ENSC 2113
Engineering Mechanics: Statics

Chapter 3:

Equilibrium of a Particle

(Section 3.1-3.3)

COLLEGE OF
ENGINEERING, ARCHITECTURE
AND TECHNOLOGY

Chapter 3 Outline:

3.1 Condition for the Equilibrium of a Particle

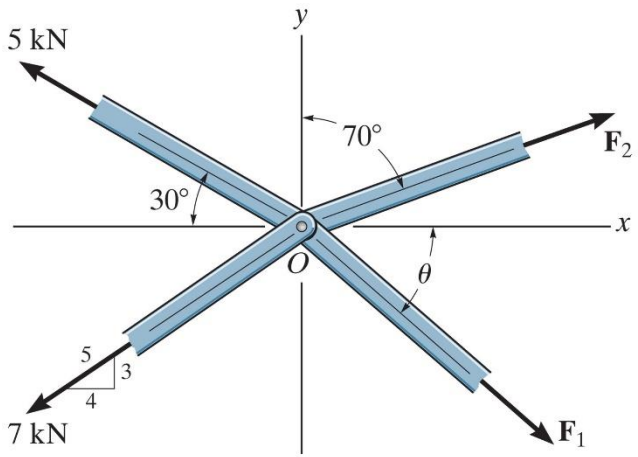
3.2 The Free-Body Diagram

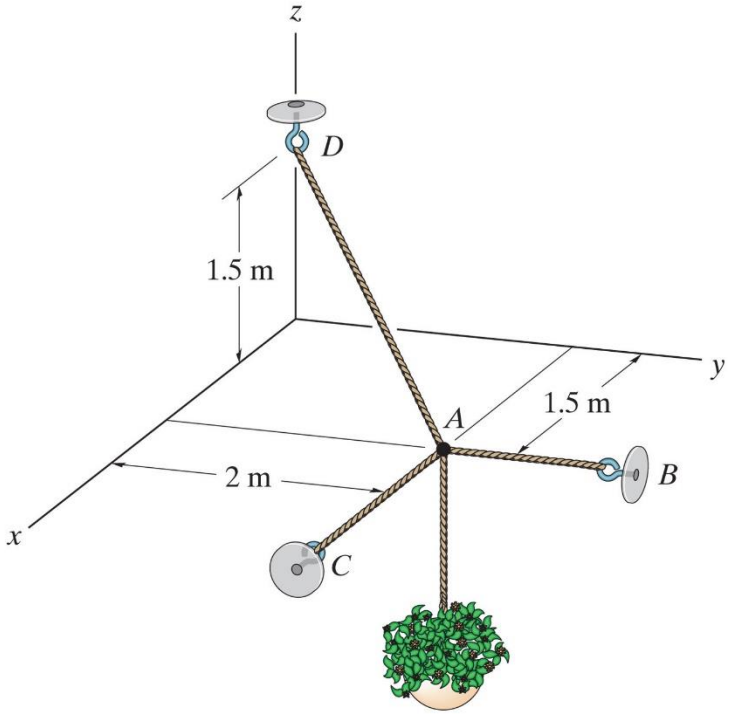
3.3 Coplanar Force Systems

3.4 Three-Dimensional Force Systems

Chapter 3 Objectives:

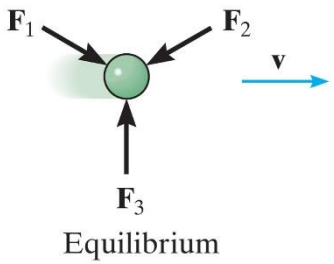
- To introduce the concept of the free-body diagram for a particle
- To show how to solve particle equilibrium problems using the equations of equilibrium





Introduction:

Equilibrium: When an object remains at rest or at constant velocity if already in motion.



