Today:

- Mechanical Systems

- Free Body Diagrams

Book: Chapter 5.1 - 5.2

Recap: Static equilibrium of a body

In general:

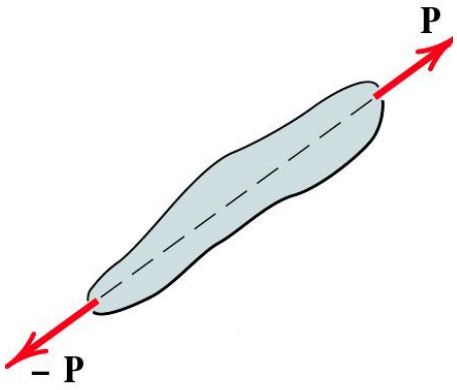
$$\sum \mathbf{F}_x = 0$$

$$\sum \mathbf{F}_y = 0$$

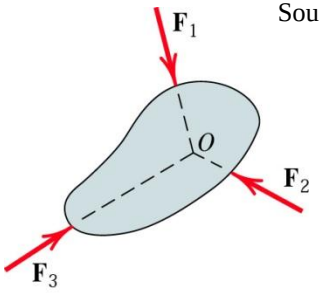
$$\sum \mathbf{M}_A = 0$$

Two- and three-force members

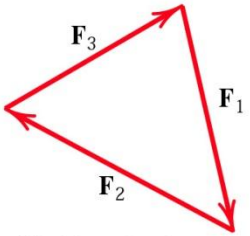
Source: R.C. Hibbeler,
"Engineering Mechanics – Statics"



Two-force member



(*a*) Three-force member



(*b*) Closed polygon satisfies $\Sigma \mathbf{F} = \mathbf{0}$

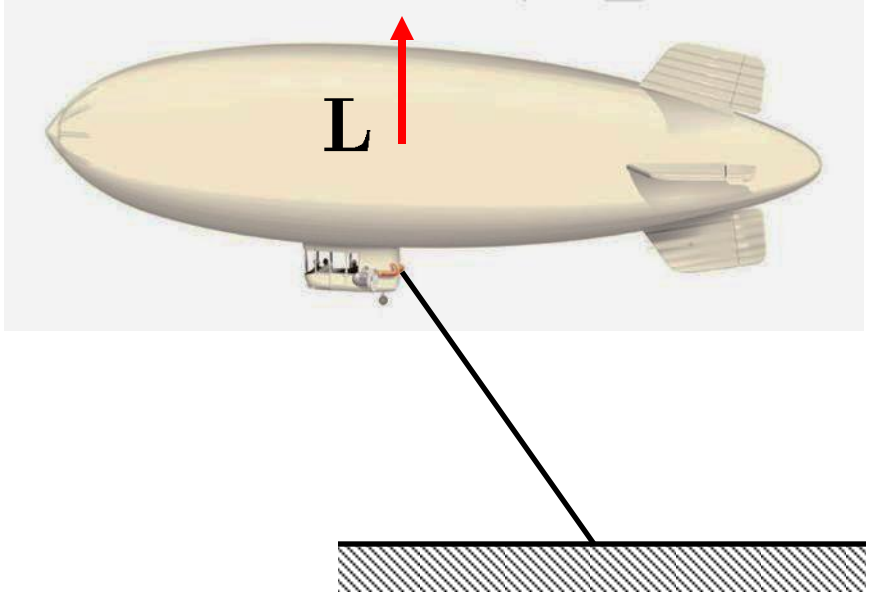
Free-body diagram

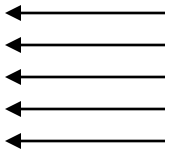
A diagrammatic representation of the isolated system treated as a single body.

Support reactions

1. If a support allows motion in a certain direction (degree-of-freedom) then it provides no reaction force in that direction
2. Conversely, if a support constrains motion in a certain direction, a reaction could be present in that direction

