Chapter Three: Equilibrium

3.1 Introduction

The body is said to be in equilibrium if the resultant of all forces acting on it has no resultant (i.e. R = zero).

$$R_x = 0 \quad \Longrightarrow \quad \sum F_x = 0 \ldots\ldots\ldots\ldots\ldots (1)$$

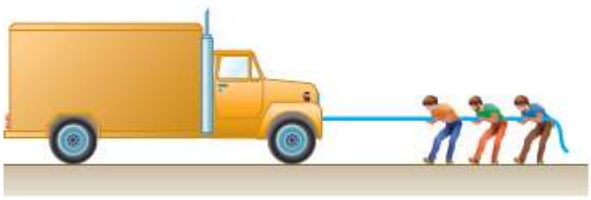
$$R_y = 0 \quad \Longrightarrow \quad \sum F_y = 0 \ldots\ldots\ldots\ldots\ldots (2)$$

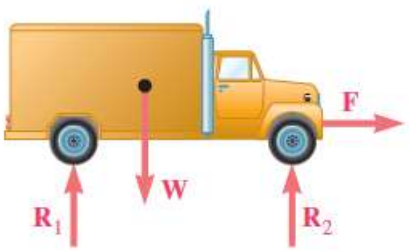
$$\sum M = 0 \ldots\ldots\ldots\ldots\ldots (3)$$

3.1.1 Free Body Diagram (F.B.D)

A free body diagram is a sketch of the mechanical system treated as a single body which is completely isolated or free from its surrounding bodies. The diagram shows all forces applied to the system by mechanical contact with other bodies

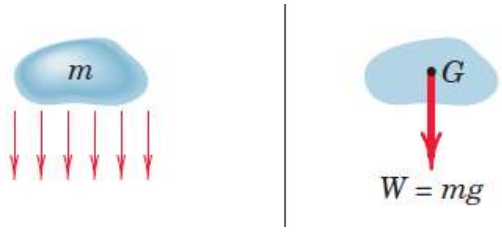
- The free-body diagram is the most important step in the solution of problems in engineering mechanics.
- Two kinds of forces must be shown to act on a free-body; they are external forces, and reactive forces replacing the supports.



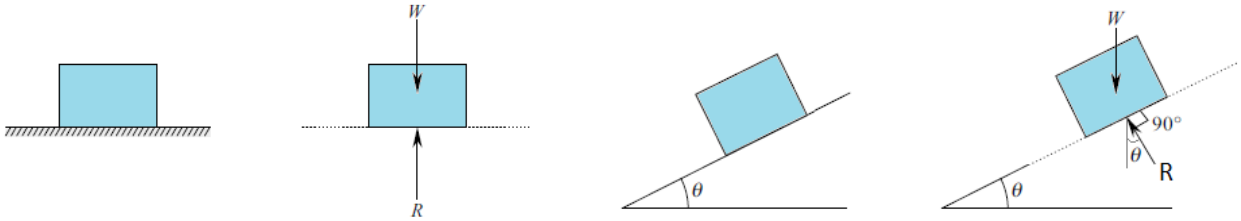


3.1.2 Reactive Forces (Supports)

a) Weight

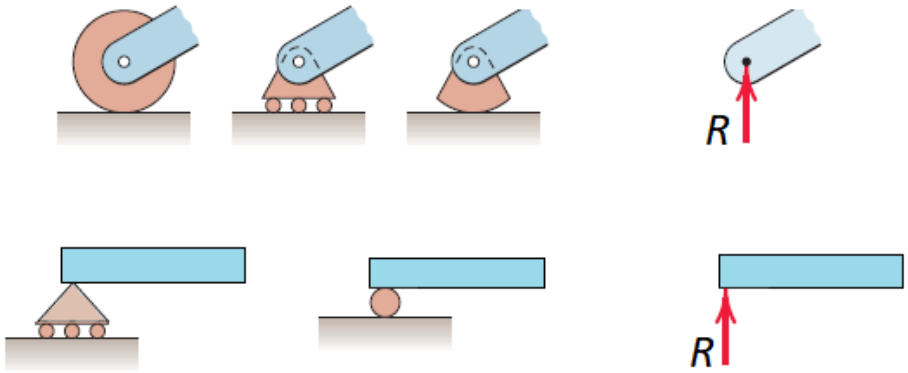


b) Smooth Surface



c) Rods, chains, string and cables

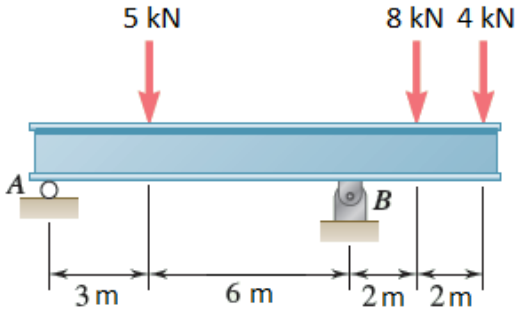
d) Roller support



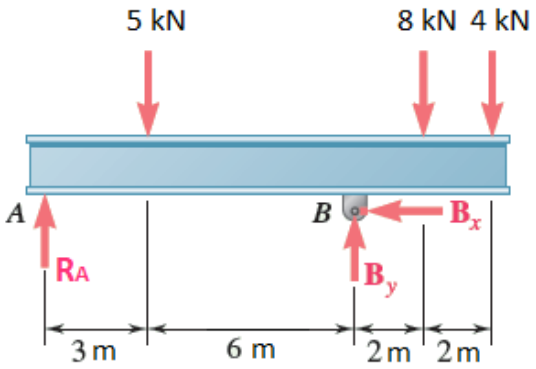
e) Hinge or pin support

f) Fixed or built-in support

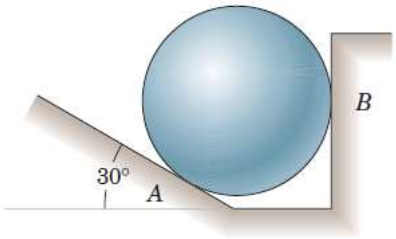
Example No. 1: Draw the free-body diagram of a beam as shown. The beam is supported by a roller at A and by a pin at B.



