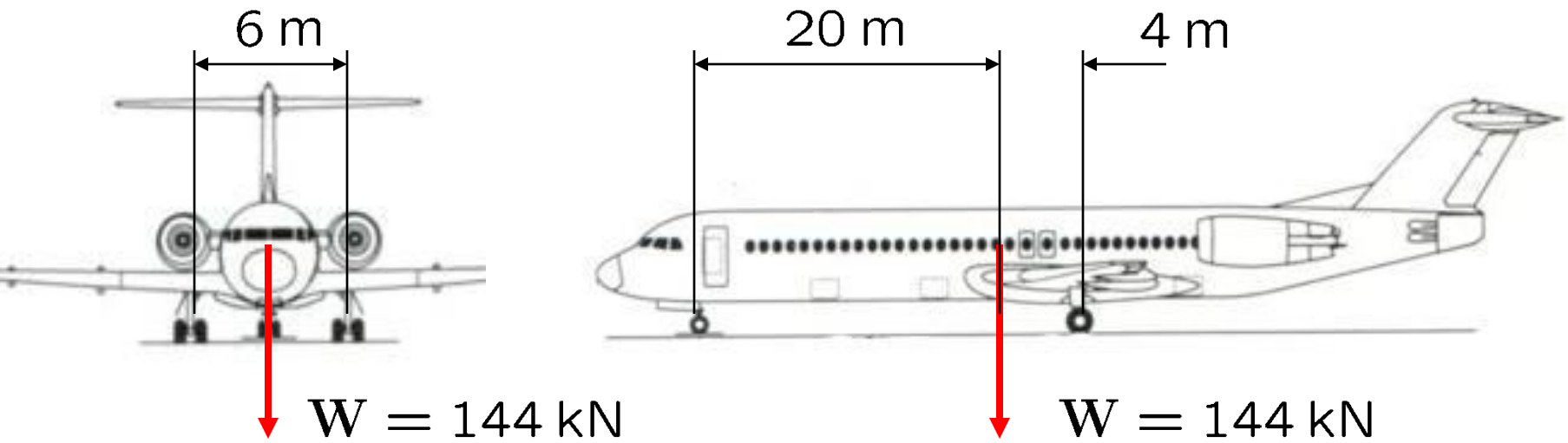
Today:

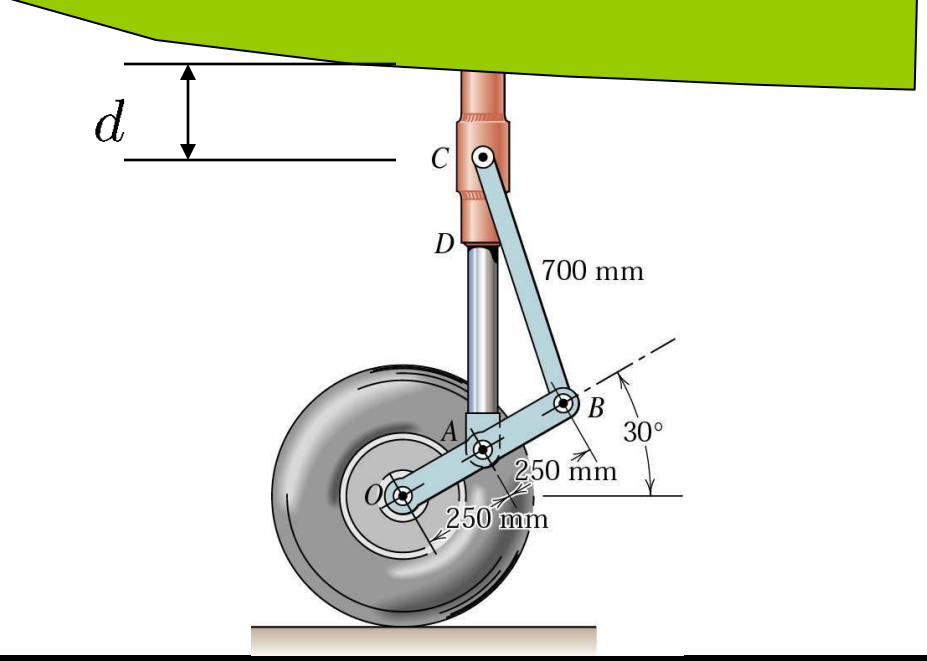
- Frames
- Centre of Mass
- Centroids of sections
- Distributed Loads

Book: Chapter 6.6, 9.1 - 9.2 and 4.9

Frame

A **frame** is a structure where at least one of its individual members is a *multi-force* member.


