1. MECHANICS

Mechanics is the physical science which deals with the effects of forces on objects. No other subject plays a greater role in engineering analysis than mechanics.

2. BASIC CONCEPTS

The following concepts and definitions are basic to the study of mechanics, and they should be under stood at the outset.

1- ***Space*** is the geometric region occupied by bodies whose positions are described by linear and angular measurement s relative to a coordinate system. For three-dimensional problems, three independent coordinates are needed. For two-dimensional problems, only two coordinates are required.

2- ***Mass*** is a measure of the amount of matter in an object. Mass is usually measured in grams (g) or kilograms (kg).

3- ***Force*** is the action of one body on another. A force tends to move a body in the direction of its action. The action of a force is characterized by its *magnitude,* by the *direction* of its action, and by its *point of application.* Thus force is a vector quantity.

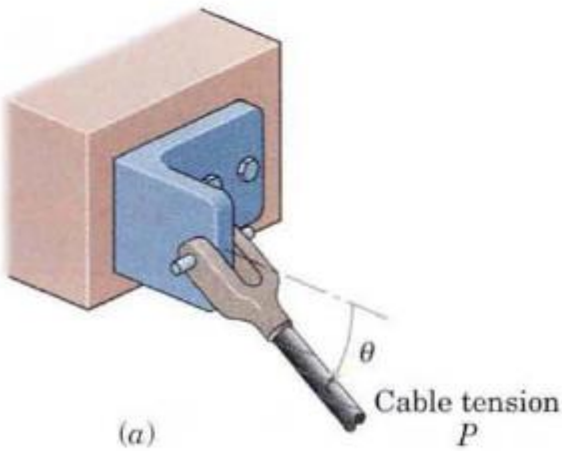
4- ***A particle*** is a body of negligible dimensions. In the mathematical sense, a particle is a body whose dimensions are considered to be near zero so that we may analyze it as a mass concentrated at a point. We often choose a particle as a differential element of a body. We may treat a body as a particle when its dimensions are irrelevant to the description of its position or the action of forces applied to it.

5- ***Rigid body*** A body is considered rigid when the change in distance between any two of its points is negligible for the purpose at hand.

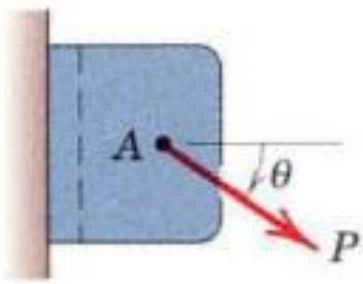
Force System

Definition of 'force' can be given in several ways. Most simply it can be defined as 'the cause of change in the state of motion of a particle or body'.

Before dealing with a group or *system* of forces, it is necessary to examine the properties of a single force in some detail. The action of the cable tension on the bracket in Fig. *1a* is represented in the side view, Fig. *1b*, by the force vector P of magnitude **P**. The effect of this action on the bracket depends on *P*, the angle *θ,* and the location of the point of application A.



(a)

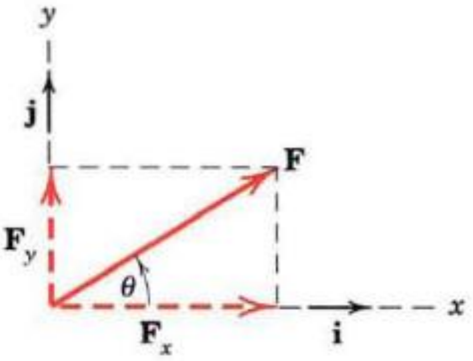


(b)

TWO-DIMENSIONAL FORCE SYSTEMS

RECTANGULAR COMPONENTS

The most common two-dimensional resolution of a force vector is into rectangular components. It follows from the parallelogram rule that the vector F of Fig. may be written as

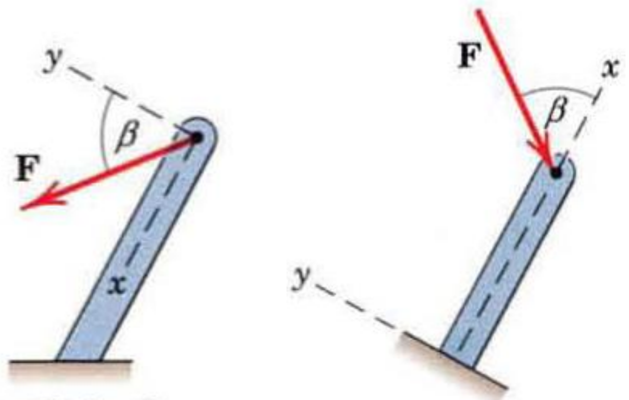


The scalar components can be positive or negative, depending on the quadrant into which F points.

