



## 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.  $R = \text{zero}$ ).

$$R_x = 0 \quad \Rightarrow \quad \sum F_x = 0 \dots\dots\dots (1)$$

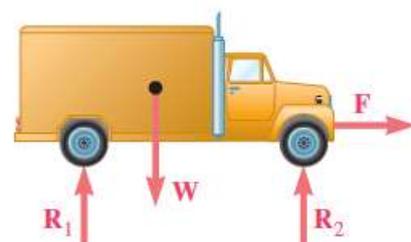
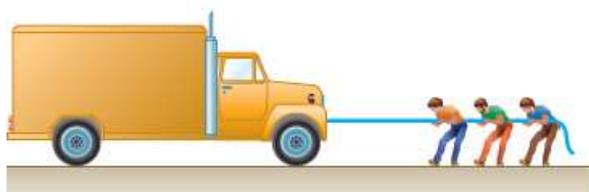
$$R_y = 0 \quad \Rightarrow \quad \sum F_y = 0 \dots\dots\dots (2)$$

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

#### 3.1.1 Free Body Diagram (F.B.D)

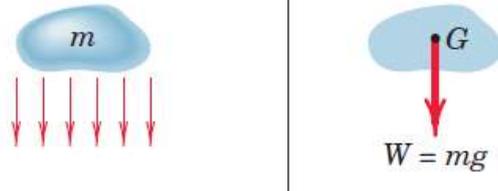
A free body diagram is a sketch of the mechanical system treated as a single body which is completely isolated or free from its surrounding bodies. The diagram shows all forces applied to the system by mechanical contact with other bodies

- 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.