6 m
20 m
4 m
W = 144 kN
W = 144 kN



Calculate the reaction forces in hinge A when the normal reaction force on the nose wheel is 24 kN.

Source: R.C. Hibbeler,

"Engineering Mechanics – Statics"

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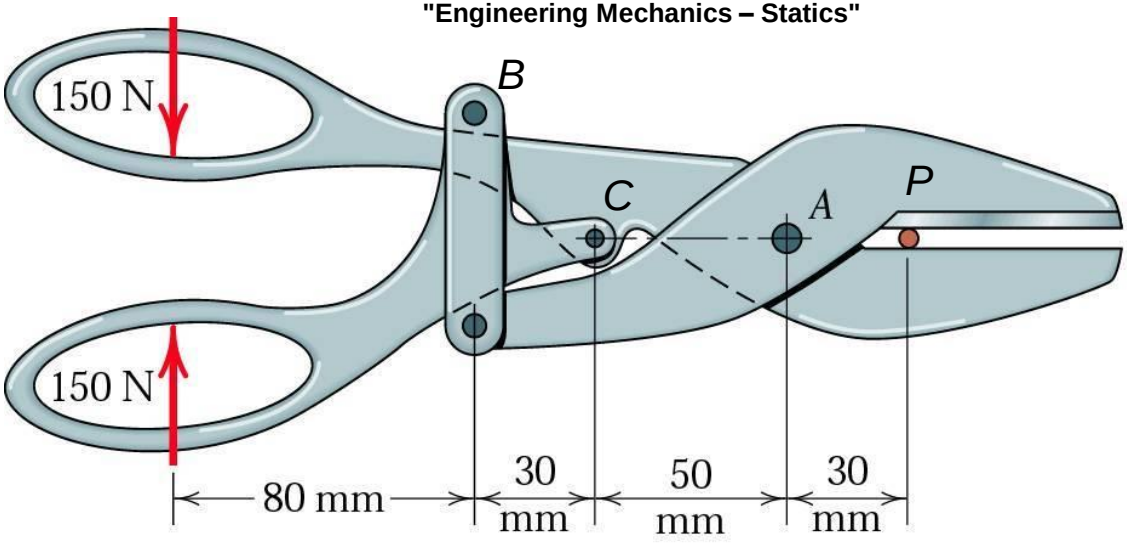
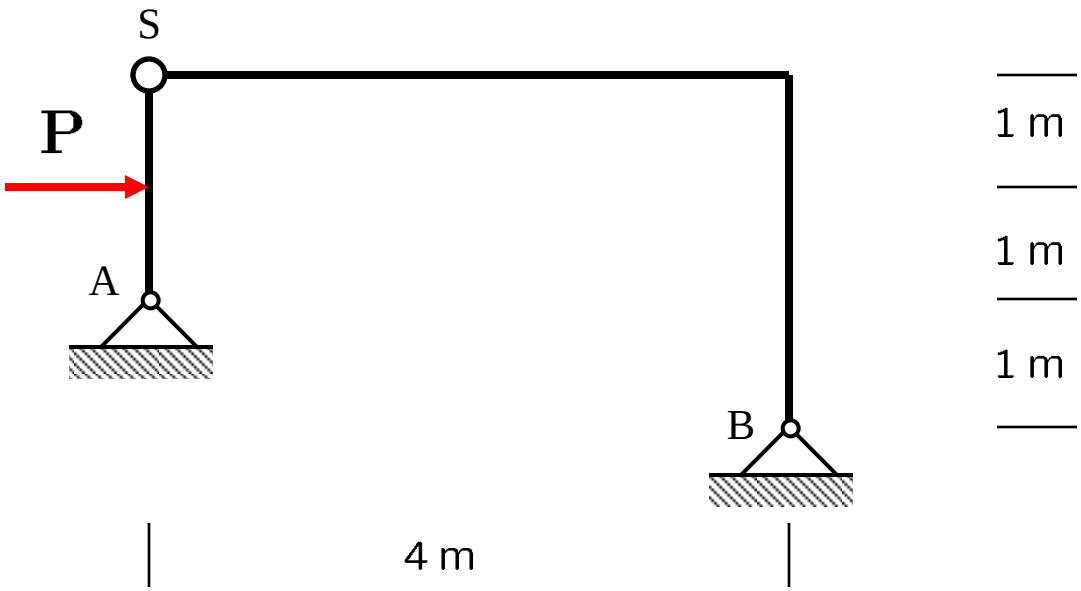
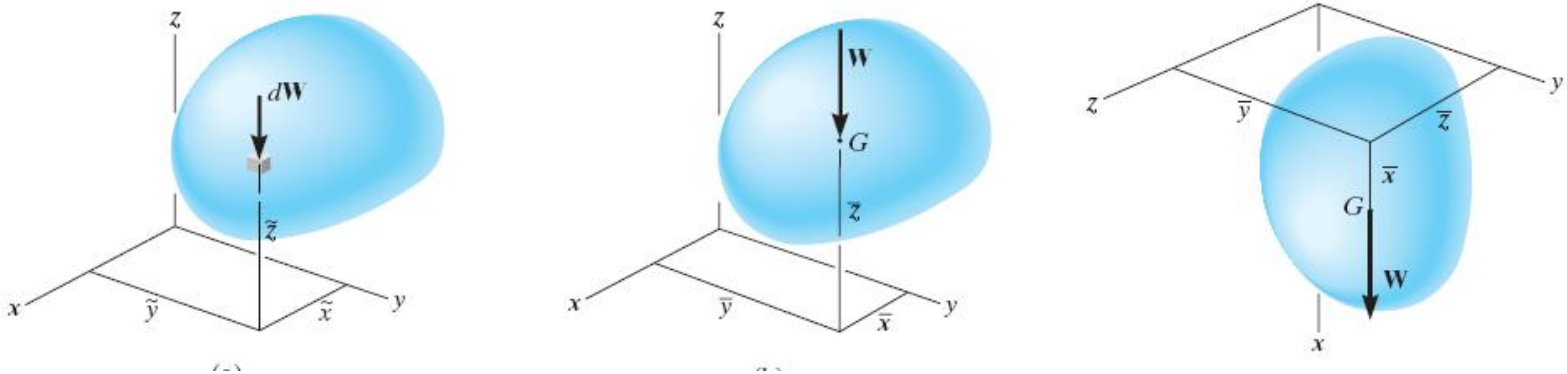