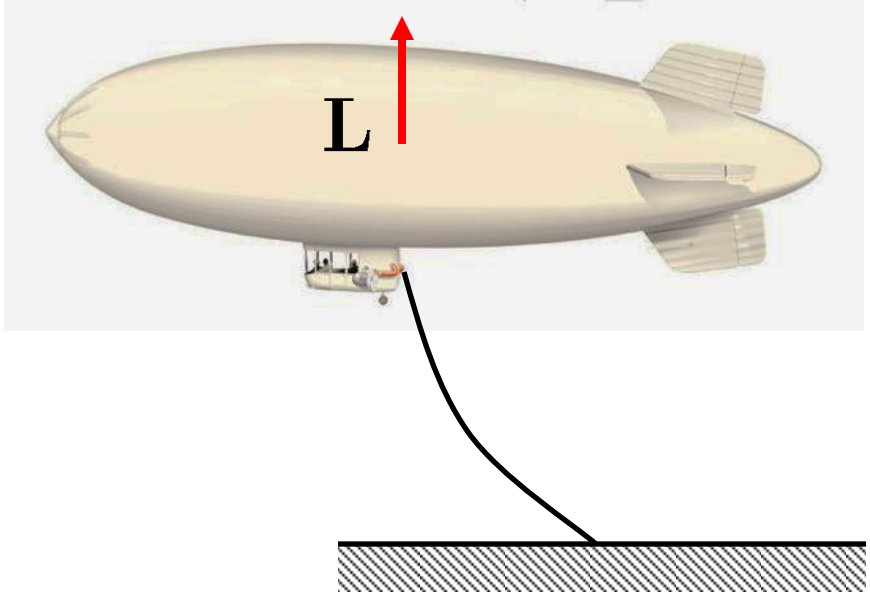
Blimp

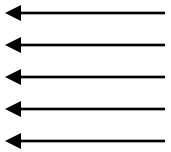




Wind direction

Blimp





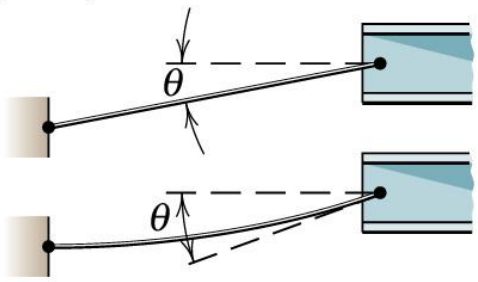
Wind direction

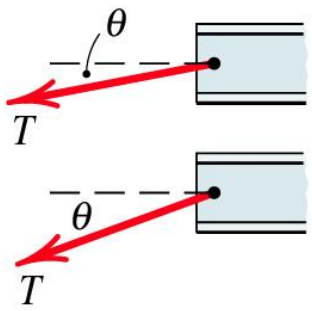
Source: R.C. Hibbeler,
"Engineering Mechanics – Statics"

1. Flexible cable, belt, chain, or rope

Weight of cable negligible

Weight of cable not negligible



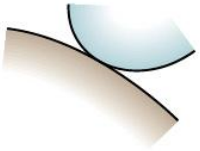


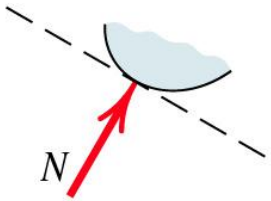
Force exerted by a flexible cable is always a tension away from the body in the direction of the cable.

Skate on ice

Source: R.C. Hibbeler,
"Engineering Mechanics – Statics"

2. Smooth surfaces



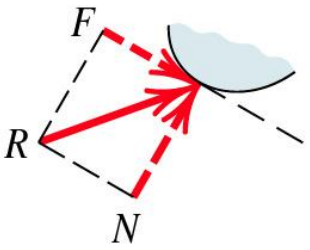


Contact force is compressive and is normal to the surface.

Shoe on a surface

Source: R.C. Hibbeler,
"Engineering Mechanics – Statics"

3. Rough surfaces

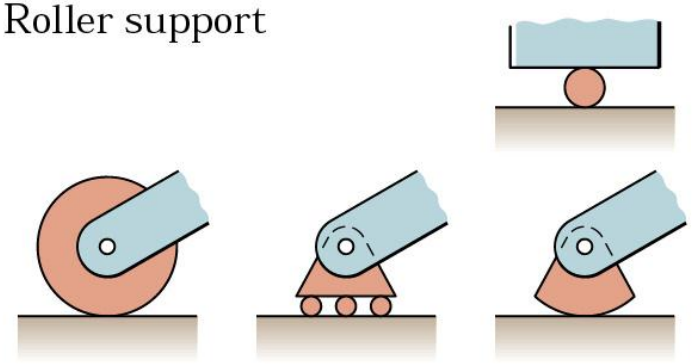


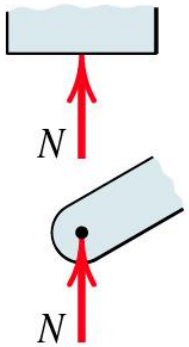
Rough surfaces are capable of supporting a tangential component F (frictional force) as well as a normal component N of the resultant contact force R.