$$F_x = F\cos\theta \qquad F = \sqrt{F_x^2 + F_y^2}$$

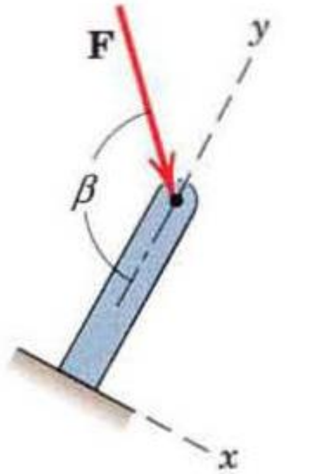
$$F_y = F\sin\theta \qquad \theta = \tan^{-1}\frac{F_y}{F_x}$$

Determining the Components of a Force Dimensions are not always given in horizontal and vertical directions, angles need not be measured counterclockwise from the x-axis, and the origin of coordinates need not be on the line of action of a force.

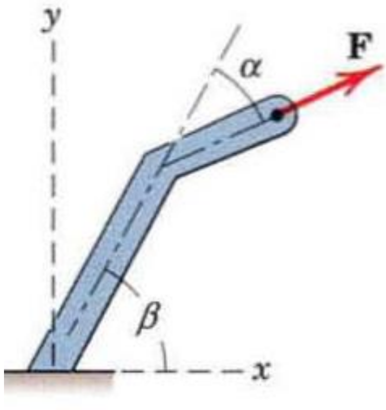


$F_x = F\sin\beta$
$F_y = F\cos\beta$

$F_x = -F\cos\beta$
$F_y = -F\sin\beta$



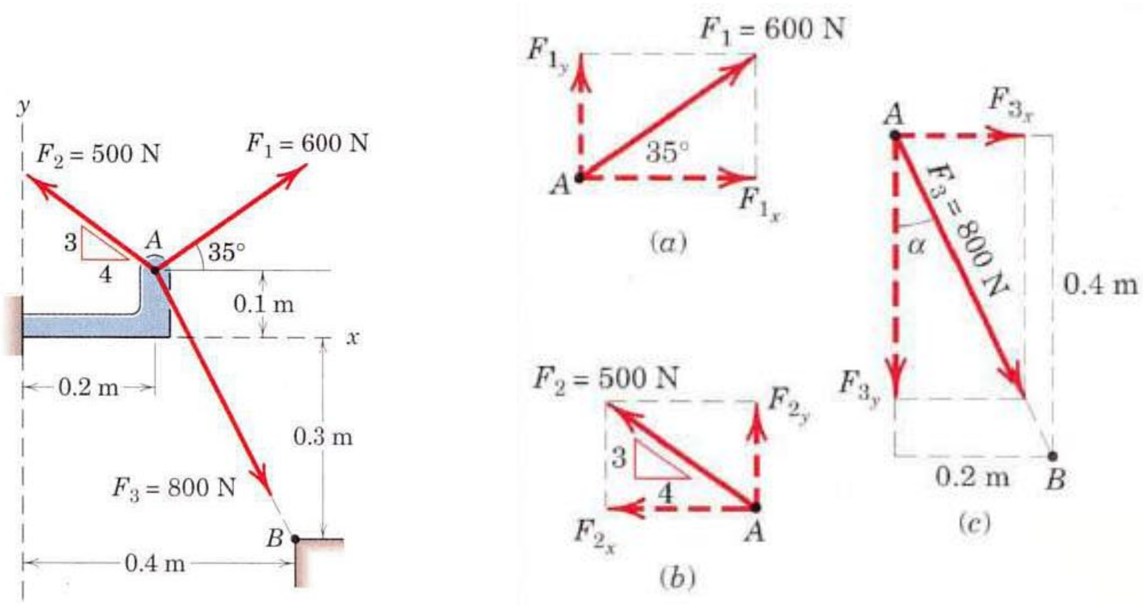
$$F_x = F\sin(\pi - \beta)$$
$$F_y = -F\cos(\pi - \beta)$$



$$F_x = F\cos(\beta - \alpha)$$
$$F_y = F\sin(\beta - \alpha)$$

Problem 1

The forces F1, F2, and F3' all of which act on point *A* of the bracket , are specified in three different ways. Determine the *x* and *y* scalar components of each of the three forces.