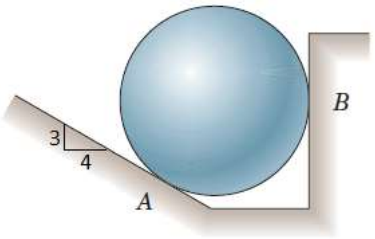
Solution:



Example No. 2: Draw the free-body diagram of ball resting in a surface as shown in Figure. Assume all contact surfaces to be smooth.

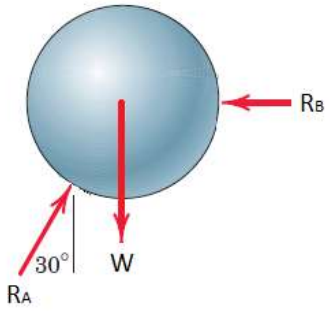


(a)

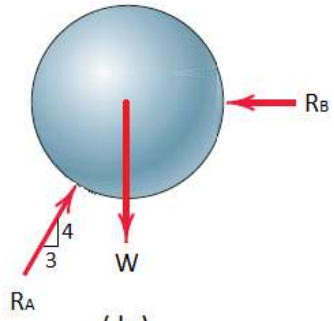


(b)

Solution:

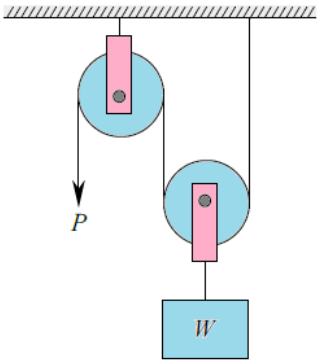


(a)

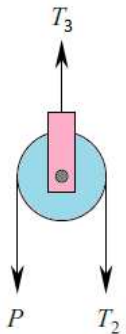


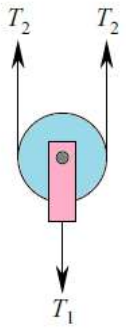
(b)

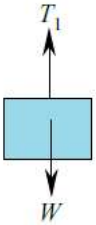
Example No. 3: Draw free-body diagrams of pulleys, block and cable in the arrangement shown. The weights of the pulleys can be neglected**.**



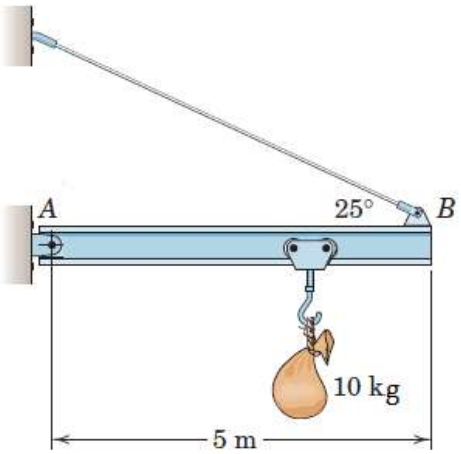
Solution:



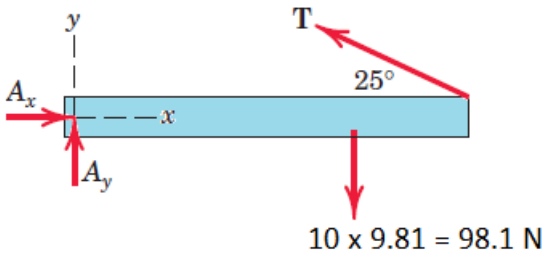




Example No. 4: Draw the free-body diagram of the beam which supports the 10-kg load and is supported by the pin at *A* and a cable at B.

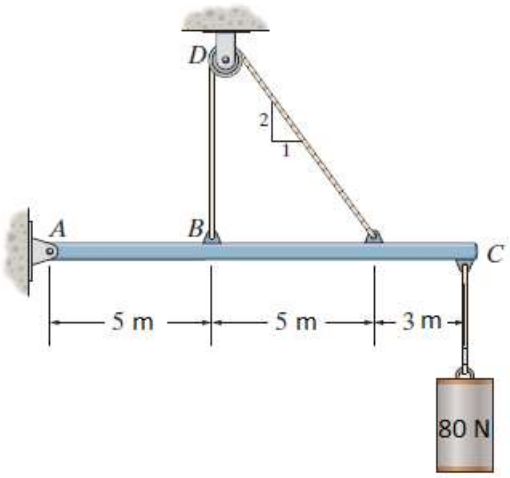


Solution:

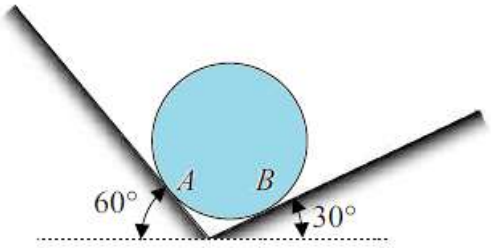


Problem:

1. Draw the free-body diagram of the beam which supports the 80 N load and is supported by the pin at *A* and a cable which wraps around the pulley at *D*.



2. Draw free-body diagram (FBD) for a cylinder of weight 600 N rests in a surface as shown in Figure.



3. Draw free-body diagram (FBD) for the system shown in Figure so that the indicated weights in equilibrium.