

GNG 1105E – Engineering Mechanics

CHAPTER S3 – EQUILIBRIUM

Assigned readings

3/4 Equilibrium conditions (3-D)

3/4 Equilibrium conditions (3D)

Force Balance: $\sum \mathbf{F} = \mathbf{0}$

$$\sum F_x = 0$$

$$\sum F_y = 0$$

$$\sum F_z = 0$$

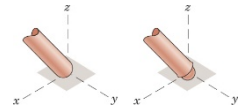
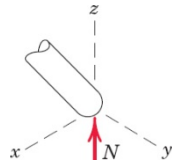
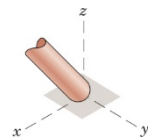
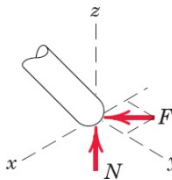
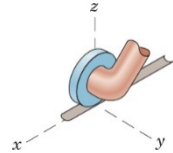
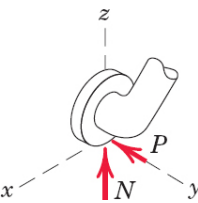
Moment Balance: $\sum \mathbf{M} = \mathbf{0}$

$$\sum M_x = 0$$

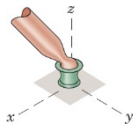
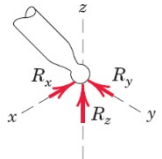
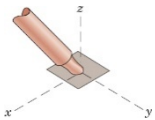
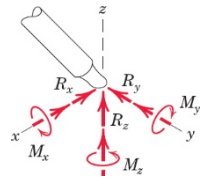
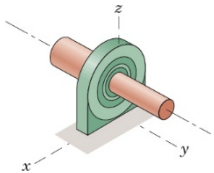
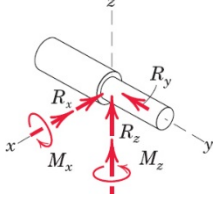
$$\sum M_y = 0$$

$$\sum M_z = 0$$

3/4 Equilibrium conditions (3D)

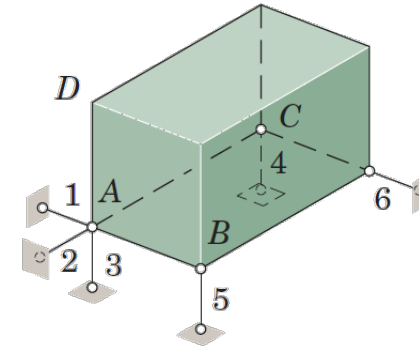
Type of Contact and Force Origin	Action on Body to Be Isolated
<p>1. Member in contact with smooth surface, or ball-supported member</p> 	<p>Force must be normal to the surface and directed toward the member.</p> 
<p>2. Member in contact with rough surface</p> 	<p>The possibility exists for a force F tangent to the surface (friction force) to act on the member, as well as a normal force N.</p> 
<p>3. Roller or wheel support with lateral constraint</p> 	<p>A lateral force P exerted by the guide on the wheel can exist, in addition to the normal force N.</p> 

3/4 Equilibrium conditions (3D)

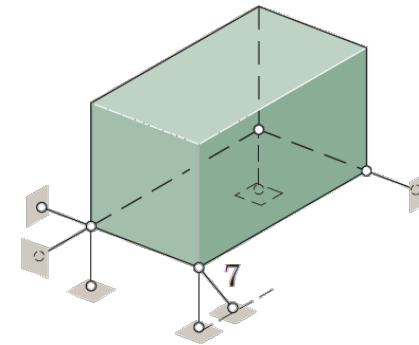
Type of Contact and Force Origin	Action on Body to Be Isolated
<p>4. Ball-and-socket joint</p> 	 <p>A ball-and-socket joint free to pivot about the center of the ball can support a force \mathbf{R} with all three components.</p>
<p>5. Fixed connection (embedded or welded)</p> 	 <p>In addition to three components of force, a fixed connection can support a couple \mathbf{M} represented by its three components.</p>
<p>6. Thrust-bearing support</p> 	 <p>Thrust bearing is capable of supporting axial force R_y as well as radial forces R_x and R_z. Couples M_x and M_z must, in some cases, be assumed zero in order to provide statical determinacy.</p>