Rollerblades on the road

Source: R.C. Hibbeler,
"Engineering Mechanics – Statics"

4. Roller support

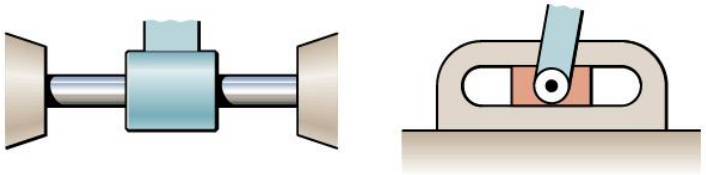


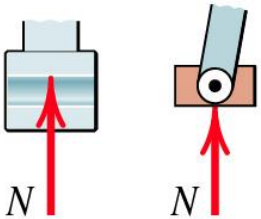


Roller, rocker, or ball support transmits a compressive force normal to the supporting surface.

Source: R.C. Hibbeler,
"Engineering Mechanics – Statics"

5. Freely sliding guide



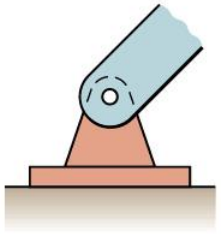


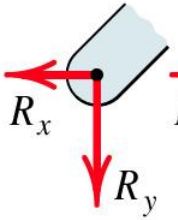
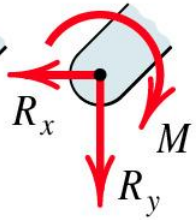
Collar or slider free to move along smooth guides; can support force normal to guide only.

Landing gear attached to a fuselage

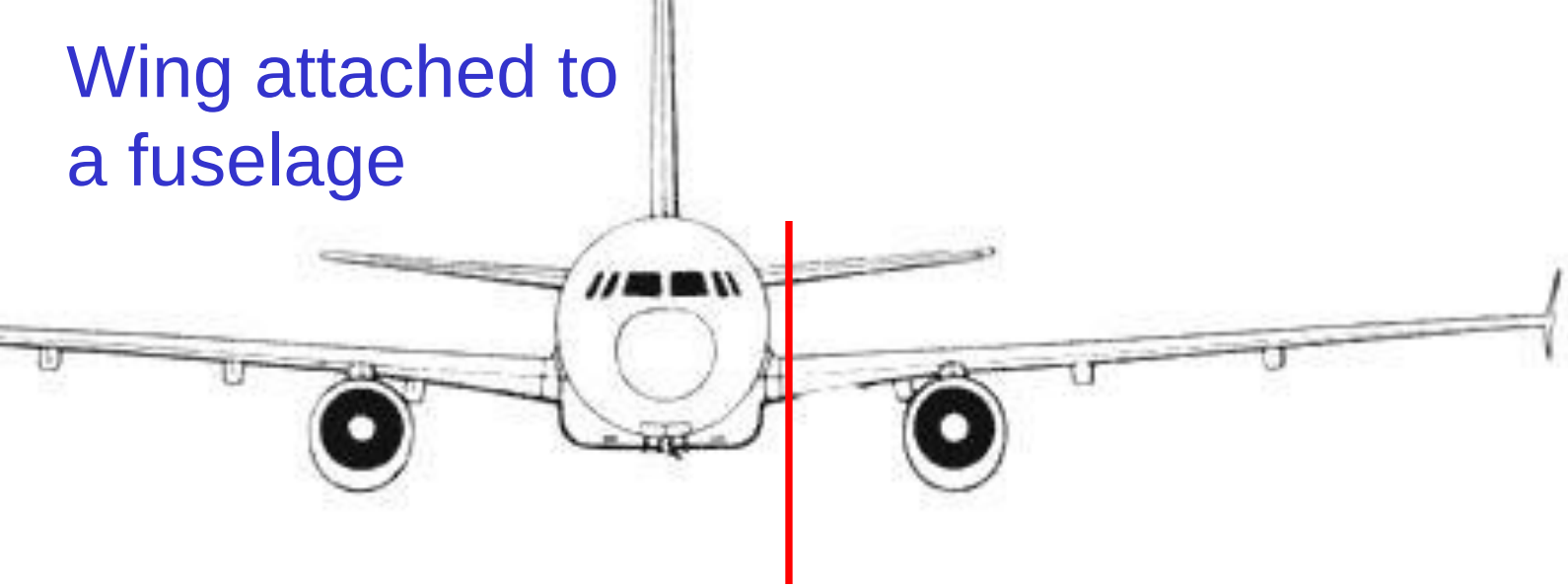
Source: R.C. Hibbeler,
"Engineering Mechanics – Statics"

6. Pin connection



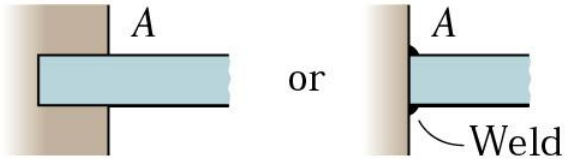
Pin free to turn	Pin not free to turn	
		A freely hinged pin connection is capable of supporting a force in any direction in the plane normal to the axis; usually shown as two components R_x and R_y. A pin not free to turn may also support a couple M.

