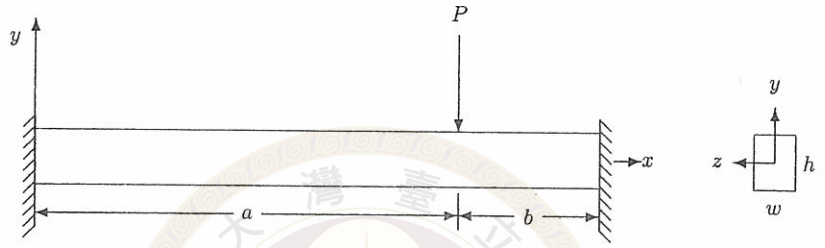
1.(25%) A rectangular beam with both ends fixed is loaded by a concentrated force P acting downward at the point $x = a$ as shown in the following figure. The beam has bending rigidity EI, width w, height h, and length $L = a + b$, where $a > 0$ and $b > 0$. The right-handed coordinates (x, y, z) are arranged in such a manner that the origin is located at the centroid of the cross section at the left fixed end, x is a horizontal axis directed longitudinally to the right, y is a vertical axis directed upward, and z is the neutral axis.
(a) How many indeterminacy does this structure have? (Explain the reason.)
(b) Calculate the deflection δ at the loading point $x = a$.
(c) Calculate the axial stress $\sigma(x, y, z)$ and the shear stress $\tau(x, y, z)$.



2.(25%) Given an unsymmetrical cross section, we set up a Cartesian coordinate system Oyz calculating $\int_A dA = 10^3$ cm^2, $\int_A y dA = -20 \times 10^3$ cm^3, $\int_A z dA = 10 \times 10^3$ cm^3, $\int_A y^2 dA = 38 \times 10^5$ cm^4, $\int_A z^2 dA = 47 \times 10^5$ cm^4, $\int_A yz dA = -10 \times 10^5$ cm^4.
(a) Locate the centroid of the cross section.
(b) Determine the principal axes through the centroid and the principal moments of inertia of the cross section.
(c) If a horizontal cantilever beam is with the above cross section and with length $L = 10$ cm, and is subjected to a vertical end-load $P = 100$ kN at the point $x = L$ acting upward in the positive y direction through the centroid, calculate the axial stress σ at a point $(x, y, z) = (5, 10, 10)$.

3.(32%) A horizontal bar of length $L = 10a$ is fixed at one end $x = 0$ and subjected to a concentrated load P at the other end $x = L$. The bar is a square thin-walled tube with midline size $a \times a$ and thickness $t = a/10$. Young's modulus is E and the shear modulus is $G = 2E/5$.
(a) If the concentrated load P at $x = L$ is given transversely and applied along one of the 4 walls of the tube so that an eccentricity $a/2$ causes the bar to twist as well as to bend, formulate the twisting angle $\phi(x)$ and the bending angle $\theta(x)$ as functions of x.
(b) If the concentrated load P at $x = L$ is compressive and is applied horizontally at the center of the tube, formulate the buckling load P in terms of a and E.

4.(8%) In a rod subjected to longitudinal concentrated and/or distributed loads and undergoing axial deformation,
(a) how is the normal strain distributed on the cross sections of the rod? and
(b) how is the normal stress distributed on the cross sections of the rod?
(c) Are there shear strains or shear stresses in the rod? If there are, how are they distributed on the cross sections?

5.(10%) In a beam subjected to transverse concentrated and/or distributed loads and undergoing bending deformation,
(a) how is the normal strain distributed on the cross sections of the beam? and
(b) how is the normal stress distributed on the cross sections of the beam?
(c) Are there shear strains or shear stresses in the beam? If there are, how are they distributed on the cross sections?