ENSC 2113
Engineering Mechanics: Statics

Chapter 3:

Equilibrium of a Particle

(Section 3.4)

COLLEGE OF
ENGINEERING, ARCHITECTURE
AND TECHNOLOGY

Chapter 3 Outline:

3.1 Condition for the Equilibrium of a Particle

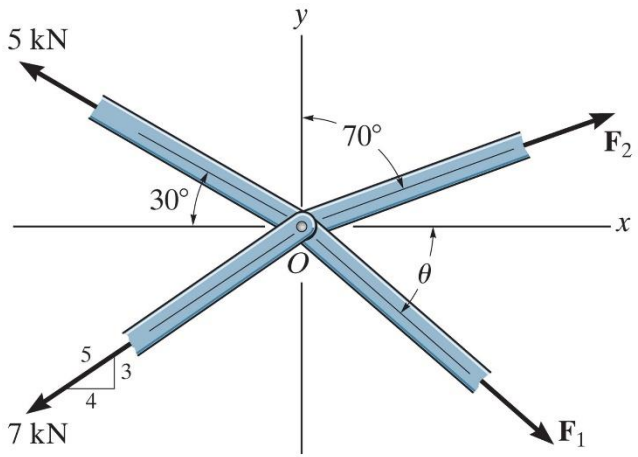
3.2 The Free-Body Diagram

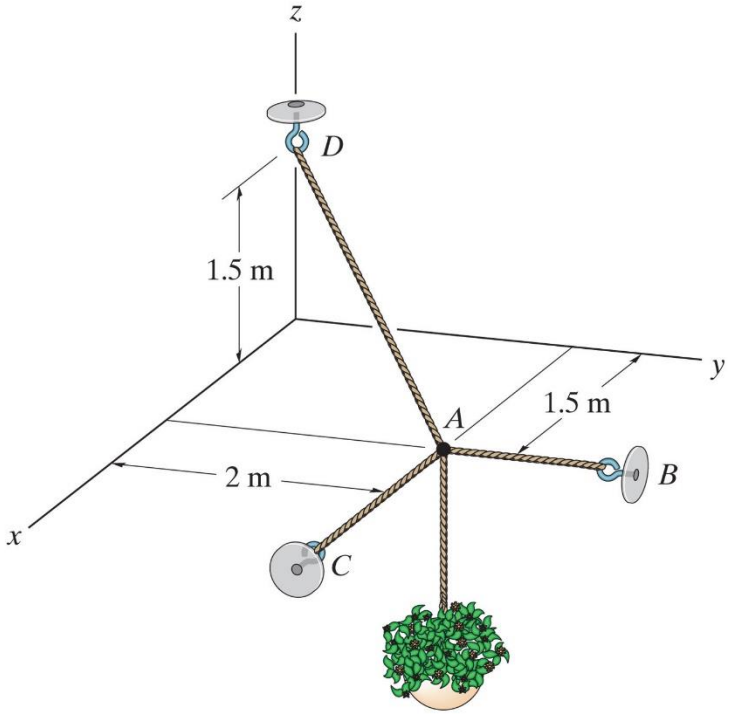
3.3 Coplanar Force Systems

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





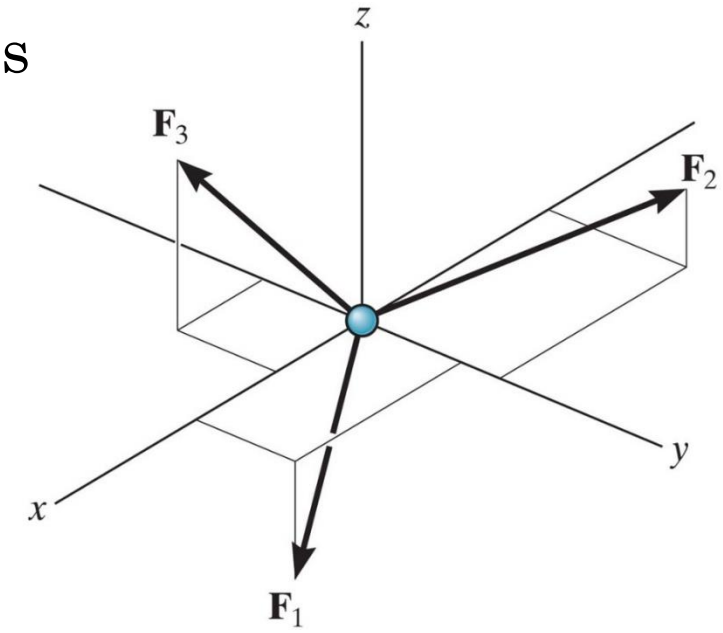
3.4 Three Dimensional Force Systems:

General form of the equilibrium equation:

$$\sum F = 0$$

Three equilibrium equations exist:

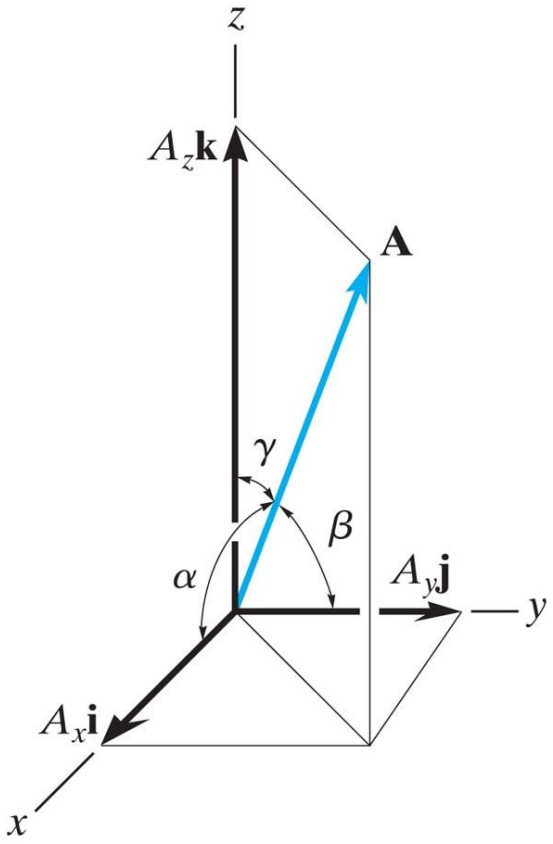
$$\sum F_x = 0$$
$$\sum F_y = 0$$
$$\sum F_z = 0$$



Note: When working on 3-D problems, placing the equations in Cartesian Vector form will greatly simplify the process

3.4 Three Dimensional Force Systems:

Recall from Chapter 2: To write a force in Cartesian form,



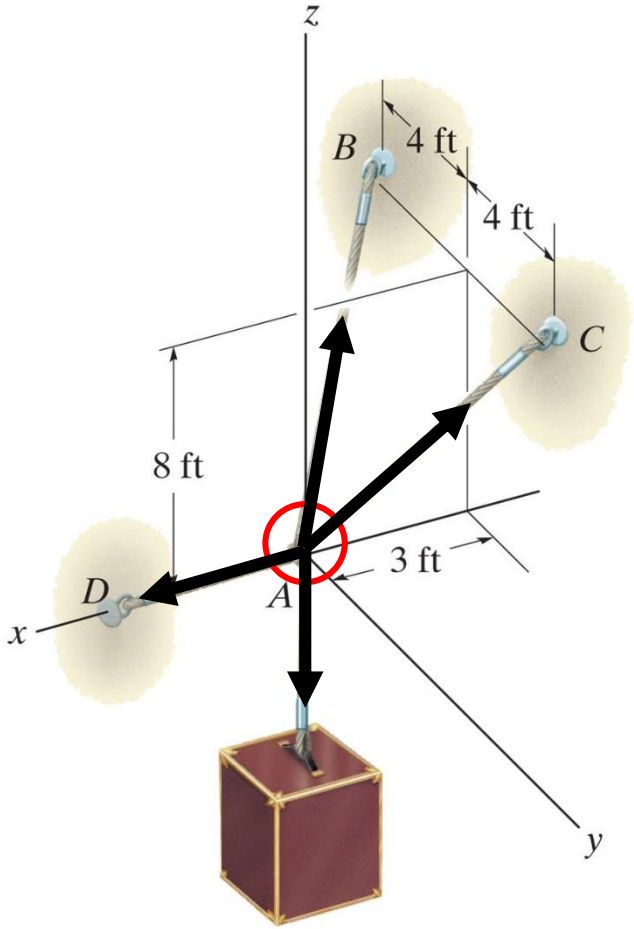
Using the unit vector of the force's line of action:

$$\vec{A} = |A|\vec{u} = |A|\frac{\vec{r}}{|r|}$$

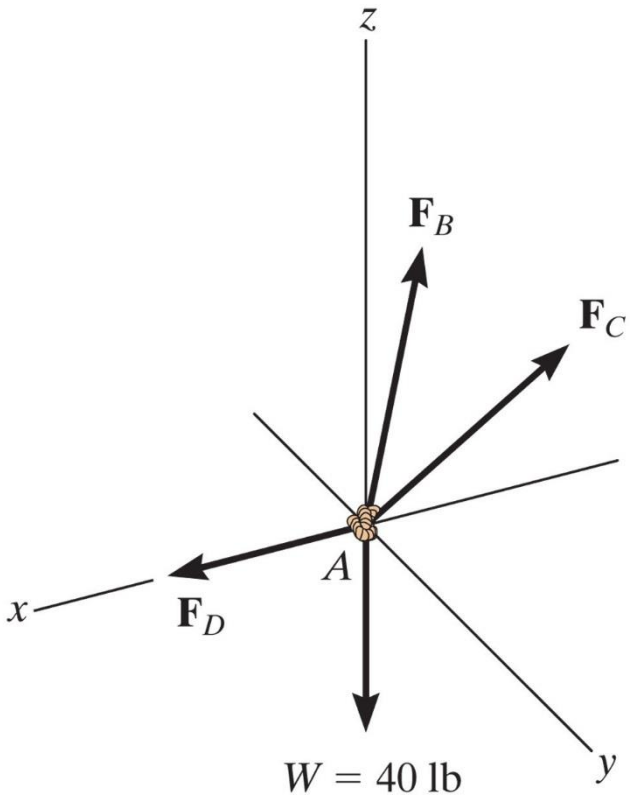
Using the direction cosines:

$$\vec{A} = |A|\vec{u} = |A|\{\cos\alpha\boldsymbol{i} + \cos\beta\boldsymbol{j} + \cos\gamma\boldsymbol{k}\}$$