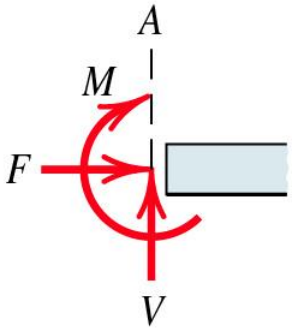
Wing attached to a fuselage



Source: R.C. Hibbeler,
"Engineering Mechanics – Statics"

7. Built-in or fixed support

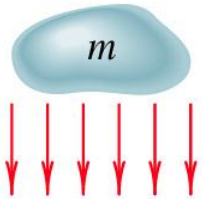


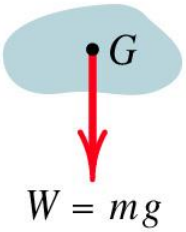


A built-in or fixed support is capable of supporting an axial force F, a transverse force V (shear force), and a couple M (bending moment) to prevent rotation.

Do not forget the gravitational attraction!

8. Gravitational attraction



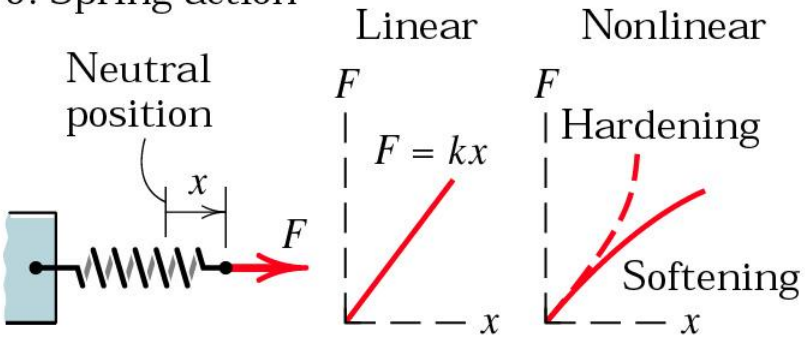


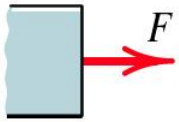
The resultant of gravitational attraction on all elements of a body of mass m is the weight $W = mg$ and acts toward the center of the earth through the center mass G.

Springs – pogo stick

Source: R.C. Hibbeler,
"Engineering Mechanics – Statics"

9. Spring action



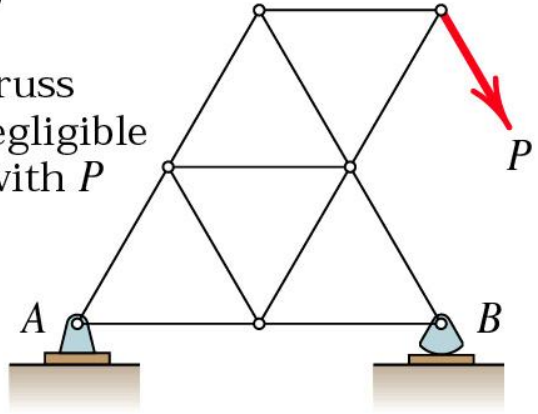


Spring force is tensile if spring is stretched and compressive if compressed. For a linearly elastic spring the stiffness k is the force required to deform the spring a unit distance.

Source: R.C. Hibbeler,
"Engineering Mechanics – Statics"