Solution : The scalar components of F l ' from Fig. a, are

F_{1x} = 600 cos 35° = 491 N
F_{1y} = 600 sin 35° = 344 N

The scalar components of F2 from Fig. *b*, are

F_{2x}= $-500(\frac{4}{5})$ = -400 N

F_{2y}= $500(\frac{3}{5})$ = 300 N

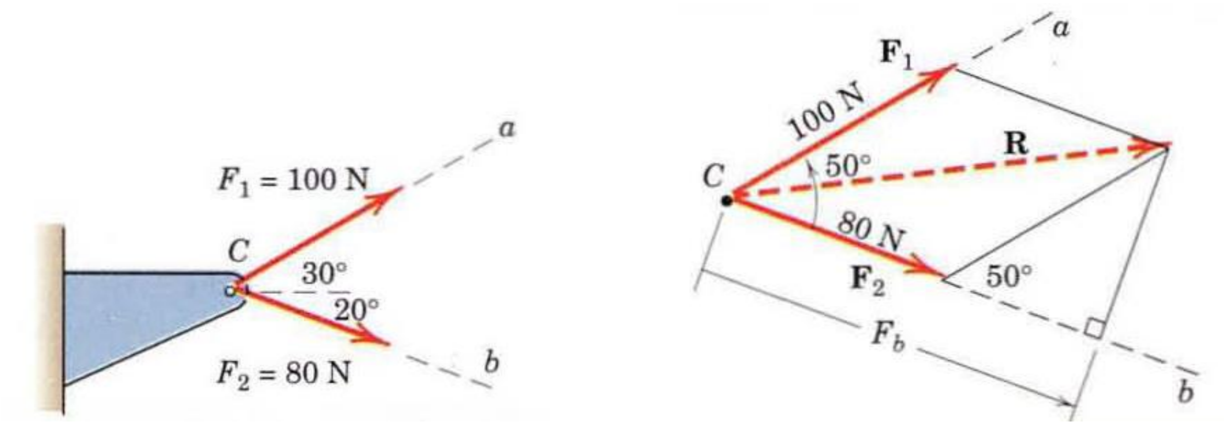
$\alpha = \tan^{-1}[\frac{0.2}{0.4}] = 26.6°$

Then $F_{3x} = F_3 \sin\alpha$ = 800 sin 26.6□□ = 358 N

$F_{3y} = -F_3 \cos\alpha$ = - 800 cos 26.6° = - 716 N

Problem 2

Forces F_1 and F_2 act on the bracket as shown Determine the project ion Fb of their resultant R onto the b-axis.



Solution. The parallelogram addition of F_1 and F_2 is shown in the figure. Using the law of cosines gives us

$R^2 = (80)^2 + (100)^2 - 2(80)(100) \cos 130$

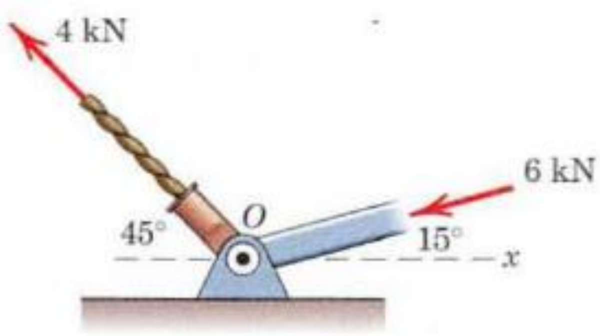
$R = 163.4$ N

The figure also shows the orthogonal projection F_b of R onto the b-axis. Its length is

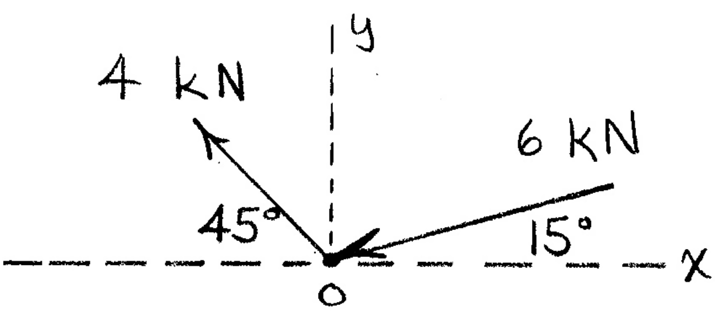
$F_b = 80 + 100 \cos 50 = 144.3$ N

Problem 3

The two structural members, one of which is in tension and the other in compression, exert the indicated forces on joint O. Determine the magnitude of the resultant R of the two forces and the angle θ which R makes with the positive .x-axis.



Solution



$$R_x = \Sigma F_x = -4\cos 45° - 6\cos 15° = -8.62\ \text{kN}$$

$$R_y = \Sigma F_y = 4\sin 45° - 6\sin 15° = 1.276\ \text{kN}$$

$$R = \sqrt{R_x^2 + R_y^2} = \underline{8.72\ \text{kN}}$$

$$\theta = \tan^{-1}\left(\frac{R_y}{R_x}\right) = \tan^{-1}\left(\frac{1.276}{-8.62}\right) = \underline{171.6°}$$