

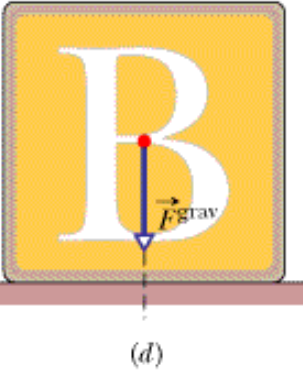
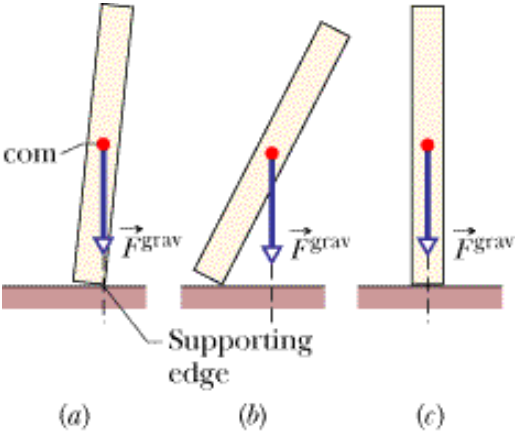
# **Chapter 13 Equilibrium**

**1. Introduction**

**2. Equilibrium**

**3. The Conditions for Equilibrium**

# Introduction



## Equilibrium

A system is in **equilibrium** if following two requirements are satisfied:

$$\vec{P}_{\text{com}} = \text{a constant} \quad \text{and} \quad \vec{L}_{\text{com}} = \text{a constant}.$$

**Static equilibrium** whenever both the translational momentum and rotational momentum of the center of **mass** of the system is zero.

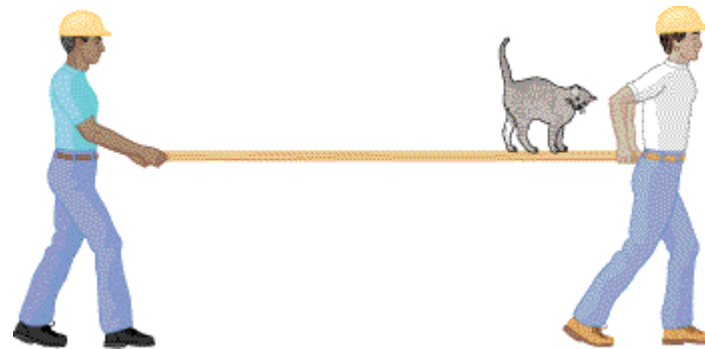
## The Conditions for Equilibrium

**If a body is in equilibrium:** (1) The vector sum of all the external forces that act on it must be zero; and (2) the vector sum of all the external torques that act on it, measured about *any* possible point, must also be zero.

Balance of Force Components	Balance of Torque Components
$F_x^{\text{net}} = \Sigma F_x = 0$	$\tau_x^{\text{net}} = \Sigma \tau_x = 0$
$F_y^{\text{net}} = \Sigma F_y = 0$	$\tau_y^{\text{net}} = \Sigma \tau_y = 0$
$F_z^{\text{net}} = \Sigma F_z = 0$	$\tau_z^{\text{net}} = \Sigma \tau_z = 0$

### TOUCHSTONE EXAMPLE 13-1: Cat on a Plank

Two workmen are carrying a 6.0-m-long plank as shown in Figure. The plank has a **mass** of 15 kg. A cat, with a mass of 5.0 kg, jumps on the plank and hangs on, 1.0 m from the end of the plank. Assuming that the workers are walking at a constant velocity, how much **force** does each workman have to exert to hold the plank up?



### TOUCHSTONE EXAMPLE 13-2: Fireman on a Ladder

In Figure *a*, a ladder of length  $L = 12$  m and mass  $m = 45$  kg leans against a slick (frictionless) wall. Its upper end is at height  $h = 9.3$  m above the pavement on which the lower end rests (the pavement is not frictionless). The ladder's center of mass is  $L/3$  from the lower end. A firefighter of mass  $M = 72$  kg climbs the ladder until her center of mass is  $L/2$  from the lower end. What then are the magnitudes of the forces on the ladder from the wall and the pavement?

