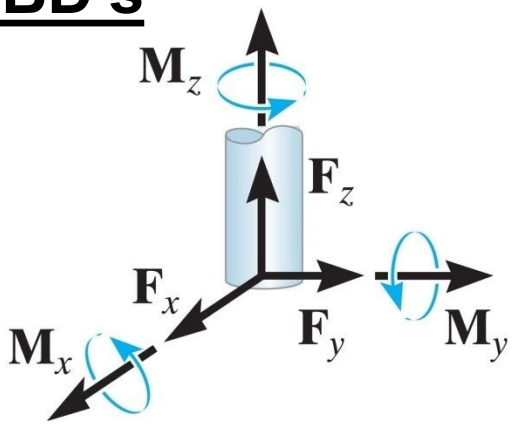
ENSC 2113
Engineering Mechanics: Statics

Lecture 19
Sections 5.5-5.7

College of Engineering, Architecture & Technology

5.5: Equilibrium in Three Dimensions - FBD's

3-D systems have *6 Degrees of Freedom*:

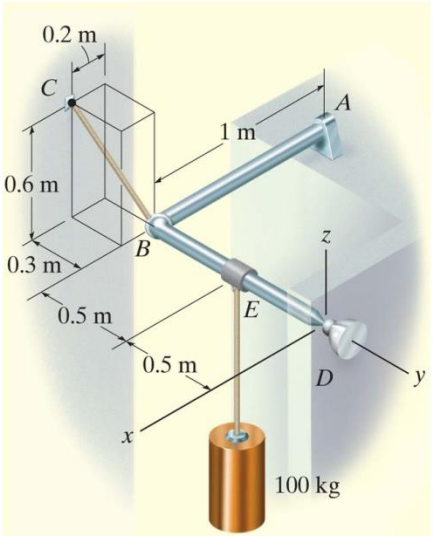


3 deformations = 3 forces

3 rotations = 3 moments

FBD for a 3-D system: follow same rules as for a 2-D system.

In 3-D systems, up to 6 reactions can be calculated.



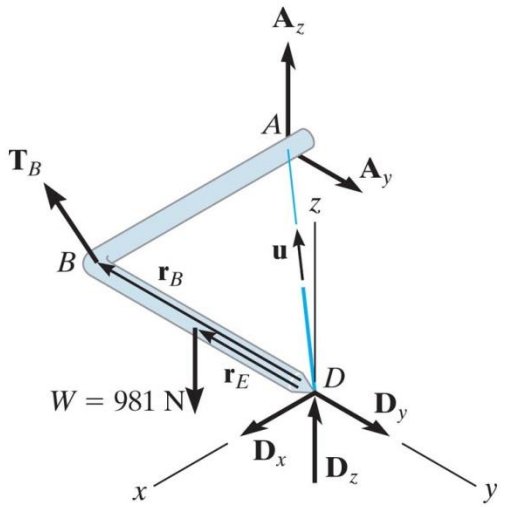
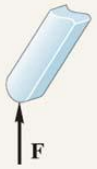
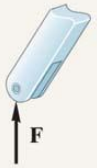


Table 5-2 gives 3-D connection types and support reactions:

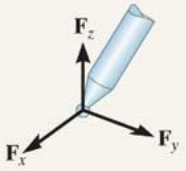
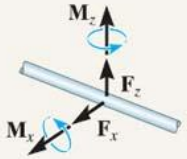
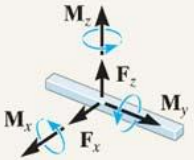
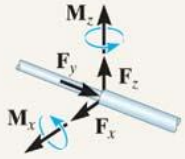
TABLE 5–2 Supports for Rigid Bodies Subjected to Three-Dimensional Force Systems

Types of Connection	Reaction	Number of Unknowns
(1)  cable		One unknown. The reaction is a force which acts away from the member in the known direction of the cable.
(2)  smooth surface support		One unknown. The reaction is a force which acts perpendicular to the surface at the point of contact.
(3)  roller		One unknown. The reaction is a force which acts perpendicular to the surface at the point of contact.

continued

Table 5-2 gives 3-D connection types and support reactions:

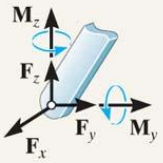
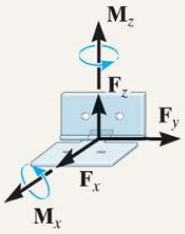
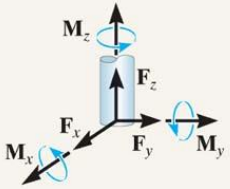
TABLE 5–2 Continued