Equilibrium

Newton's first law of motion requires the resultant force of a particle in equilibrium to be equal to zero.

$$\sum F = 0$$

Accelerated motion

Newton's second law of motion states that a particle subjected to an unbalanced force experiences an acceleration.

$$\sum F = m\cancel{a}^{0} = 0$$

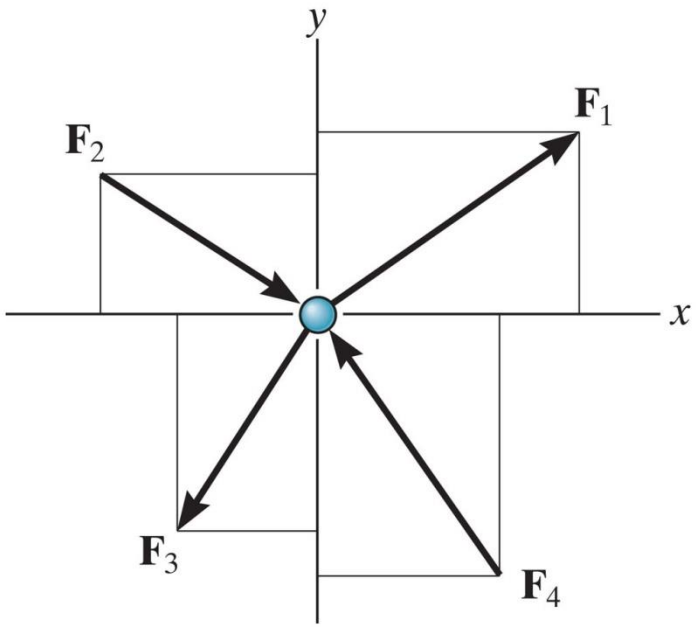
However, in equilibrium, acceleration is zero.

3.1 Equilibrium of a particle:

Particle: Any object which may be modeled as a concentrated point or mass.

Size and shape do not influence applied forces.

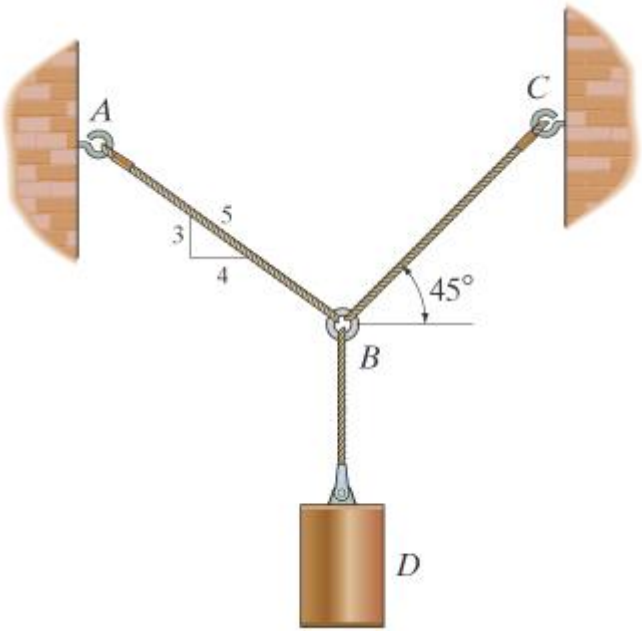
Forces applied to a particle must be "c*oncurrent*", with *line of action* passing through a common point.

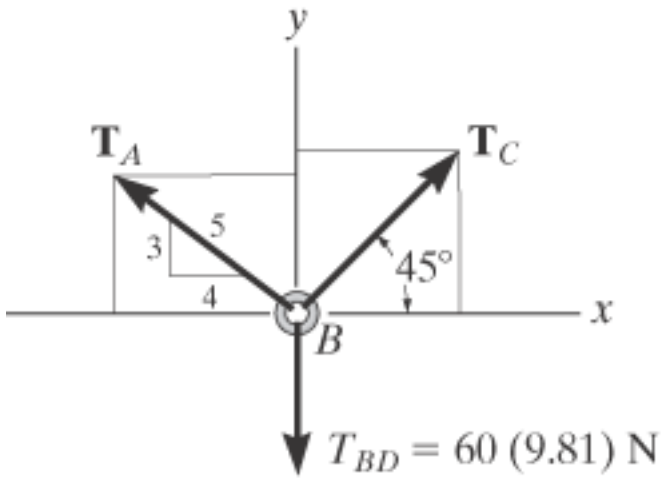


3.2 The Free-body Diagram:

Free-body diagram:

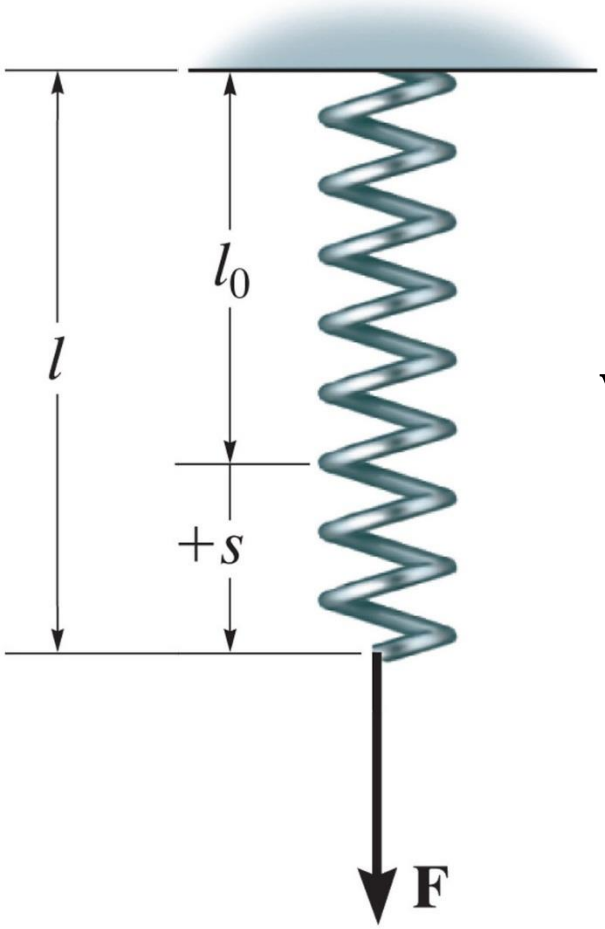
- A drawing that shows the particle as isolated and free from its surroundings
- Includes *all* forces acting on the particle





3.2 The Free-body Diagram:

- Springs: The length of a spring will change in direct proportion to the force acting on it.