Compound-lever snips are designed to replace regular tinners' snips when large cutting forces are required. For the gripping force of 150 N, what is the cutting force P at a distance of 30 mm along the blade from the pin at A



Determine the orientation of the reaction force in A graphically .

Centre of Gravity



Source: R.C. Hibbeler,

"Engineering Mechanics – Statics"

Centre of mass:

- Equal to centre of gravity if g = constant
- Independent of gravity

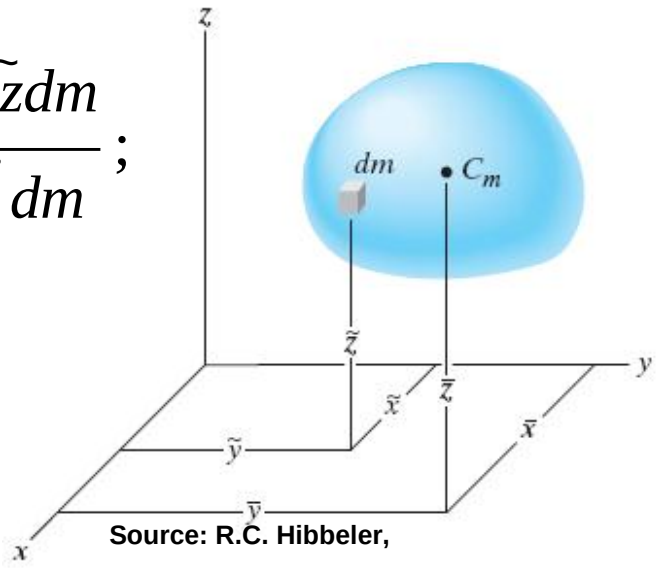
In formulas:

$$\bar{x} = \frac{\int \tilde{x} dm}{\int dm}; \quad \bar{y} = \frac{\int \tilde{y} dm}{\int dm}; \quad \bar{z} = \frac{\int \tilde{z} dm}{\int dm};$$

For bars: $dm = \rho A dx$

For surfaces: $dm = \rho t dA$

For volumes: $dm = \rho dV$



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

Center of mass for n particles

$$\bar{x} = \frac{\sum_{i=1}^{n} \tilde{x}_i m_i}{\sum_{i=1}^{n} m_i}; \qquad \bar{y} = \frac{\sum_{i=1}^{n} \tilde{y}_i m_i}{\sum_{i=1}^{n} m_i}; \qquad \bar{z} = \frac{\sum_{i=1}^{n} \tilde{z}_i m_i}{\sum_{i=1}^{n} m_i};$$

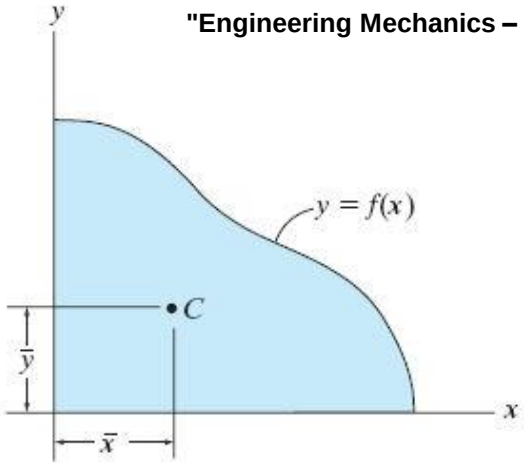
Centroid (= geometrical centre):

- Equal to centre of mass if ρ = constant
- Property depends on the shape of the body

So for a given area A:

$$\bar{x} = \frac{\int_A \tilde{x}\,dA}{\int_A dA}; \quad \bar{y} = \frac{\int_A \tilde{y}\,dA}{\int_A dA};$$

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



(a)

First moment of area

$$Q_x = \int_A \tilde{y} dA \,;\; Q_y = \int_A \tilde{x} dA$$

$$\bar{x} = \frac{Q_y}{\int_A dA};\; \bar{y} = \frac{Q_x}{\int_A dA};$$

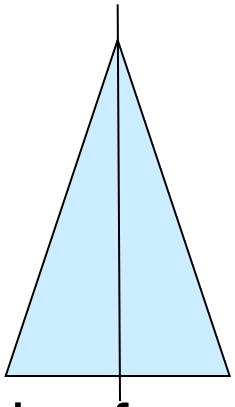
Special cases:

- If a body has an axis of symmetry, C (= centroid) is on this axis

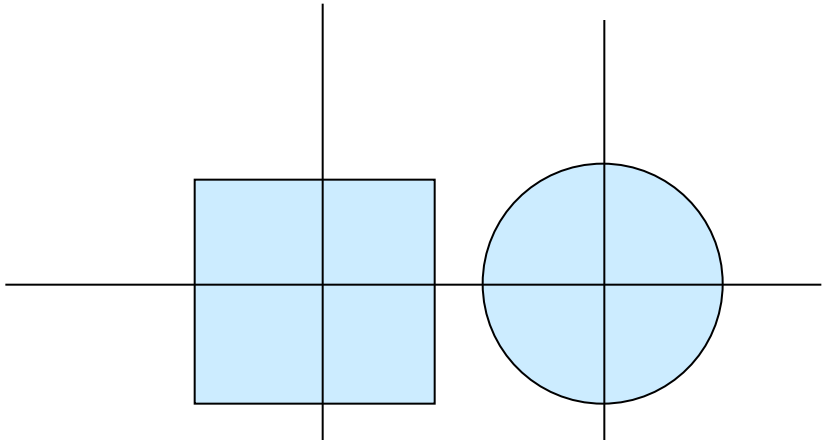
- If a body has two or more axes of symmetry, C is where both axes cross