1. Plane truss

Weight of truss assumed negligible compared with P



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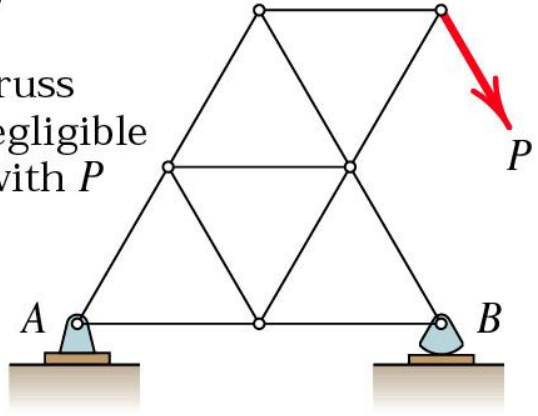
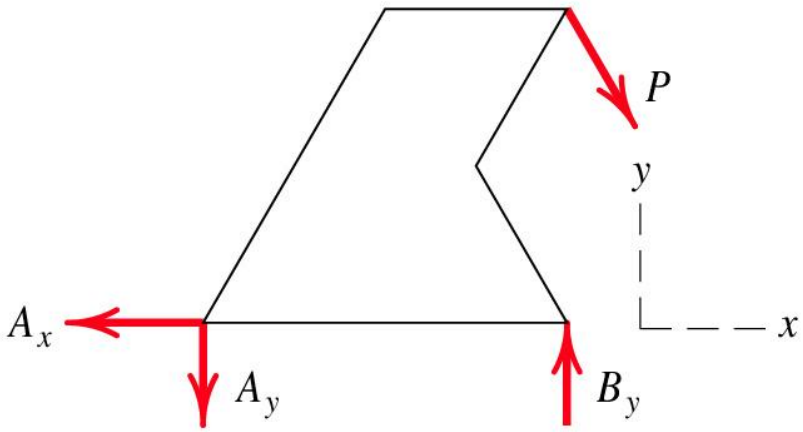
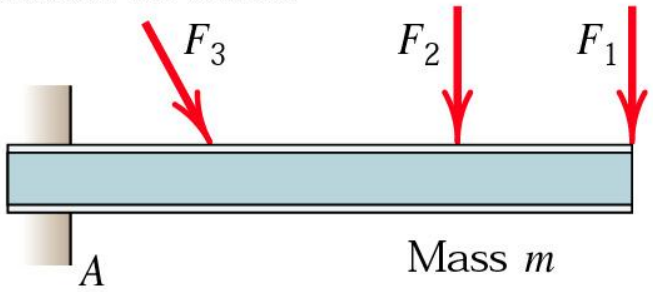




Source: R.C. Hibbeler,
"Engineering Mechanics – Statics"

2. Cantilever beam



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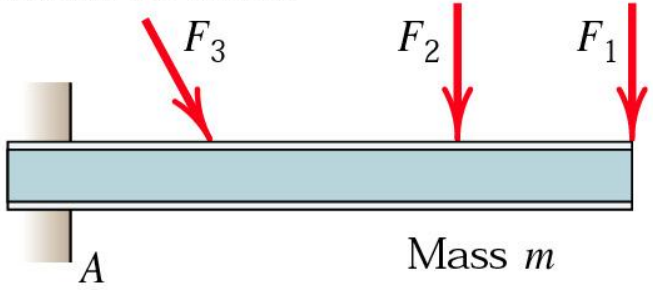
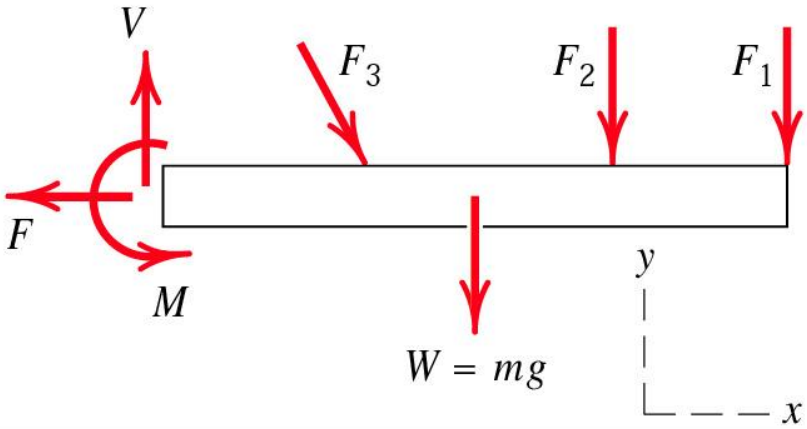
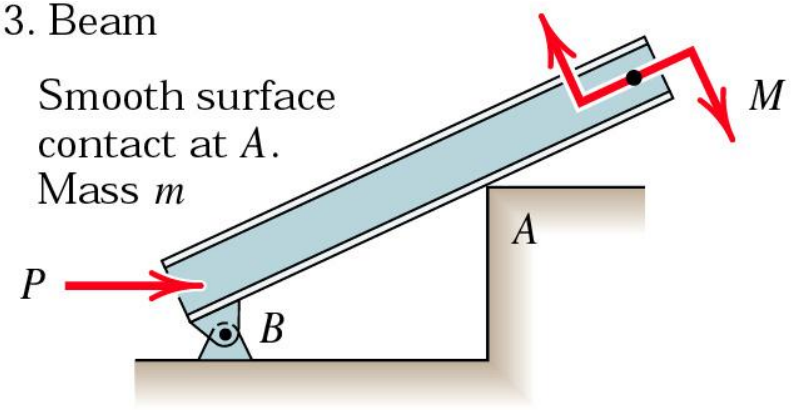




