A short course on

Equilibrium

This video:
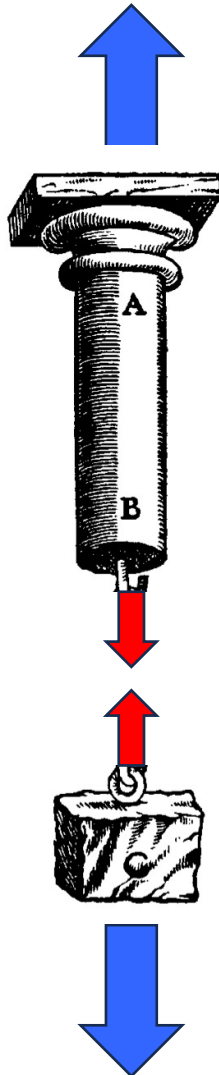
Forces and Moments
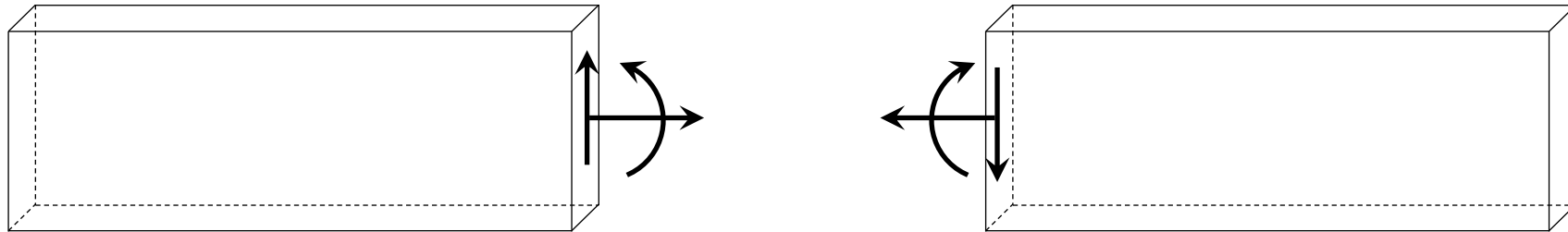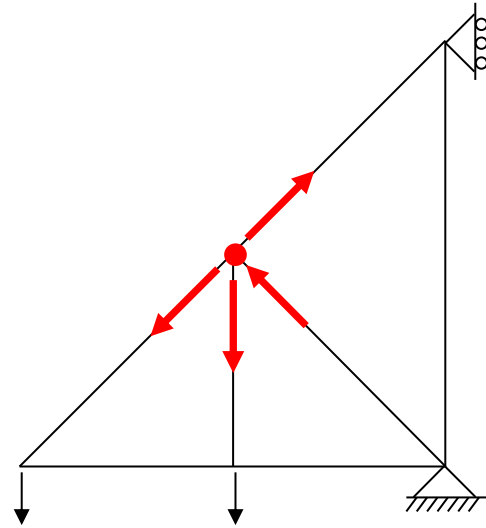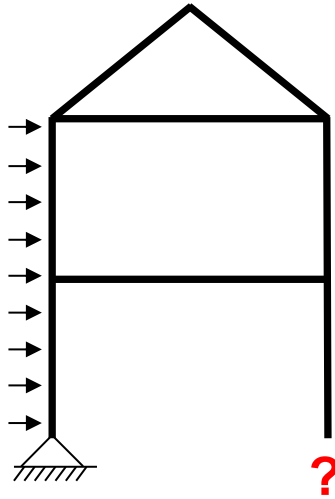
Balance of Forces

Galileo (1638)

Newton (1687)