3/4 Equilibrium conditions (3D)

Complete Fixity (Adequate Constraints)



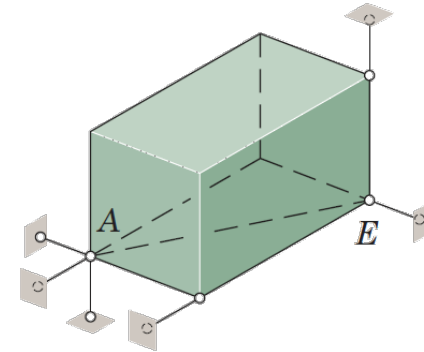
Excessive Fixity (Redundant Constraints)



3/4 Equilibrium conditions (3D)

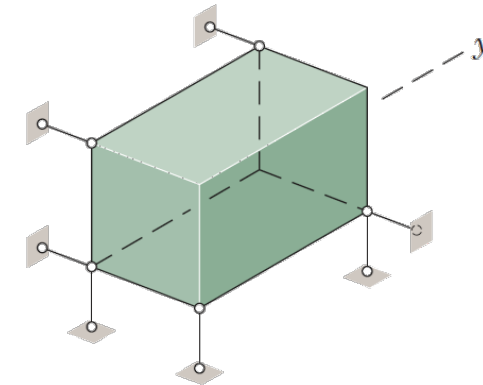
Incomplete Fixity (Partial Constraints)

- No Moment Resistance about Line AE



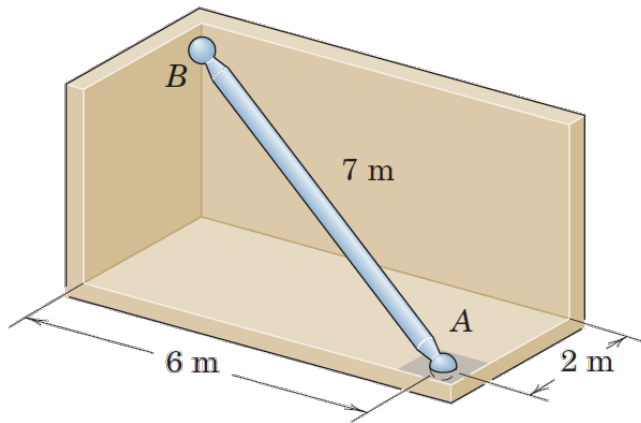
Incomplete Fixity (Partial Constraints)

- No Force Resistance along y -Axis

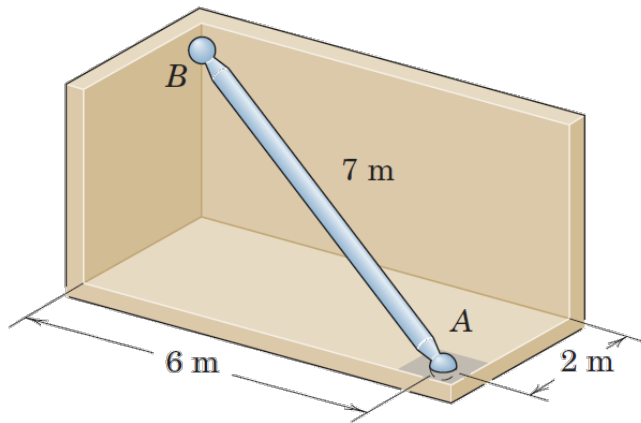


Sample problem 3/5

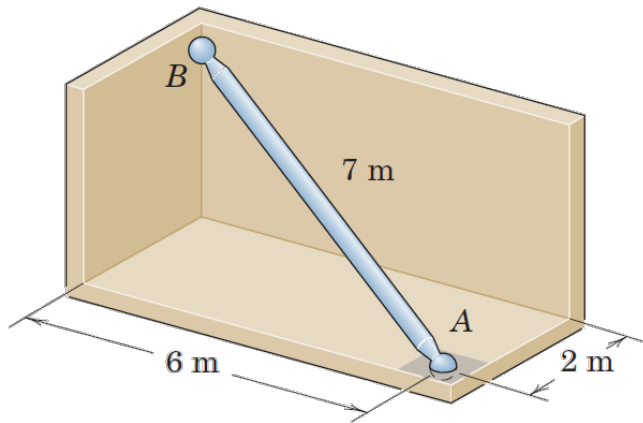
The uniform 7-m steel shaft has a mass of 200 kg and is supported by a ball-and-socket joint at A in the horizontal floor. The ball end B rests against the smooth vertical walls as shown. Compute the forces exerted by the walls and the floor on the ends of the shaft.