Source: R.C. Hibbeler,
"Engineering Mechanics – Statics"

3. Beam

Smooth surface
contact at A.
Mass m



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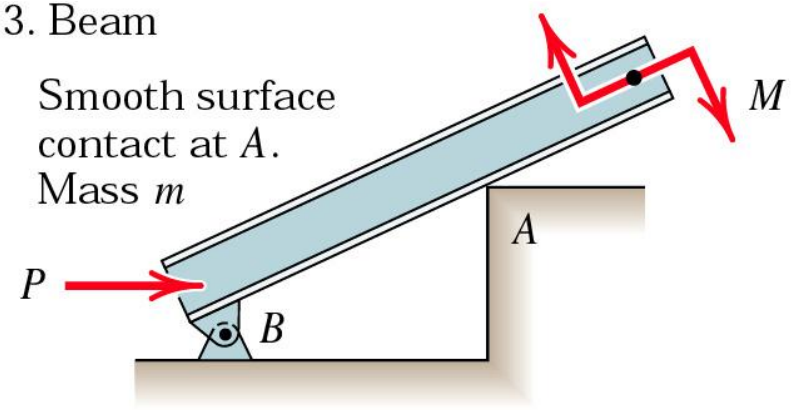
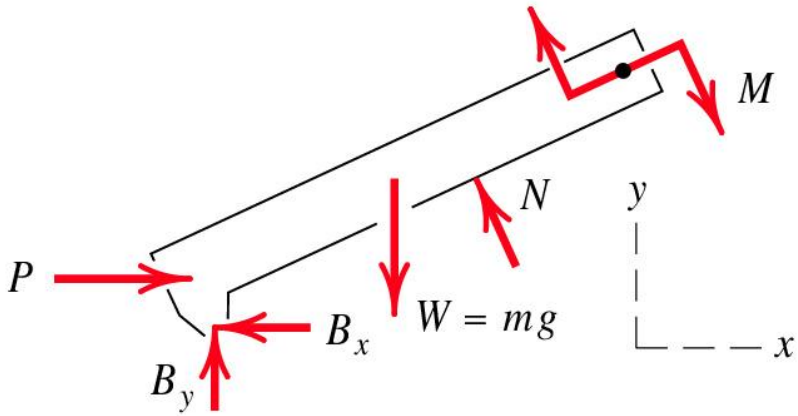
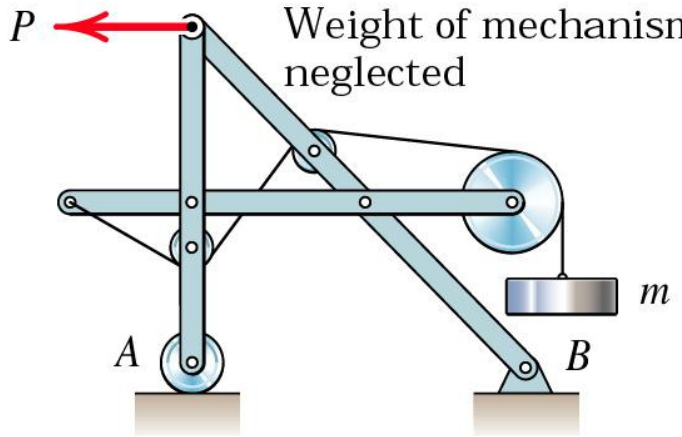




