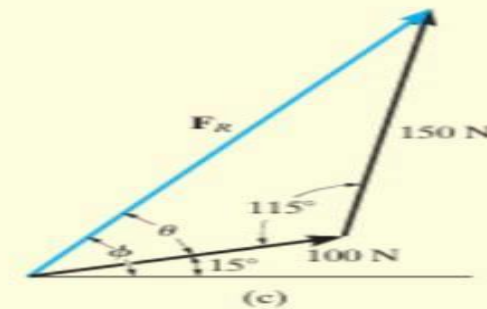


Fig. 2-11

A close-up photograph of a pink rose, showing the delicate layers of its petals. The colors range from light pink to a deeper, more vibrant pink. The rose is positioned on the left side of the slide, partially overlapping the white background.

***Thank you  
for listening***