1. A body remains at rest, or in motion at a constant speed in a straight line, unless acted upon by a _force_

2. When a body is acted upon by a _force_, the time rate of change of its momentum equals the _force_

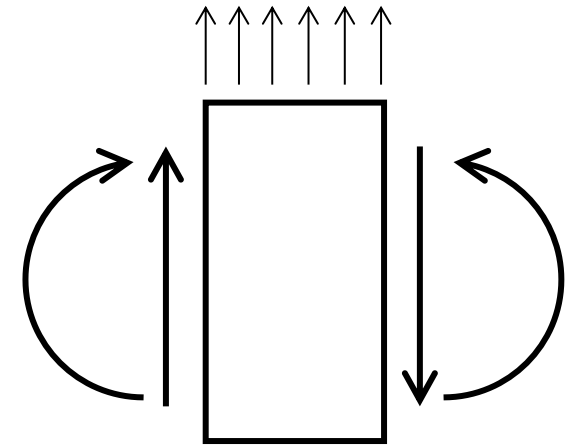3. If two bodies exert forces on each other, these _forces_ have the same magnitude but opposite directions
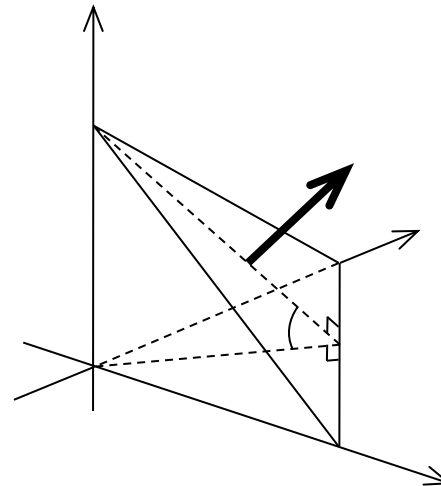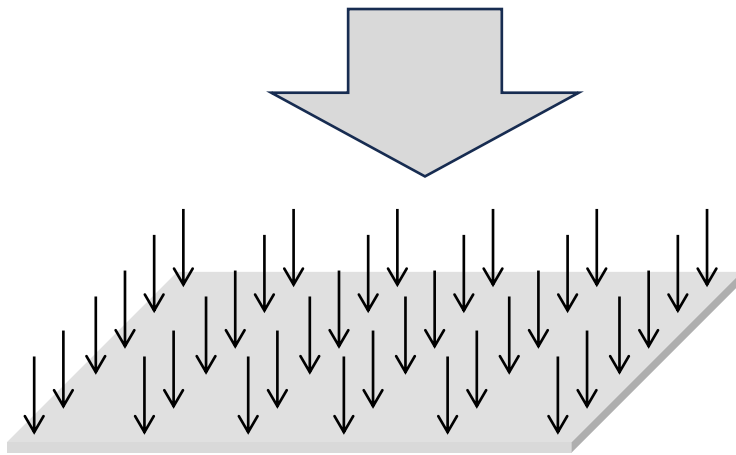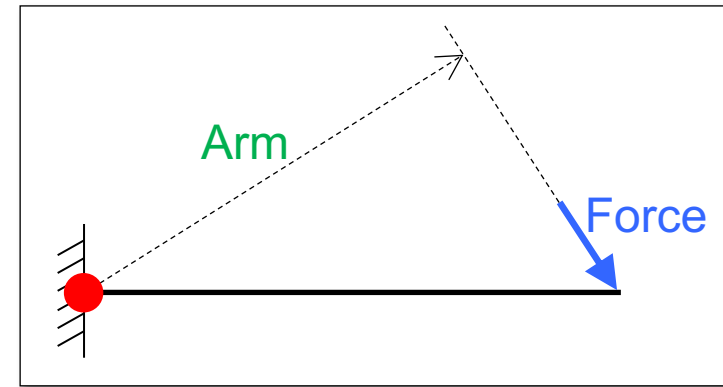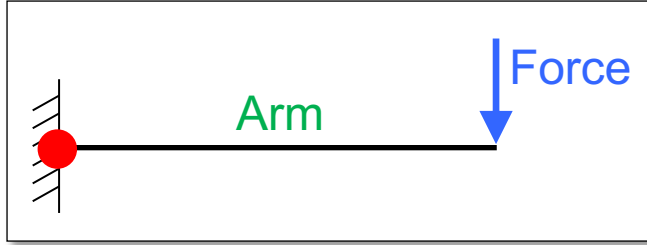
Equal & Opposite