4. Rigid system of interconnected bodies analyzed as a single unit



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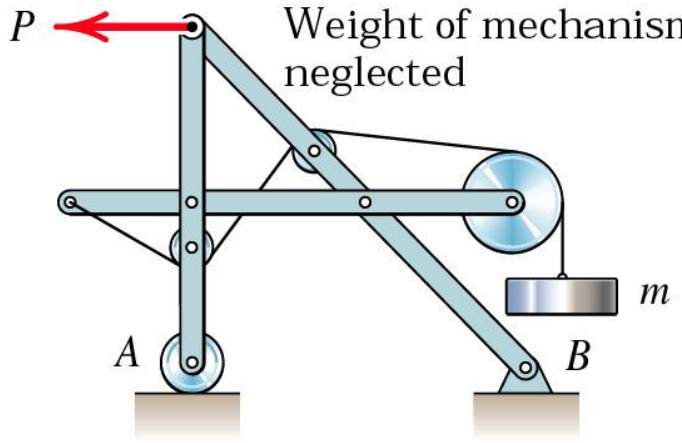
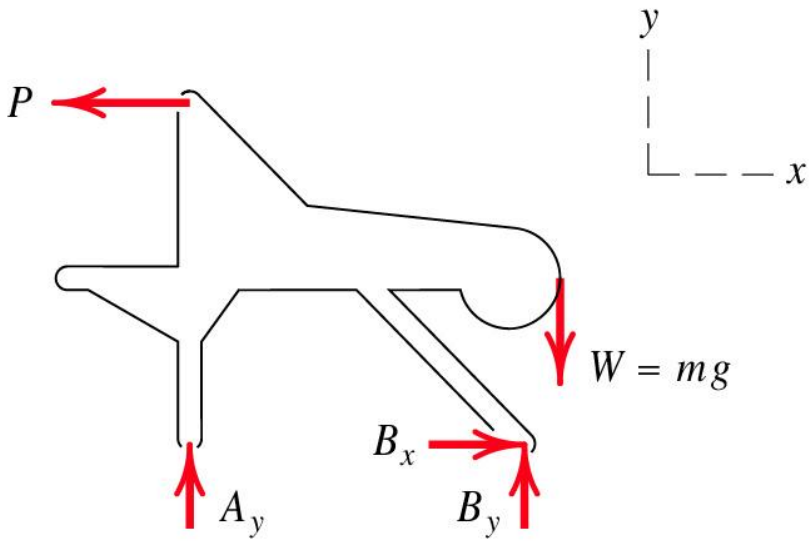
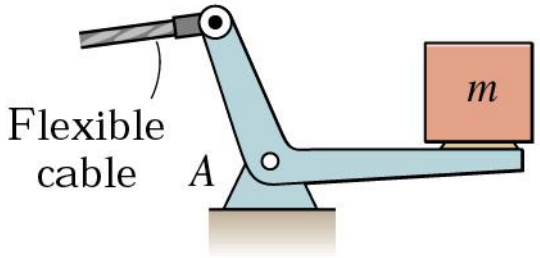
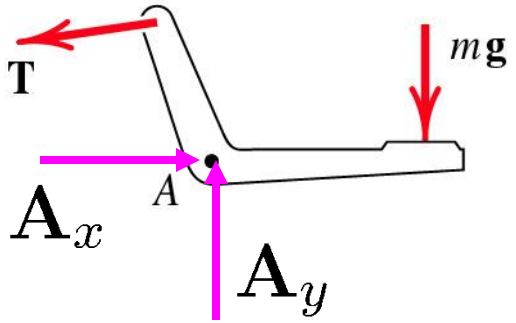




Complete the Free-Body Diagram

1. Bell crank supporting mass m with pin support at A.

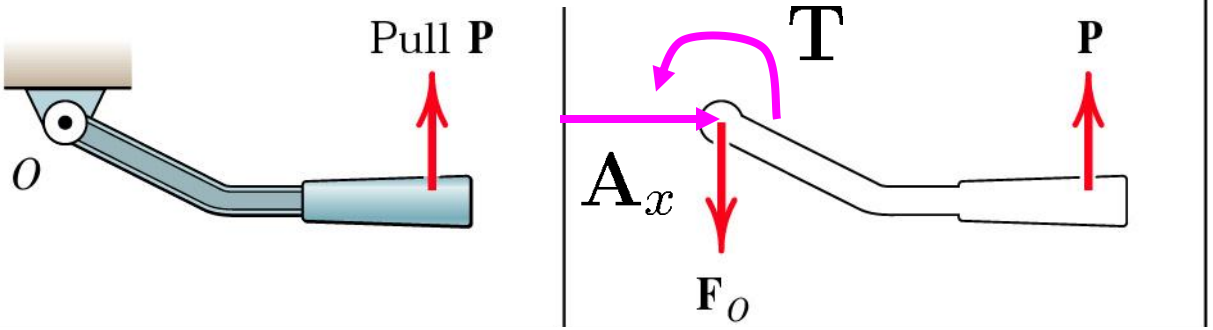




Complete the Free-Body Diagram

Source: R.C. Hibbeler,
"Engineering Mechanics – Statics"

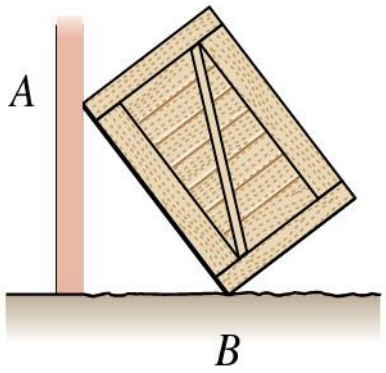
2. Control lever applying torque to shaft at O.

