Problem M11

A solid steel shaft of length 3 m is required to transmit a torque of 200 kNm. The maximum allowable shear stress that the steel can support, τ_y, is 200 MPa (shear yield stress).

(a) If the shaft has a solid circular cross section, determine the minimum diameter of the shaft to transmit the torque without yielding.

(b) If the shaft is instead hollow with a ratio of external to internal diameter of 5/4, what is now the required diameter of the shaft, what is the weight saving over case (a)?.

(c) What is the ratio of (i) the angle of twist between the ends of the shafts and (ii) the torsional stiffness in the two cases?.

(d) What is the maximum extensional stress acting in the shaft in (b), in what direction(s) does it act?.