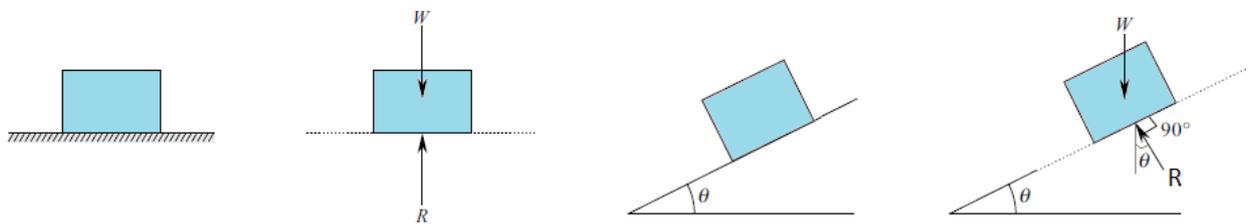


### 3.1.2 Reactive Forces (Supports)

#### a) Weight



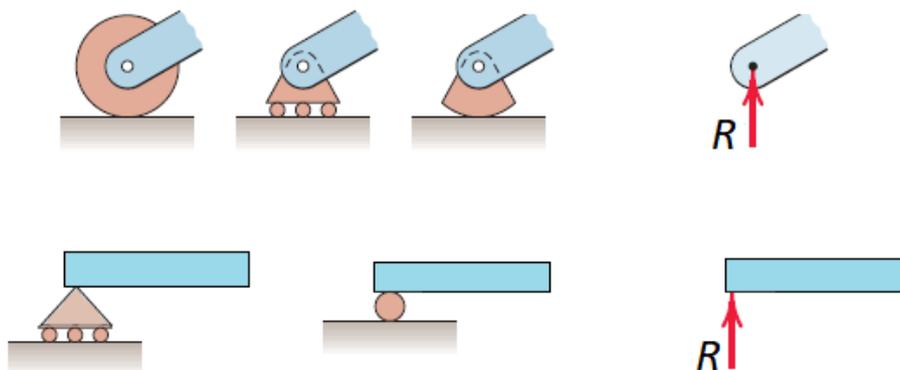
#### b) Smooth Surface



#### c) Rods, chains, string and cables



#### d) Roller support



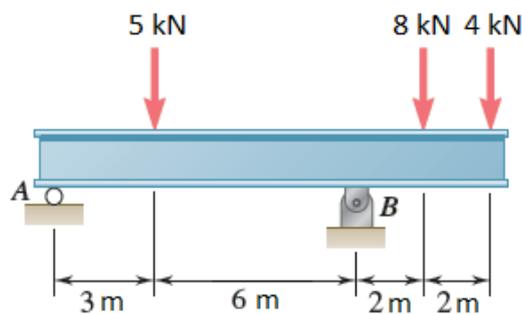
e) Hinge or pin support



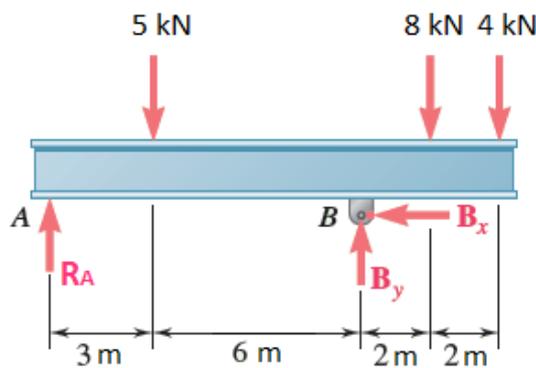
f) Fixed or built-in support



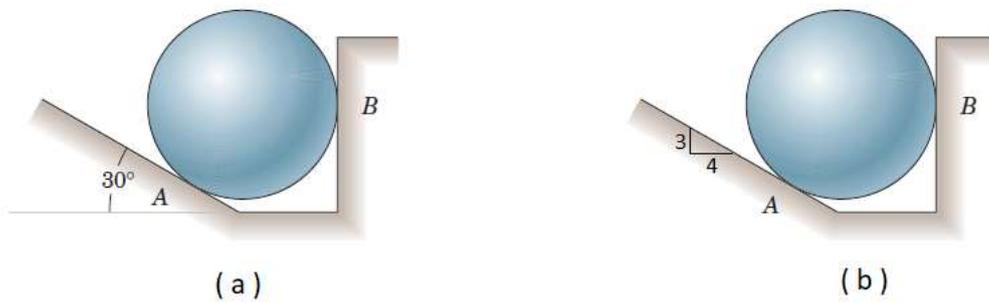
**Example No. 1:** Draw the free-body diagram of a beam as shown. The beam is supported by a roller at A and by a pin at B.



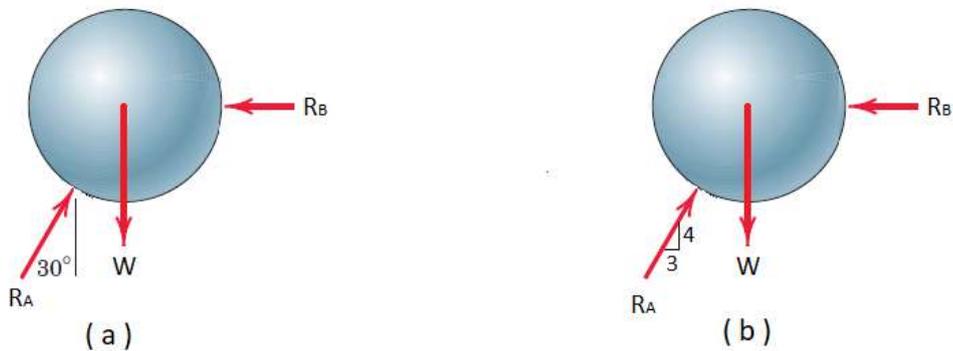
**Solution:**



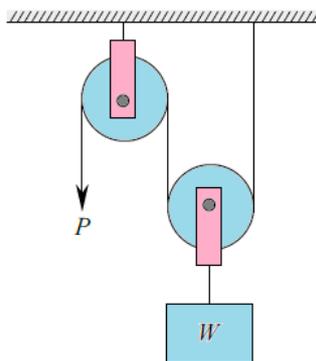
**Example No. 2:** Draw the free-body diagram of ball resting in a surface as shown in Figure. Assume all contact surfaces to be smooth.