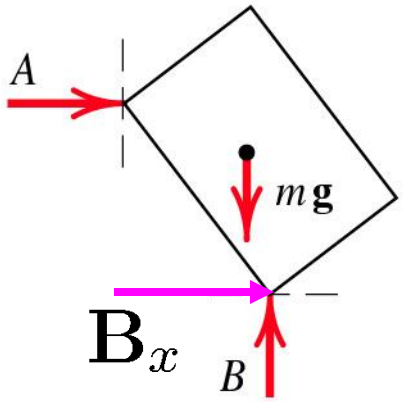


Complete the Free-Body Diagram

Source: R.C. Hibbeler,
"Engineering Mechanics – Statics"

4. Uniform crate of mass m leaning against smooth vertical wall and supported on a rough horizontal surface.

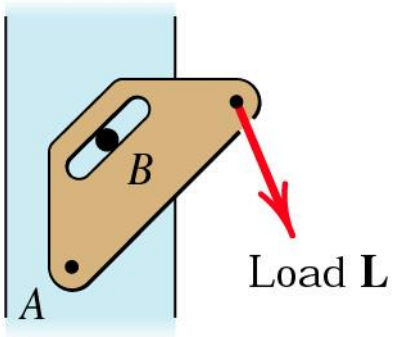


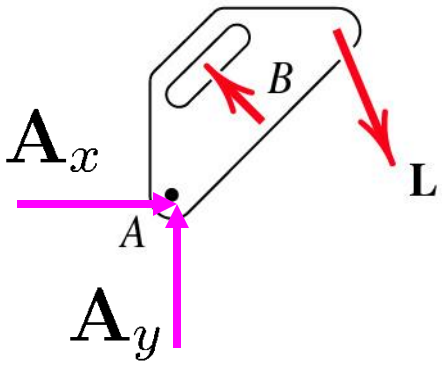


Complete the Free-Body Diagram

Source: R.C. Hibbeler,
"Engineering Mechanics – Statics"

5. Loaded bracket supported by pin connection at A and fixed pin in smooth slot at B.

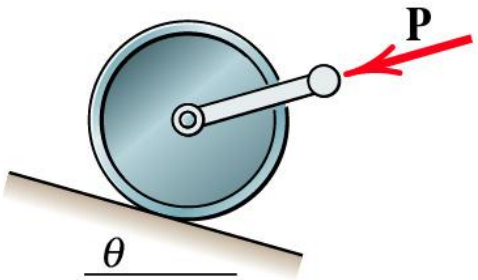


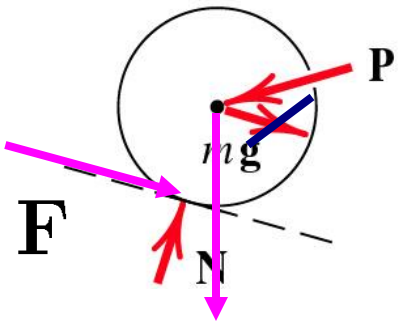


Complete or correct the Free-Body Diagram

Source: R.C. Hibbeler, "Engineering Mechanics – Statics"

1. Lawn roller of mass m being pushed up incline θ.

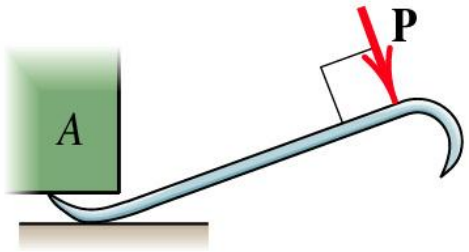


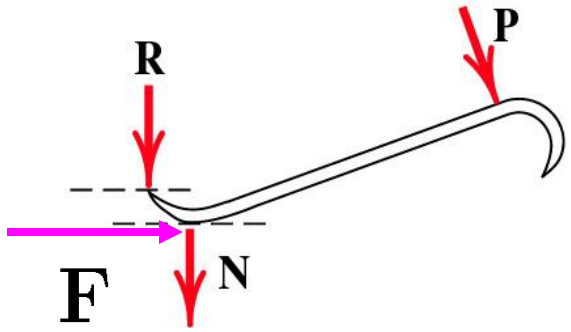


Complete or correct the Free-Body Diagram

Source: R.C. Hibbeler, "Engineering Mechanics – Statics"

2. Prybar lifting body *A* having smooth horizontal surface. Bar rests on horizontal rough surface.





Complete or correct the Free-Body Diagram

Source: R.C. Hibbeler, "Engineering Mechanics – Statics"

4. Supporting angle bracket for frame; Pin joints.