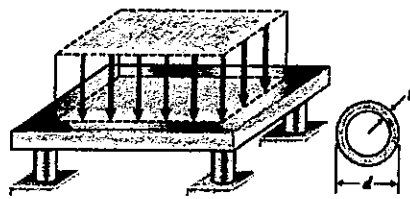(15%)　1. A steel pad supporting heavy machinery rests on four short, hollow, cast iron piers. The ultimate strength of the cast iron in compression is 344.5 MPa. The outer diameter of the piers is $d = 114$ mm and the wall thickness is $t = 10$ mm.

Using a factor of safety of 4.0 with respect to the ultimate strength, determine the total load P that may be supported by the pad.

(20%)　2. A prismatic bar AB of length L and solid circular cross section (diameter d) is loaded by a distributed torque of constant intensity t per unit distance.
(a) Determine the maximum shear stress τ_{max} in the bar. (10%)
(b) Determine the angle of twist ϕ between the ends of the bar. (10%)
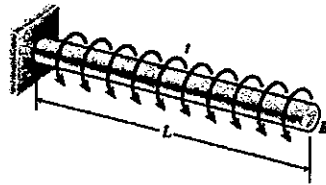
(20%)　3. A wood beam ABC with simple supports at A and B and an overhang BC has height $h = 300$ mm. The length of the main span of the beam is $L = 3.6$ m and the length of the overhang is $L/3 = 1.2$ m. The beam supports a concentrated load $3P = 18$ kN at the midpoint of the main span and a moment $PL/2 = 10.8$ kN · m at the free end of the overhang. The wood has weight density $\gamma = 5.5$ kN/m³.
(a) Determine the required width b of the beam based upon an allowable bending stress of 8.2 MPa. (10%)
(b) Determine the required width based upon an allowable shear stress of 0.7 MPa. (10%)
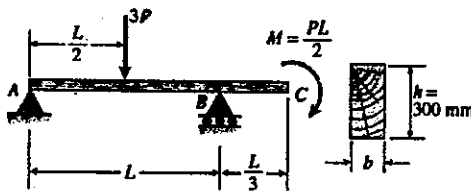
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(15%)　　4. An element on the surface of a drive shaft is in pure shear and is subjected to stresses τ_{xy} = 19 MPa. Determine the following.

(a) The stresses acting on an element oriented at a counterclockwise angle $\theta = 52°$ from the x axis. (8%)

(b) The principal stresses. (7%)

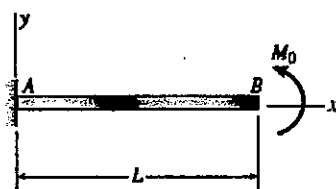Show all results on sketches of properly oriented elements.
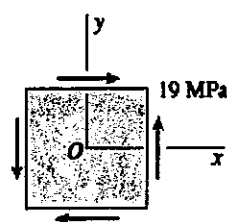
(15%)　　5. A gondola on a ski lift is supported by two bent arms. Each arm is offset by the distance b = 180 mm from the line of action of the weight force W. The allowable stresses in the arms are 100 MPa in tension and 50 MPa in shear.

If the loaded gondola weighs 12 kN, what is the minimum diameter d of the arms?
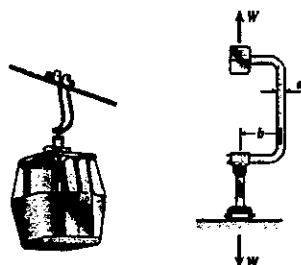
(15%)　　6. Derive the equation of the deflection curve for a cantilever beam AB when a couple M_0 acts counterclockwise at the free end. Also, determine the deflection δ_B and slope θ_B at the free end.

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