1. Demonstrate that the critical load $P$ for the **pinned-fixed** column at the first buckling mode is $\frac{20.19EI}{L^2}$. Assume that the length of the column is $L$, the moment of inertia is $I$ and the Young's modulus is $E$. Please draw the free body diagram and write down all of the derivation procedures in detail. (20%) (Hint: the smallest value of $\lambda L$ in the characteristic equation, $\tan(\lambda L) = \lambda L$, is 4.493)

2. A couple, $M_0$, is applied to a uniform cantilever beam as show in Fig 1.
   (a) Determine the expressions for the slope and deflection of the beam. (10%)
   (b) Determine the reactions at A and B (10%)
   (c) Draw the shear force and bending moment diagram for the beam (10%)

![Fig 1](image_url)

3. For the given stress state shown in Fig 2, please determine the absolute maximum shear stress. (10%)

![Fig 2](image_url)
4. The cantilever beam of an equal-leg, thin-wall X-shaped section is subjected to a transverse concentrated force $P$ shown in Fig. 3. This beam has elastic modulus $E$ and dimensions $a << b << L$.

(a) Determine the maximum tensile and compressive bending stresses. (10%)

(b) Determine the maximum value of the longitudinal shear flow. (10%)

5. The slender beam of constant flexural rigidity $EI$ suspended by two elastic springs at its ends is subjected to a linear distributed load of intensity $q(x)$ shown in Fig. 4. Both linear elastic springs are pinned to ends A, B and have the same spring constant $k$. Refer to the Cartesian coordinate system whose origin is set at the undeformed position of end point A.

(a) Determine the elastic deflection function $w(x)$. (15%)

(b) What would be the deflection function $w(x)$ if the beam was rigid? (5%)

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**Fig. 3**

**Fig. 4**