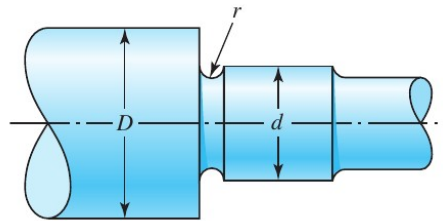


You have to submit all the problems by 11.00 pm, 26/9/2024 [Moodle].

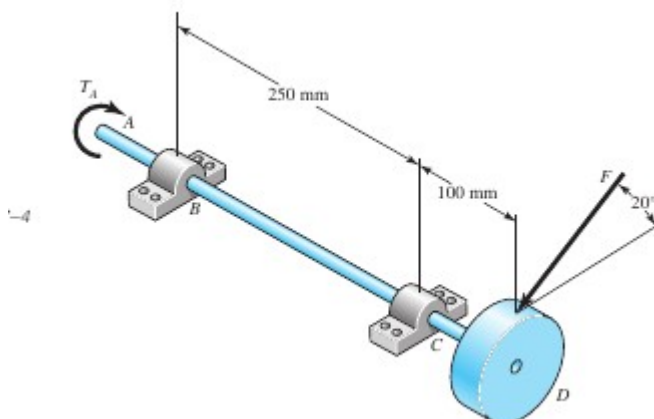
1. A shaft is loaded in bending and torsion such that $M_a = 70$ Nm, $T_a = 45$ Nm, $M_m = 55$ Nm, and $T_m = 35$ Nm. For the shaft, ultimate strength = 700 MPa, yield strength = 560 MPa, and a fully corrected endurance limit of = 210 MPa is assumed. Let $K_f = 2.2$ and $K_{fs} = 1.8$. For a factor of safety of 2.0 determine the minimum acceptable diameter of the shaft. Use the Goodman criterion. Clearly mention any assumptions that you make.

2. The section of shaft shown in the figure is to be designed to approximate relative sizes of $d = 0.75D$ and $r = D/20$ with diameter d conforming to that of standard rolling-bearing bore sizes. The shaft is to be made of SAE 2340 steel, heat-treated to obtain minimum strengths in the shoulder area of 1200 MPa ultimate tensile strength and 1100 MPa yield strength with a Brinell hardness not less than 370. At the shoulder the shaft is subjected to a completely reversed bending moment of 67.800 Nmm, accompanied by a steady torsion of 45.200 Nmm. Use a factor of safety of 2.5 and size the shaft for an infinite life using the DE-Goodman criterion.

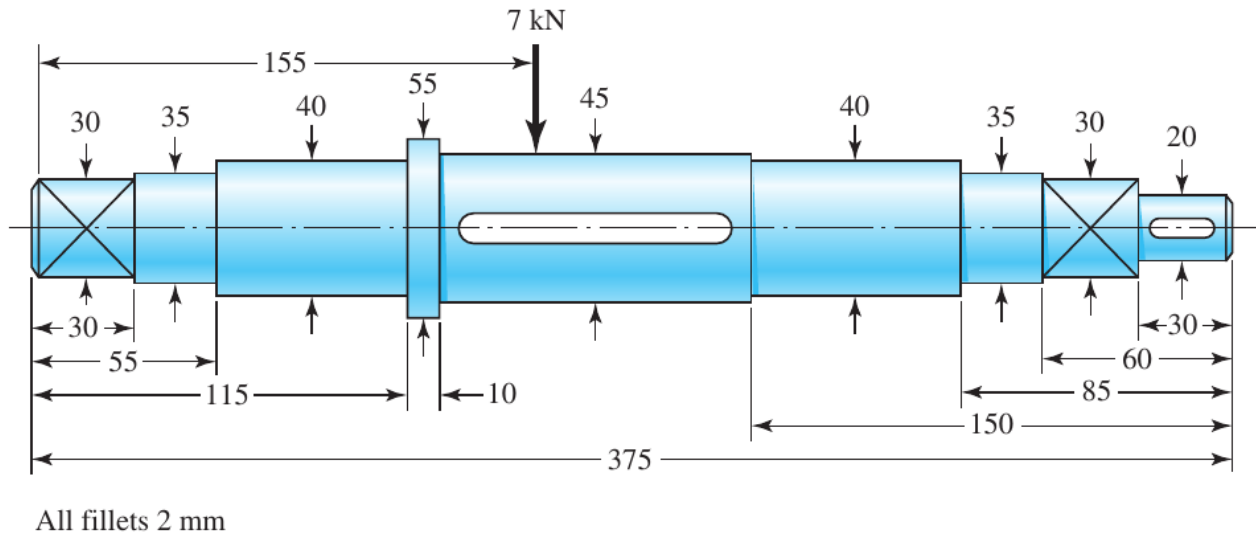
Problem 1-3
Section of a shaft containing a grinding-relief groove. Unless otherwise specified, the diameter at the root of the groove $d_r = d - 2r$, and though the section of diameter d is ground, the root of the groove is still a machined surface.



3. The rotating solid steel shaft is simply supported by bearings at points B and C and is driven by a gear (not shown) which meshes with the spur gear at D, which has a 150-mm pitch diameter. The force F from the drive gear acts at a pressure angle of 20° . The shaft transmits a torque to point A of $T_A = 340$ Nm. The shaft is machined from steel with yield strength = 420 MPa and ultimate tensile strength = 560 MPa. Using a factor of safety of 2.5, determine the minimum allowable diameter of the 250-mm section of the shaft based on (a) a static yield analysis using the distortion energy theory and (b) a fatigue-failure analysis. Assume sharp fillet radii at the bearing shoulders for estimating stress-concentration factors.



4. An AISI 1020 cold-drawn steel shaft with the geometry shown in the figure carries a transverse load of 7 kN and a torque of 107 Nm. Examine the shaft for strength and deflection. If the largest allowable slope at the bearings is 0.001 rad and at the gear mesh is 0.0005 rad, what is the factor of safety guarding against damaging distortion? What is the factor of safety guarding against a fatigue failure assuming the Goodman criterion? If the shaft turns out to be unsatisfactory, what would you recommend to correct the problem?



5. Consider a simply supported steel shaft as depicted in with 25.4 mm diameter and a 787.4 mm span between bearings, carrying two gears weighing 155.69 and 244.65 N. Estimate the first critical speed in rpm using Rayleigh's method.