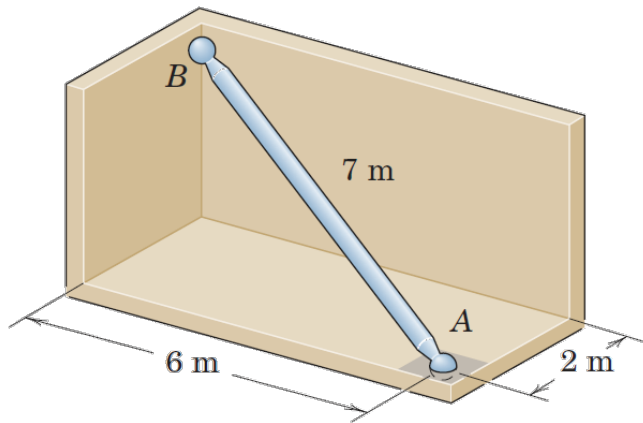
Sample problem 3/5



Sample problem 3/5

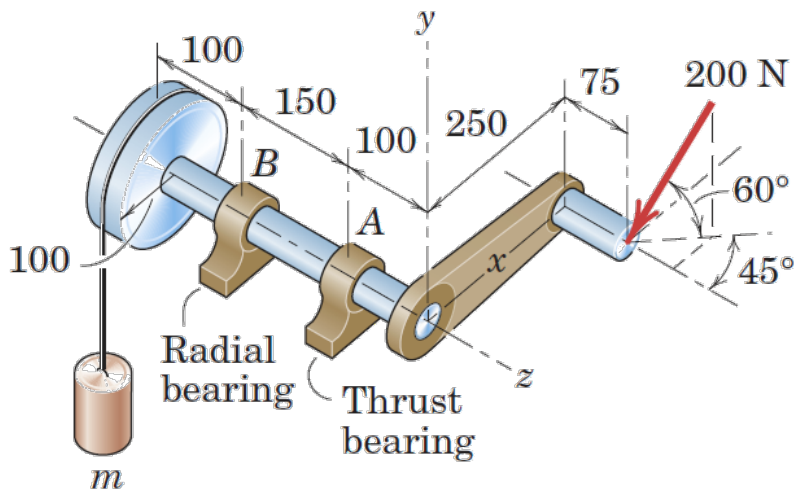


Sample problem 3/5



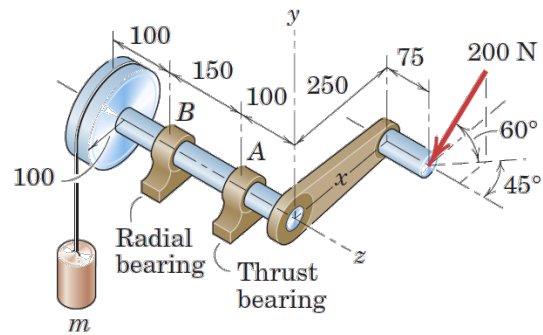
Sample problem 3/6

A 200-N force is applied to the handle of the hoist in the direction shown. The bearing *A* supports the thrust (force in the direction of the shaft axis), while bearing *B* supports only radial load (load normal to the shaft axis). Determine the mass *m* which can be supported and the total radial force exerted on the shaft by each bearing. Assume neither bearing to be capable of supporting a moment about a line normal to the shaft axis.

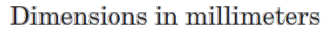


Dimensions in millimeters

Sample problem 3/6



Dimensions in millimeters



Recommended problems

Chapter S3 Practice Problems

- Questions 21-38