Equilibrium is Always Important
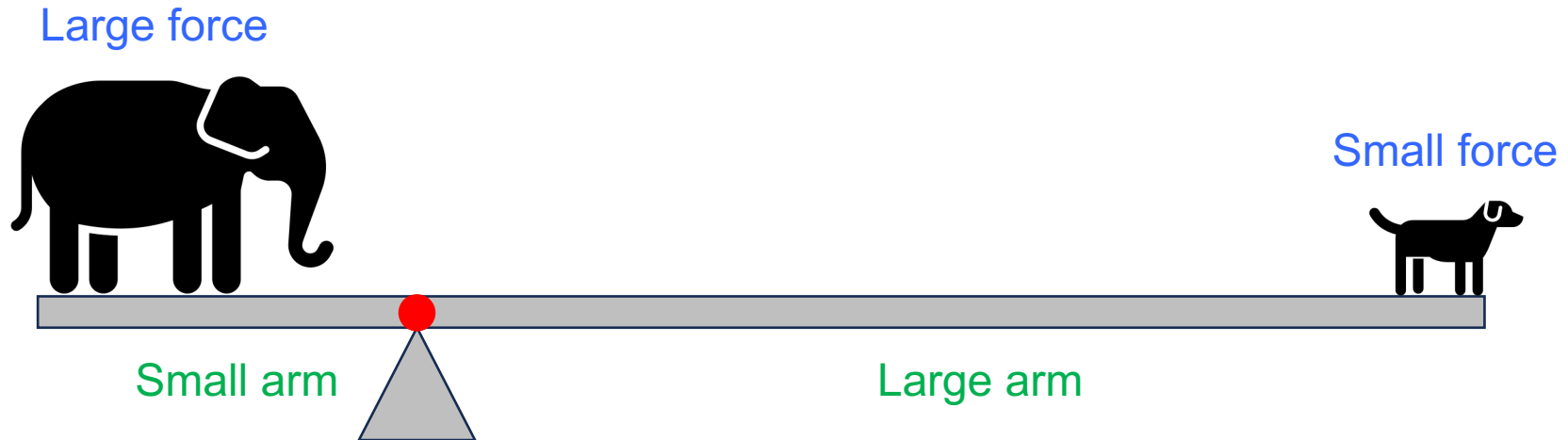

$$\int \sigma \cdot \delta\varepsilon = \delta W_{\text{ext}}$$
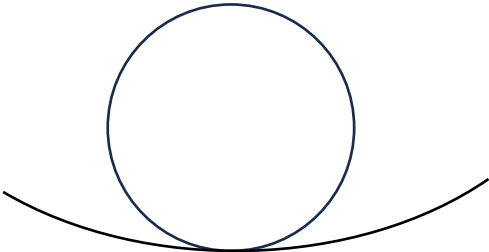
$$\mathbf{Ku} = \mathbf{F}$$

