

Chapter 12

Static Equilibrium



Static Equilibrium



- Static Equilibrium implies the object is at rest (static)
- Static equilibrium is a common situation in engineering
- Principles involved are of particular interest to civil engineers, architects, and mechanical engineers

Conditions for Equilibrium



- The net force equals zero
 - $\sum \vec{F} = 0$
 - If the object is modeled as a particle, then this is the only condition that must be satisfied
- The net torque equals zero
 - $\sum \vec{\tau} = 0$
 - This is needed if the object cannot be modeled as a particle
- These conditions describe the rigid objects in equilibrium analysis model

Equilibrium Equations



- We will restrict the applications to situations in which all the forces lie in the xy plane
 - These are called coplanar forces since they lie in the same plane
- There are three resulting equations
 - $\Sigma F_x = 0$
 - $\Sigma F_y = 0$
 - $\Sigma \tau = 0$

Axis of Rotation for Torque Equation

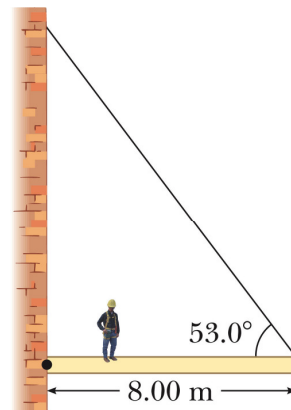


- The net torque is about an axis through any point in the xy plane
- The choice of an axis is arbitrary

Horizontal Beam Example



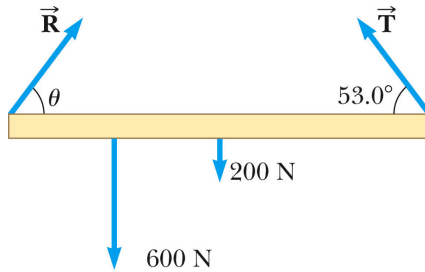
- The beam is uniform
 - So the center of gravity is at the geometric center of the beam
- The person is standing on the beam
- What are the tension in the cable and the force exerted by the wall on the beam?



Horizontal Beam Example, 2



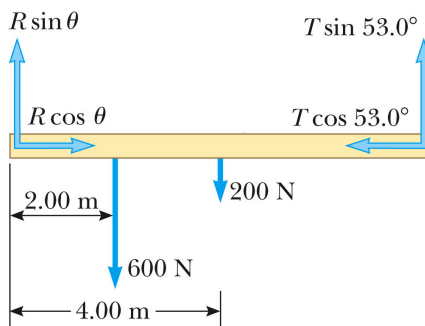
- Analyze
 - Draw a free body diagram
 - Use the pivot in the problem (at the wall) as the pivot
 - This will generally be easiest
 - Note there are three unknowns (T , R , θ)



Horizontal Beam Example, 3

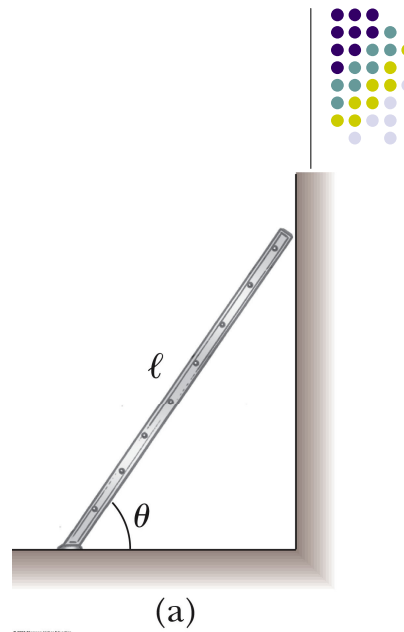


- The forces can be resolved into components in the free body diagram
- Apply the two conditions of equilibrium to obtain three equations
- Solve for the unknowns



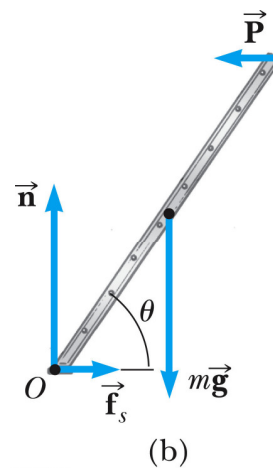
Ladder Example

- The ladder is uniform
 - So the weight of the ladder acts through its geometric center (its center of gravity)
- There is static friction between the ladder and the ground



Ladder Example, 2

- Analyze
 - Draw a free body diagram for the ladder
 - The frictional force is $f_s = \mu_s n$
 - Let O be the axis of rotation
 - Apply the equations for the two conditions of equilibrium
 - Solve the equations

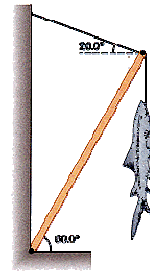




Problem 1

A 10600 N shark is supported by a cable attached to a 4.00 m rod that can pivot at the base.

- Calculate the tension in the tie-rope between the rod and the wall if it is holding the system in the position. (Neglect the weight of the rod.) ans: 5.38 kN
- Find the horizontal force and the vertical force exerted on the base of the rod. 5.06 kN, 8.76 kN



Problem 2

An 85 kg person stands on a uniform 7.4 kg ladder that is 3.9 m long, as shown. The floor is rough; hence it exerts both a normal force, f_1 , and a frictional force, f_2 , on the ladder. The wall, on the other hand, is frictionless; it exerts only a normal force, f_3 . Using the dimensions in the figure, find the magnitudes of f_1 , f_2 , and f_3 . Ans: 906, 162, 162 N.