3.4 Three Dimensional Force Systems:

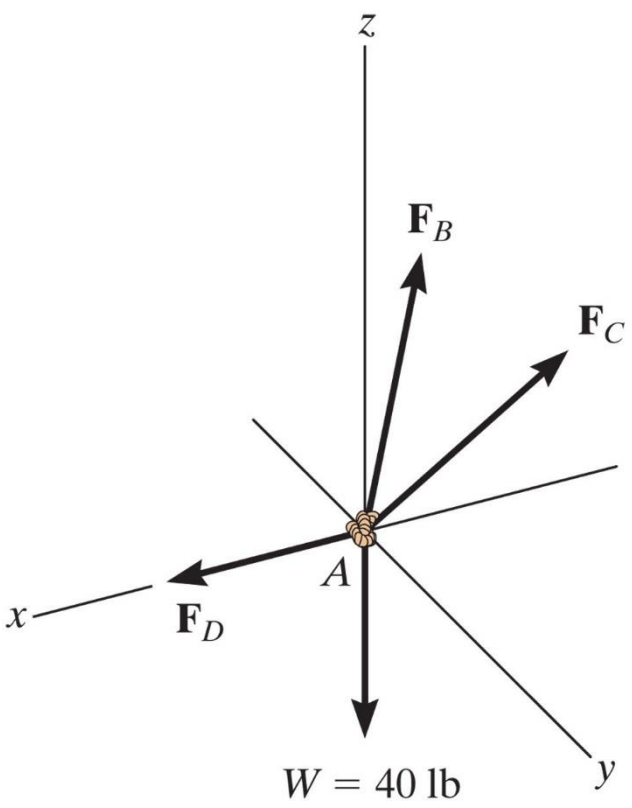


Original System



FBD of System

3.4 Three Dimensional Force Systems:



FBD of System

F_D and W are already in Cartesian Form:

$$\overrightarrow{F_D} = \{F_D\boldsymbol{i} + 0\boldsymbol{j} + 0\boldsymbol{k}\}lb$$

$$\overrightarrow{W} = \{0\boldsymbol{i} + 0\boldsymbol{j} - W\boldsymbol{k}\}lb$$

Unit vectors are utilized to place F_B and F_C in Cartesian Form:

$$\overrightarrow{F_B} = F_B\frac{\overrightarrow{r_{AB}}}{r_{AB}} = \left\{-F_{Bx}\boldsymbol{i} - F_{By}\boldsymbol{j} + F_{Bz}\boldsymbol{k}\right\}lb$$

$$\overrightarrow{F_C} = F_C\frac{\overrightarrow{r_{AC}}}{r_{AC}} = \left\{-F_{Cx}\boldsymbol{i} + F_{Cy}\boldsymbol{j} + F_{Cz}\boldsymbol{k}\right\}lb$$

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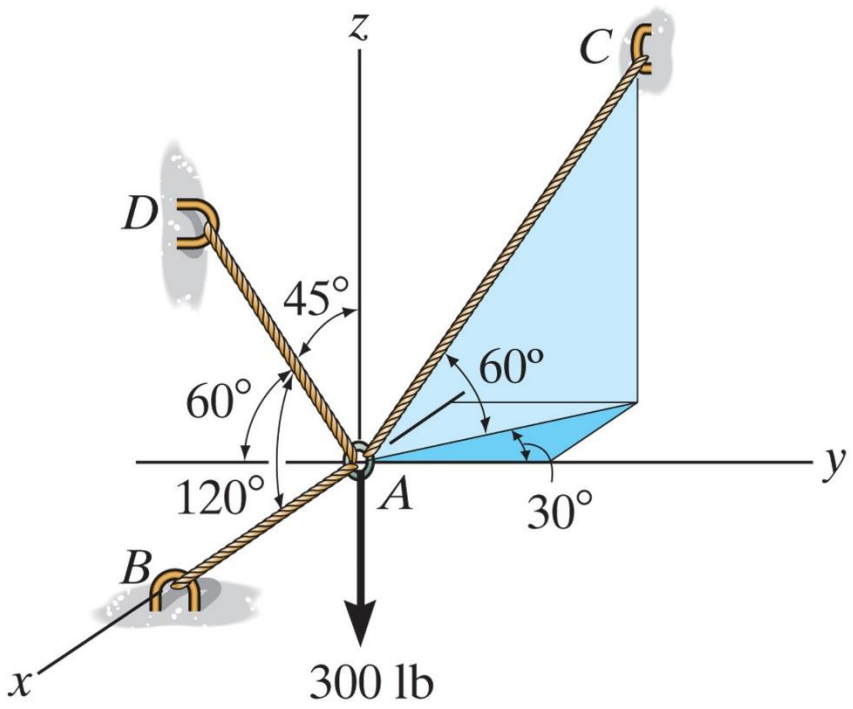
Example:

- Calculate the force in cables AB, AD, and AC.



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