Balance of Moments

Arm

Force
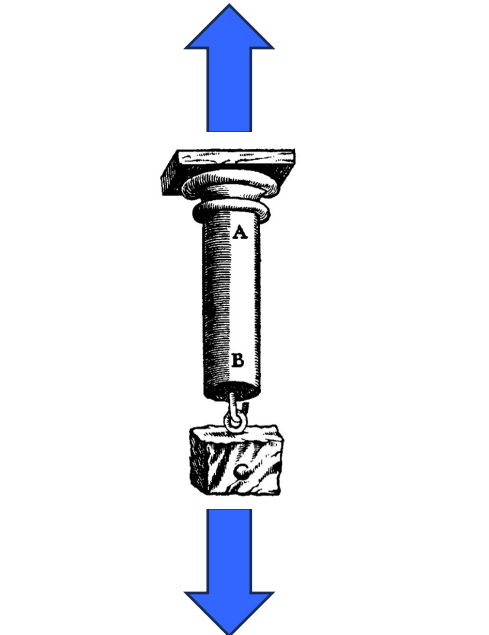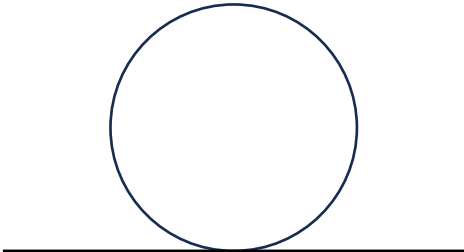
Arm

Force

$$\text{Moment} = \text{Force} \cdot \text{Arm}$$

Large force

Small force
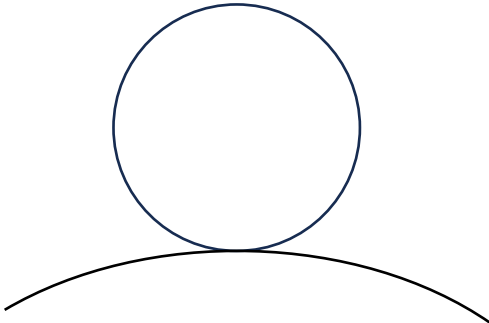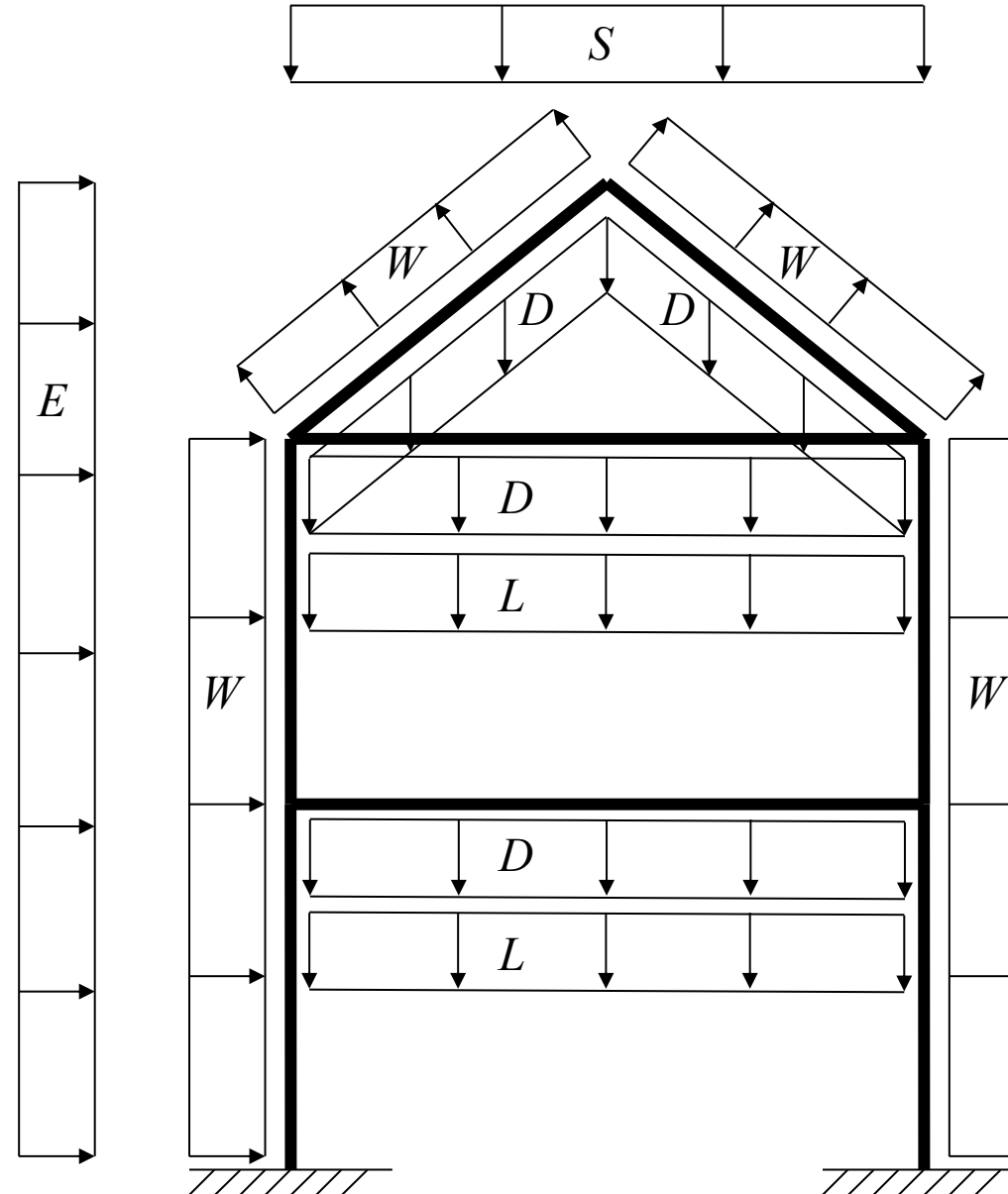
Small arm