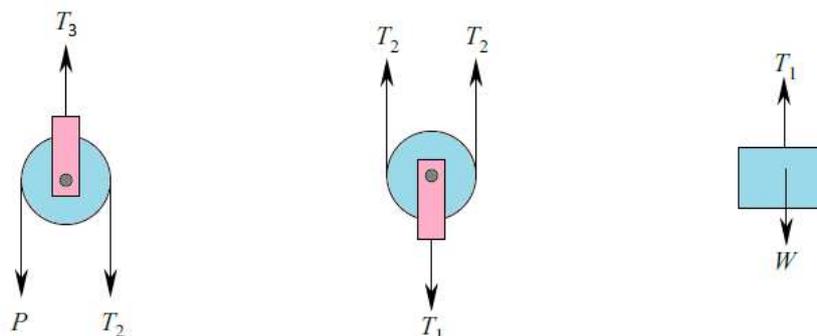
**Solution:**



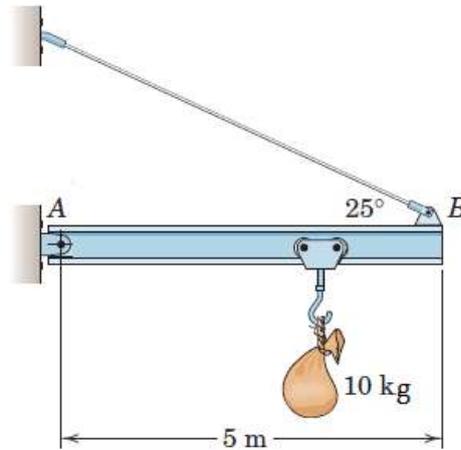
**Example No. 3:** Draw free-body diagrams of pulleys, block and cable in the arrangement shown. The weights of the pulleys can be neglected.



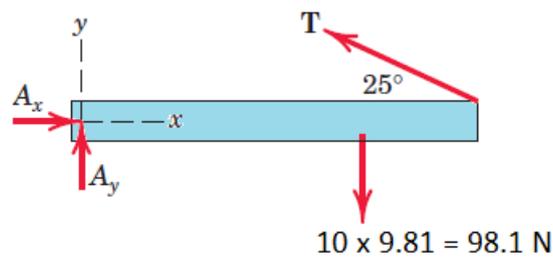
**Solution:**



**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.

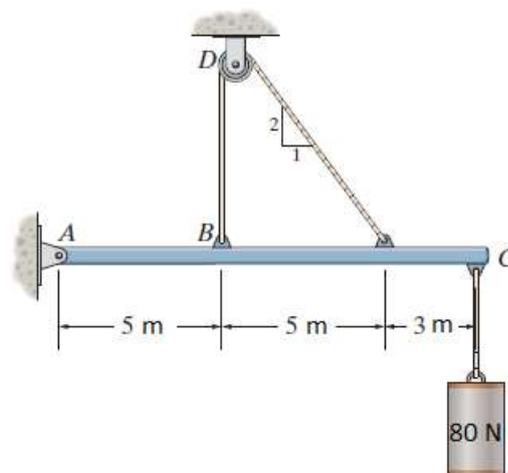


**Solution:**

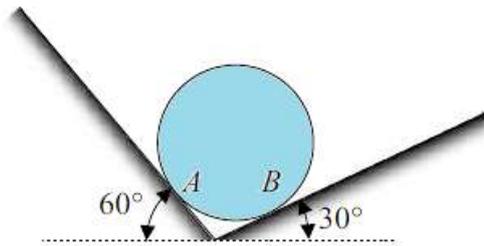


**Problem:**

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.