$$F = ks$$

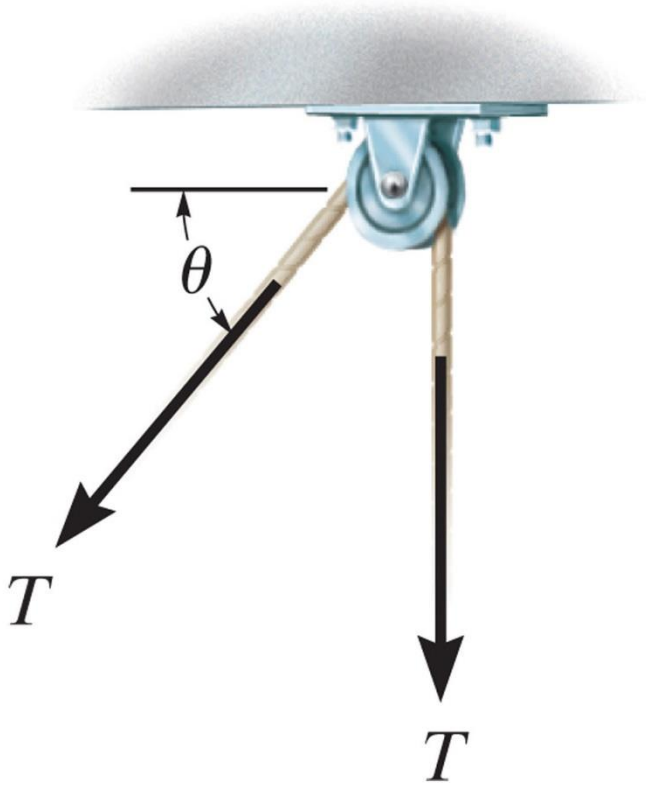
where,

$k =$ spring constant

$$s = l - l_0$$

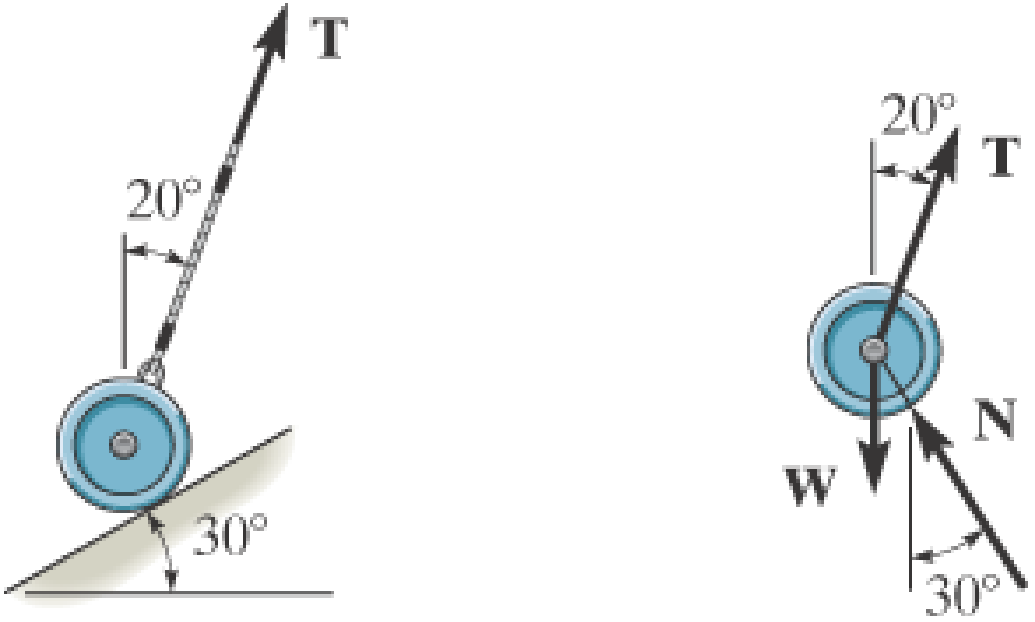
3.2 The Free-body Diagram:

- Cables and Pulleys: All cables will be assumed to have negligible weight and cannot stretch. Cables can support tension only (pulling force). Cables have constant magnitude as they pass over pulleys.



3.2 The Free-body Diagram:

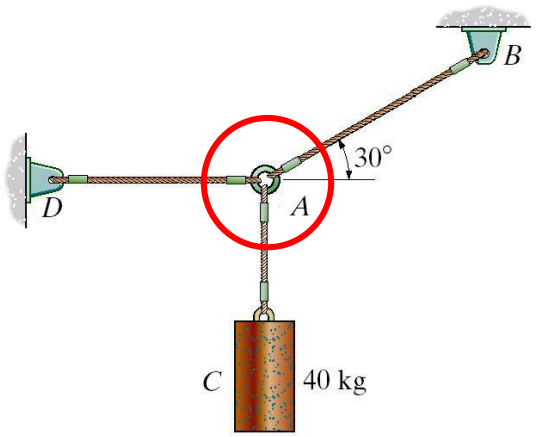
- Smooth Contact: If an object rests on a smooth surface, the surface will exert a force on the object normal to the surface at the point of contact



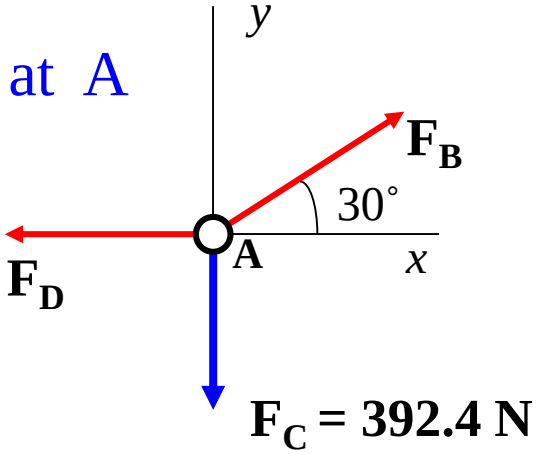
3.2 The Free-body Diagram:

Procedure:

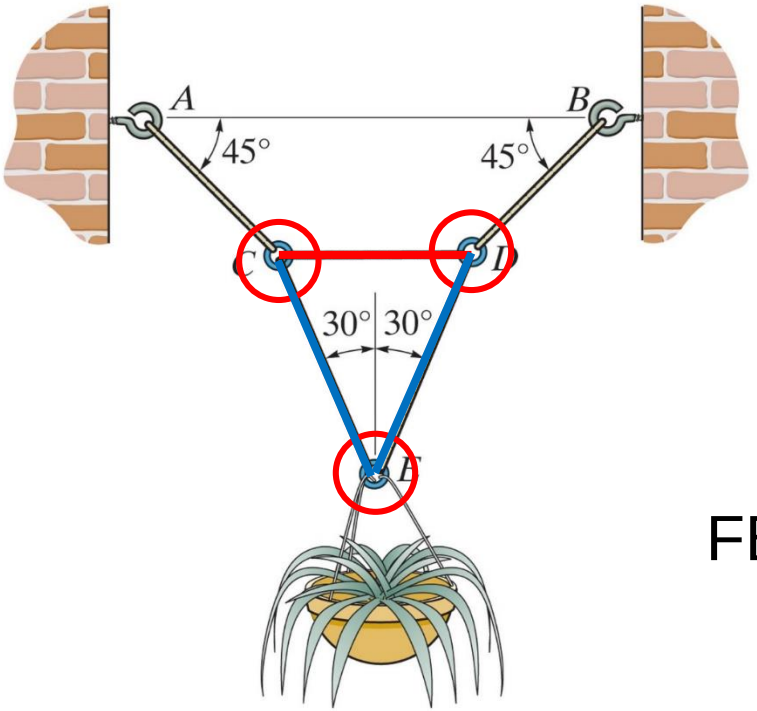
- Draw the Outlined Shape
  - Isolate the system by removing the supports and drawing the outlined shape
- Show All Forces
  - Active forces that set the particle in motion
  - Reactive forces that prevent motion
- Identify Each Force
  - Knowns
  - Unknowns



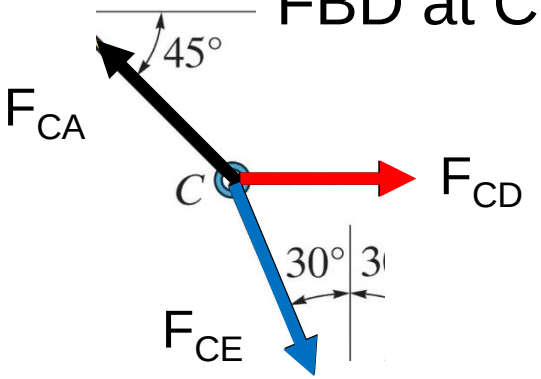
FBD at A

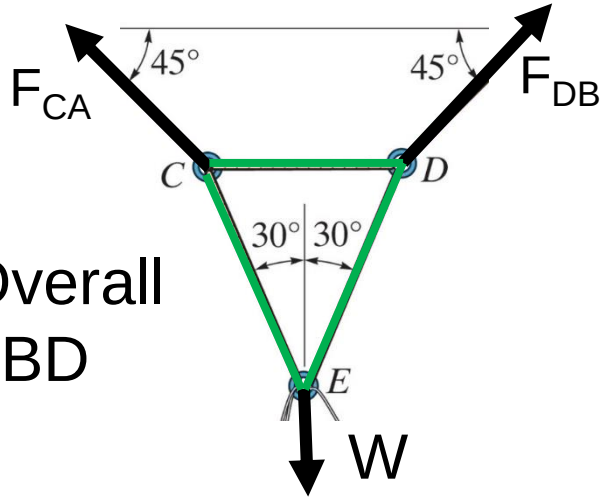


For some problems, multiple FBDs will be required to solve.