Large arm

Types of Equilibrium
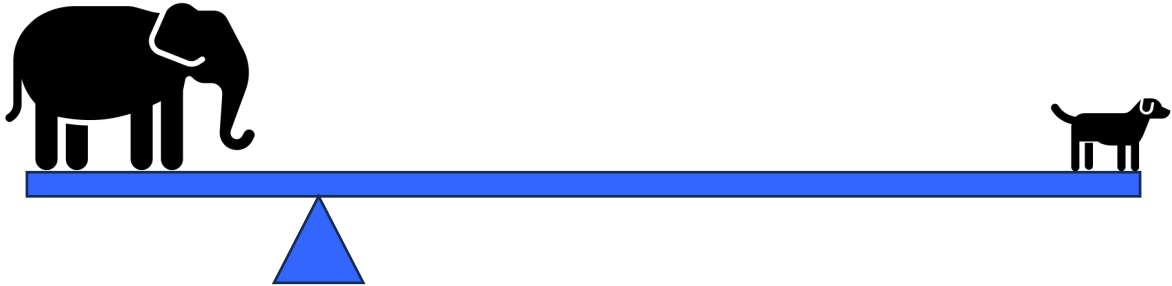
Stable

Neutral

Unstable

Forces on Structures

- *S* = snow

- *W* = wind

- *D* = dead load
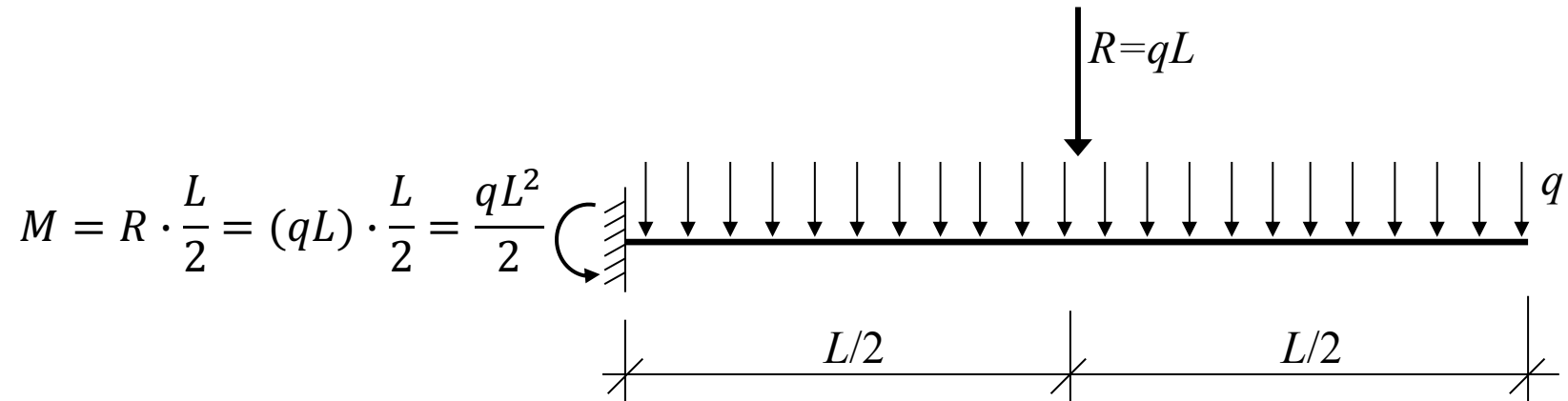