- If a body is symmetric about a point, C is that point

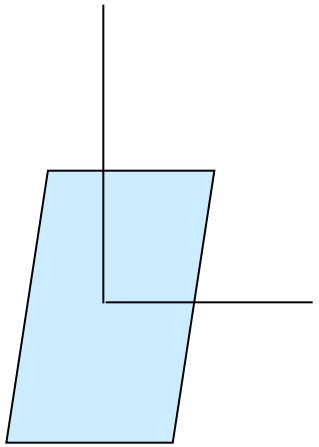
Special cases:



1 axis of symmetry



multiple axis
of symmetry

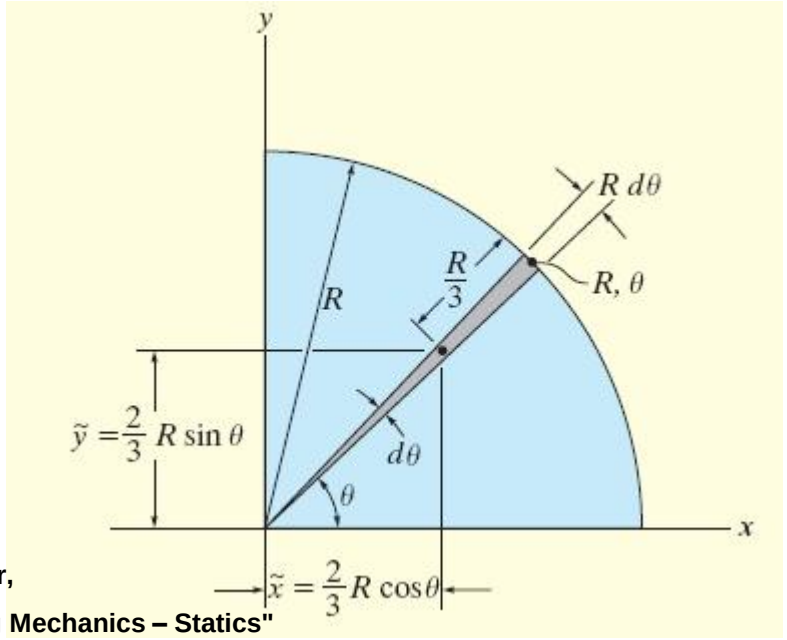


symmetry
about a point

Example:

Calculate centroid

(i.e. the coordinates)



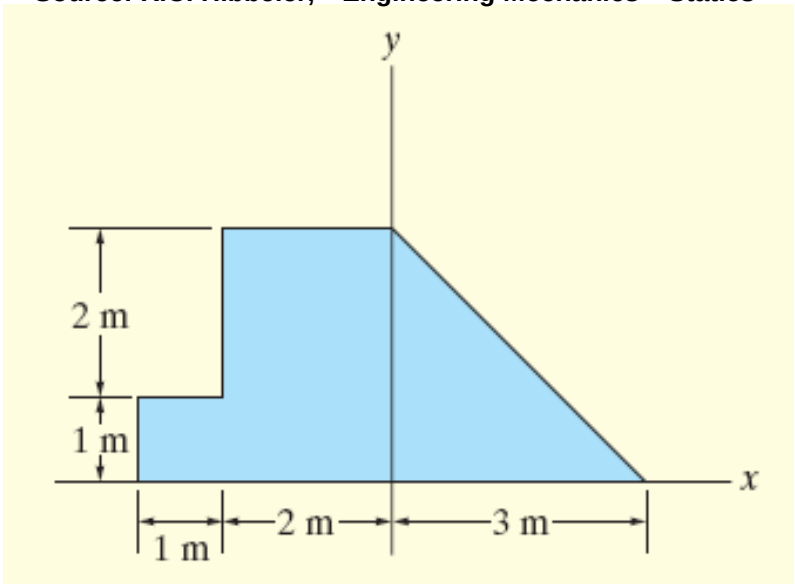
Source: R.C. Hibbeler,

"Engineering Mechanics – Statics"

