Chapter 3: Equilibrium of Particles

Equilibrium of Particles in 2D (3.1)

<u>Force on a particle</u>

Concurrent force system → lines of action of all forces intersect at a common point

Static equilibrium → $\vec{a} = \vec{0}$

$$\sum \vec{F} = \vec{0} \Rightarrow \sum F_x \,\hat{\imath} + \sum F_y \,\hat{\jmath} = \vec{0}$$

$$\sum F_x = 0, \sum F_y = 0$$

Free-body duagram (FBD): *sketch of a body/portion of a body demonstrating all forces acting on the body*

<u>Pulleys</u>

If a pulley has friction → $T_1 \neq T_2$ (generally)

If a pulley has *no* friction → $T_1 = T_2$ (ALWAYS)

Behavior of Cables, Bars, and Springs (3.2)

General terms

Deformable: *if a material is subject to force, it will change shape*

Cables: *assume to be inextensible, and perfectly flexible*

➔ Assume cables length does not change regardless of the tensile load

Bars: *assume to be rigid; inextensible in tension and compression*

Springs

Spring: *mechanical device that produces a force when it undergoes a deformation*

Coil spring: *particular type of spring that is constructed of wire (or some other material) in the shape of a helix*

Understanding the behavior of a linear elastic spring…

$$F_s = k\delta = k(L - L_0)$$

➔ $k = spring\ stiffness$

➔ $\delta = L - L_0 = elongation\ of\ spring$

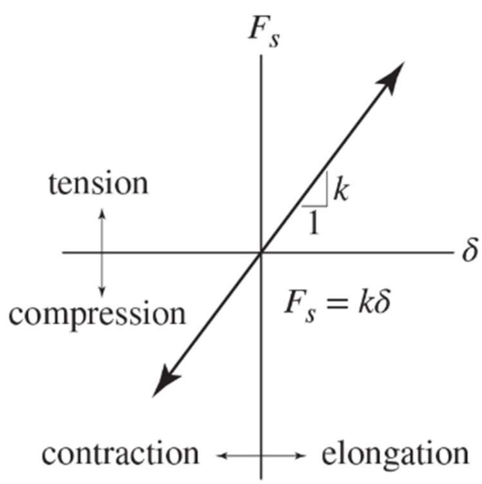

Figure 3.15
Spring law for a linear elastic spring.

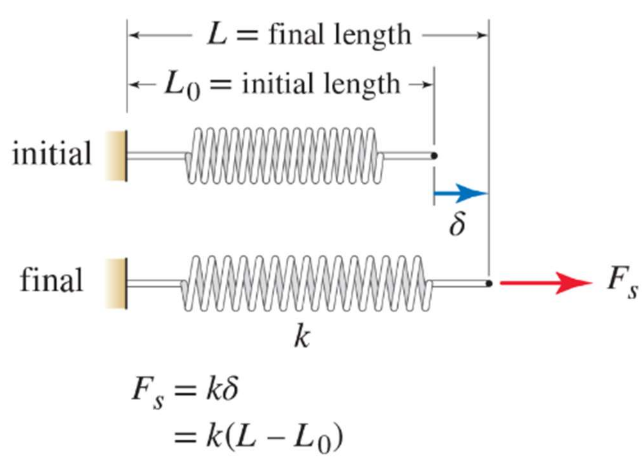

*****Figure directly from textbook*****

Equilibrium of Particles in 3D (3.3)

Conditions for 3D

$$\sum \vec{F} = \vec{0}: \sum F_x \hat{\imath} + \sum F_y \hat{\jmath} + \sum F_z \hat{k} = \vec{0}$$

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

Analysis of one particle in 3D will involve solving three equilibrium equations with three unknowns

Solving for the force F in the direction of $\vec{r}$…

$$\sum F_r = 0: \vec{F}_1 \cdot \frac{\vec{r}}{r} + \vec{F}_2 \cdot \frac{\vec{r}}{r} + \cdots + \vec{F}_n \cdot \frac{\vec{r}}{r} = 0$$

Engineering Design (3.4)

$$allowable\ load = \frac{faluire\ load}{factor\ of\ saftey}$$

$$factor\ of\ saftey = \frac{failure\ load}{allowable\ load}$$