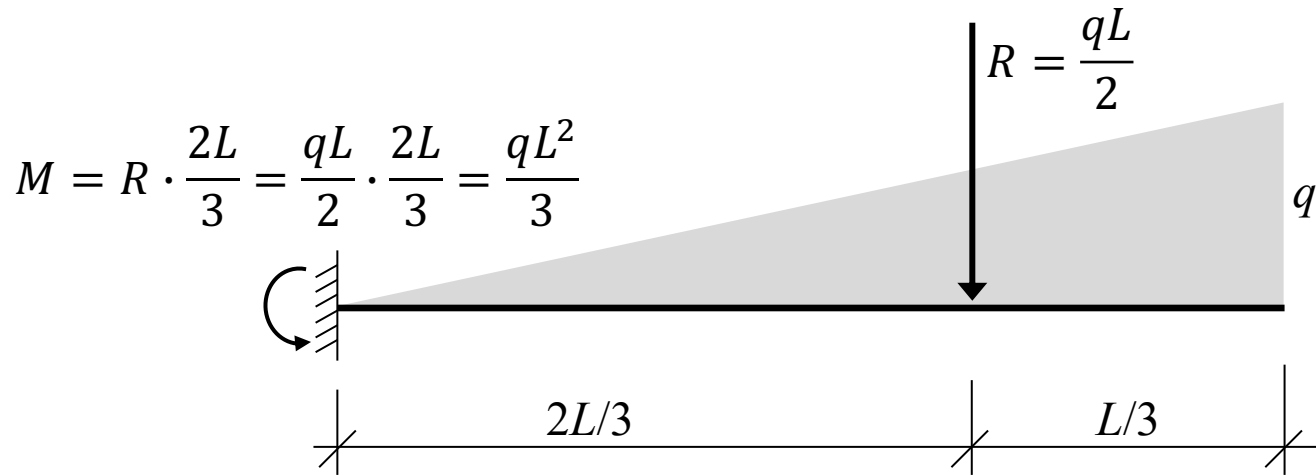
- *L* = live load

- *E* = earthquake

Force → Moment

$M=FL$ ⟲ ⫼━━━━━━━━━ L ━━━━━━━━━ ↓F
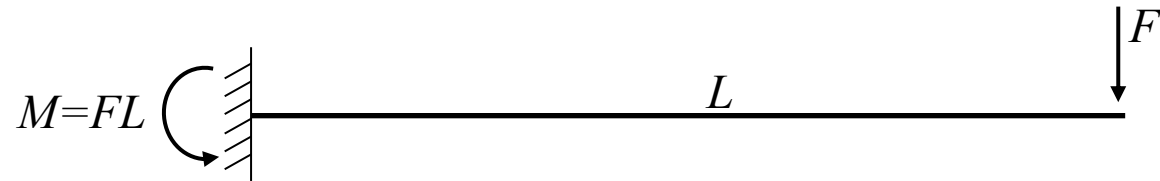
Distributed Load → Force → Moment