Types of Connection	Reaction	Number of Unknowns
(4)  ball and socket		Three unknowns. The reactions are three rectangular force components.
(5)  single journal bearing		Four unknowns. The reactions are two force and two couple-moment components which act perpendicular to the shaft.
(6)  single journal bearing with square shaft		Five unknowns. The reactions are two force and three couple-moment components.
(7)  single thrust bearing		Five unknowns. The reactions are three force and two couple-moment components.

continued

Table 5-2 gives 3-D connection types and support reactions:

TABLE 5–2 Continued

Types of Connection	Reaction	Number of Unknowns
(8)  single smooth pin		Five unknowns. The reactions are three force and two couple-moment components.
(9)  single hinge		Five unknowns. The reactions are three force and two couple-moment components.
(10)  fixed support		Six unknowns. The reactions are three force and three couple-moment components.

5.6: Equilibrium in Three Dimensions - FBD's

6 Degrees of Freedom = 6 Equilibrium Equations:

$$\sum F = 0 \qquad \sum M = 0$$

$$\sum F_x = 0 \qquad \sum M_x = 0$$

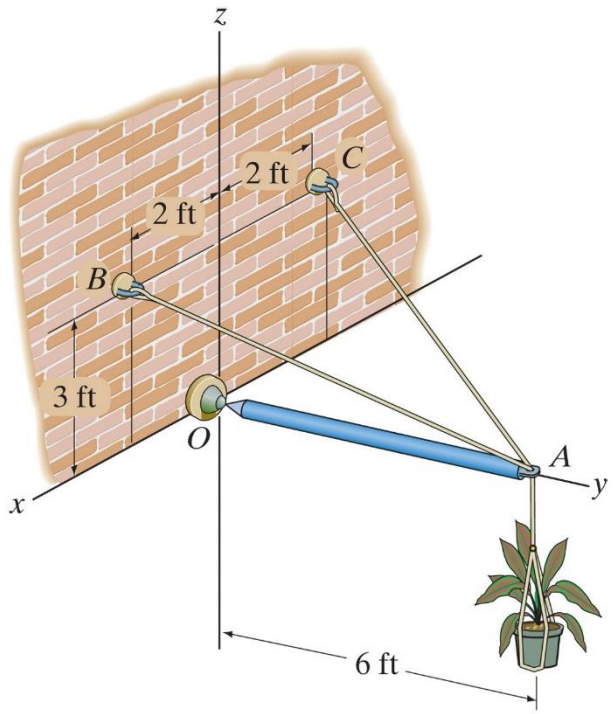
$$\sum F_y = 0 \qquad \sum M_y = 0$$

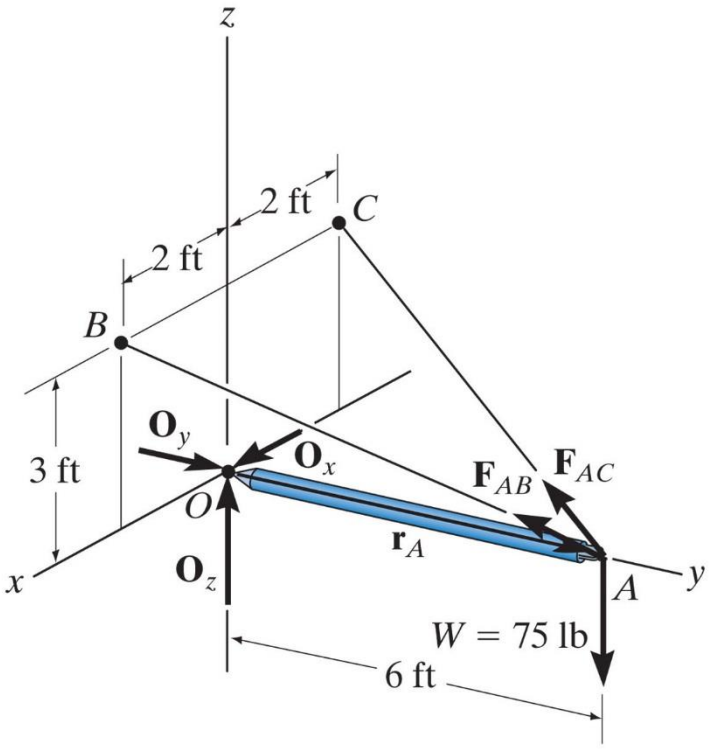
$$\sum F_z = 0 \qquad \sum M_z = 0$$

For 3-D systems, *Cartesian Vector* formulation can be used to simplify the process.

Place tension cables AB and AC in *Cartesian Vector Formulation* before applying equilibrium equations:

$$\bar{F} = |F|\bar{u} \qquad \bar{u} = \frac{\bar{r}}{|r|}$$





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