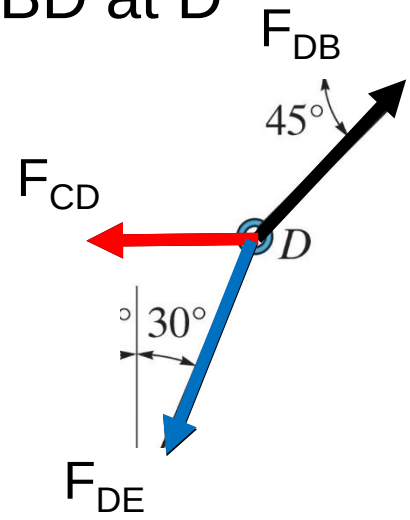
FBD at C



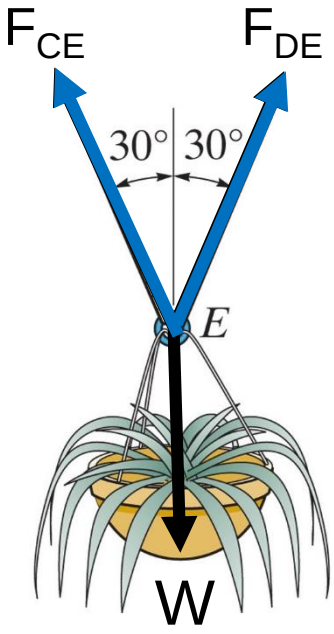


Overall FBD

FBD at D



FBD at E



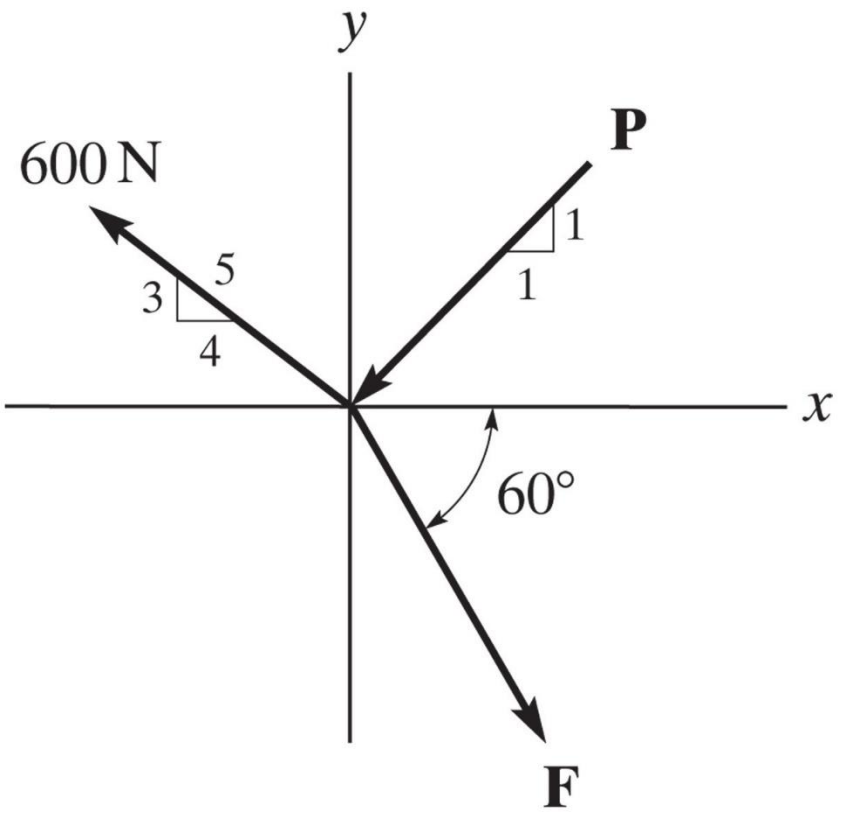
Equilibrium:

Equations in 2-D:

- With two equations, two unknowns can be solved

$$\sum F_x = 0$$

$$\sum F_y = 0$$



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