$$M = R \cdot \frac{L}{2} = (qL) \cdot \frac{L}{2} = \frac{qL^2}{2}$$

$$R = qL$$

$$L/2 \qquad L/2$$

$$q$$

Beyond Uniform Load

$$R = \frac{qL}{2}$$

$$M = R \cdot \frac{2L}{3} = \frac{qL}{2} \cdot \frac{2L}{3} = \frac{qL^2}{3}$$

q

2L/3   L/3

Shapes with length L	Area	Centroid location
h	$A = \dfrac{h \cdot L}{2}$	$\bar{x} = \dfrac{L}{3}$
h	$A = \dfrac{h \cdot L}{3}$	$\bar{x} = \dfrac{L}{4}$
h	$A = \dfrac{2 \cdot h \cdot L}{3}$	$\bar{x} = \dfrac{3L}{8}$

Moment → Force Pair

F

L
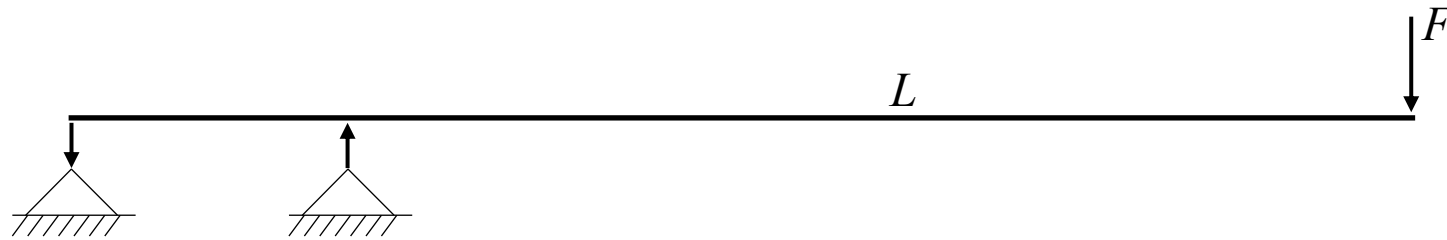
Moment → Force Pair
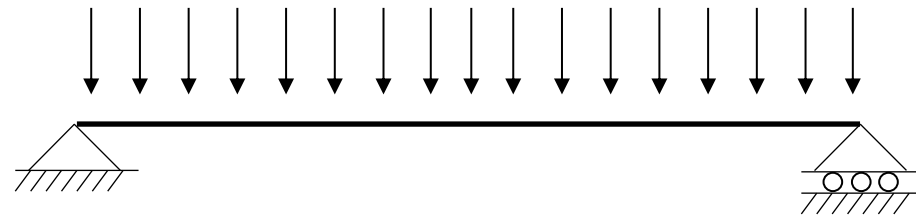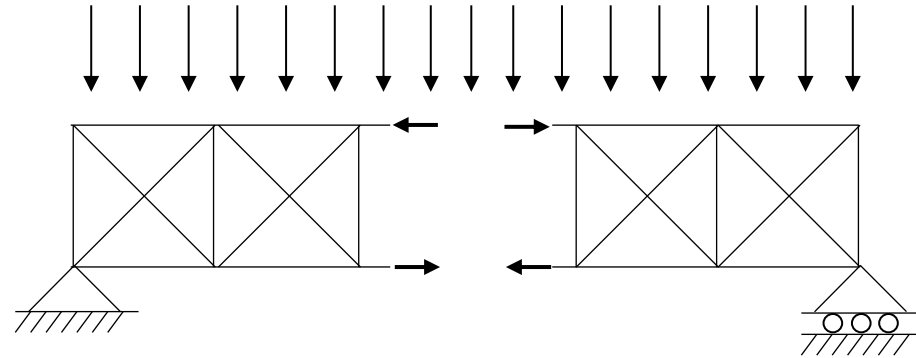
More lectures:

Terje's Toobox: