

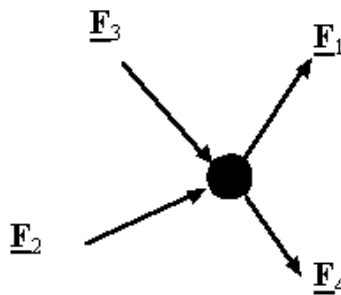
Static Equilibrium for a Particle

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

A particle: An object with inertia (mass) but of negligible dimensions.

A particle at rest: A particle is at rest if originally at rest or has a constant velocity if originally in motion.

Equilibrium equations for a particle: A particle is in equilibrium if the resultant of **ALL** forces acting on the particle is equal to zero (Newton's first law is that a body at rest is not subjected to any unbalanced forces).



Sum of all forces acting on a particle = $\sum \underline{\mathbf{F}} = 0$

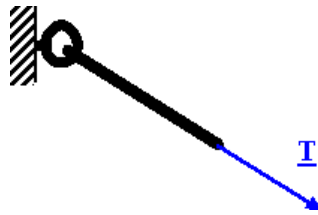
Equilibrium equations in component form: In a rectangular coordinate system the equilibrium equations can be represented by three scalar equations:

$$\begin{aligned}\sum F_x &= 0 \\ \sum F_y &= 0 \\ \sum F_z &= 0\end{aligned}$$

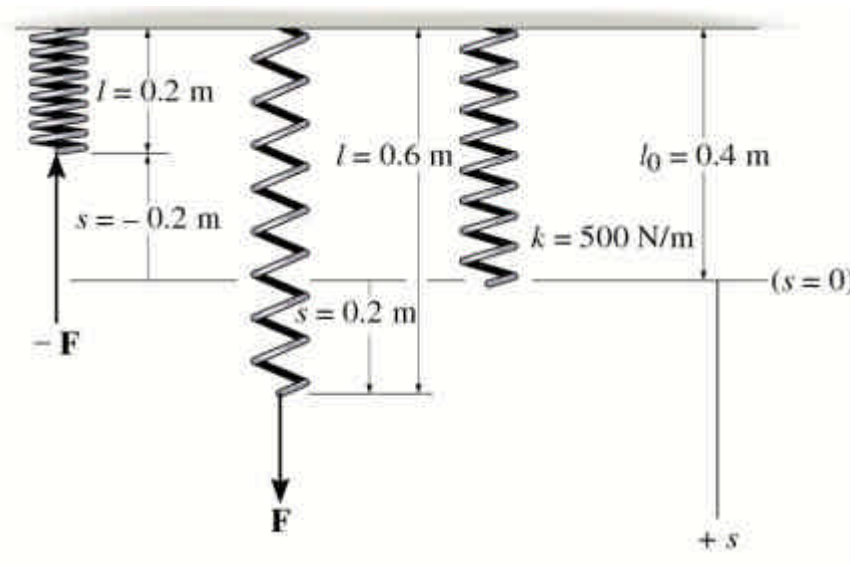
To apply equilibrium equations we must account for all **known** and **unknown forces** acting on the particle. The best way to do this is to draw a free-body diagram of the particle.

Free-Body Diagram (FBD): A diagram showing the particle under consideration and all the forces and moments acting on this particle. Each force in this diagram must be labeled (This is a sketch that shows the particle “free” from its surroundings with all the forces acting on it).

String or cable: A mechanical device that can only transmit a **tensile force** along itself.

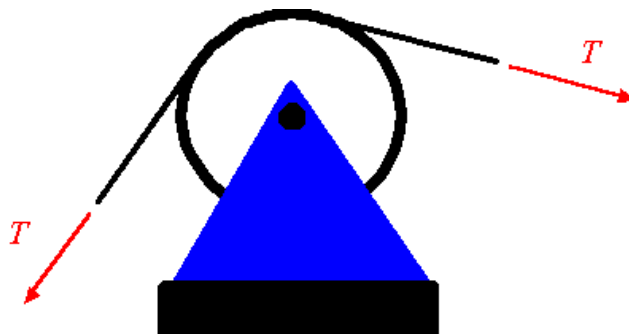


Linear spring: A mechanical device which exerts a force along its line of action and proportional to its extension ($F = kX$).



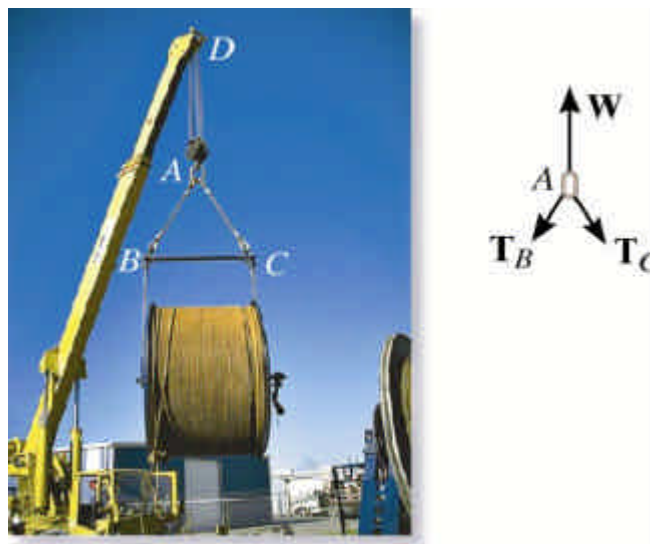
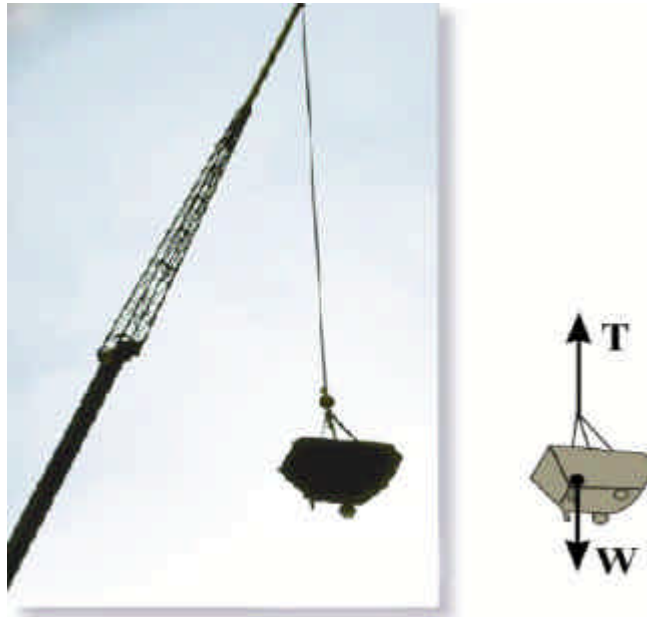
Frictionless pulleys:

Cables are assumed to have negligible weight and they cannot stretch. They can only support tension or pulling (you can't push on a rope). Pulleys are assumed to be frictionless. A continuous cable passing over a frictionless pulley must have tension force of a constant magnitude. The tension force is always directed in the direction of the cable (For a frictionless pulley in static equilibrium, the tension in the cable is the same on both sides of the pulley).



How to draw a Free Body Diagram:

1. **Draw outlined shape** - Imagine the particle isolated or cut “free” from its surroundings
2. **Show all forces and moments** - Include “active forces” and “reactive forces”. Place each force and couple at the point that it is applied.
3. **Identify each force** - Known forces labeled with proper magnitude and direction. Letters used for unknown quantities.
4. Add any relevant dimensions onto your picture.



Force types:

Active Forces - tend to set the particle in motion.

Reactive Forces - result from constraints or supports and tend to prevent motion.