For an area A composed of n parts:

$$\bar{x} = \frac{\sum_{i=1}^{n} \tilde{x}_i A_i}{\sum_{i=1}^{n} A_i}; \qquad \bar{y} = \frac{\sum_{i=1}^{n} \tilde{y}_i A_i}{\sum_{i=1}^{n} A_i}$$

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



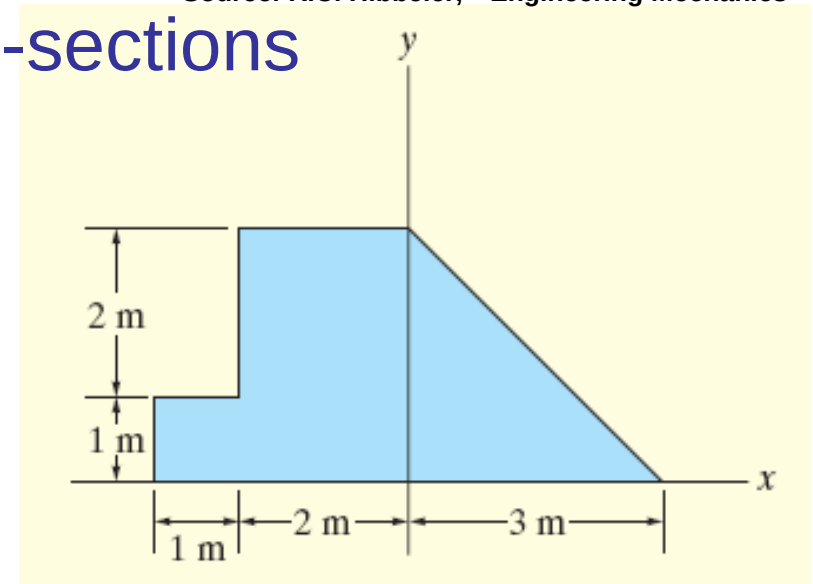
Source: R.C. Hibbeler, "Engineering Mechanics – Statics"

Example: composite cross-sections

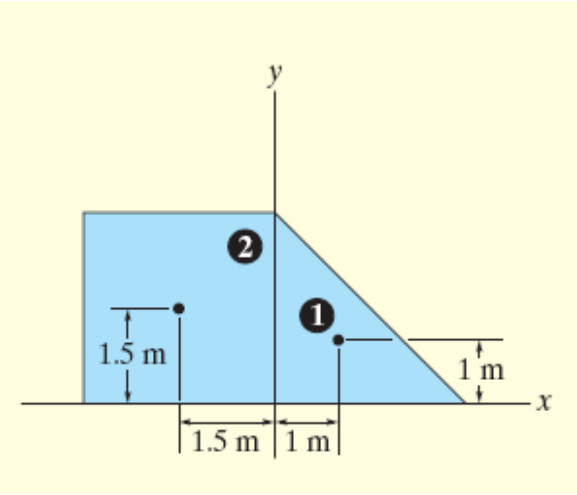
Locate the *x*- and

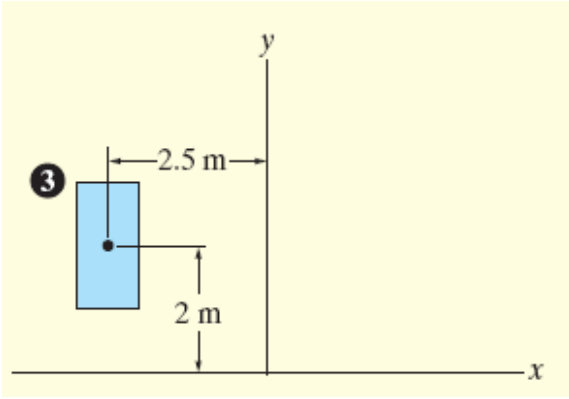
y – coordinates of

the centroid



Example continued:





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