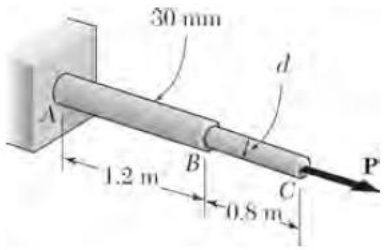
Mechanical Engineering Science

Assignment questions/self study/Home work material:

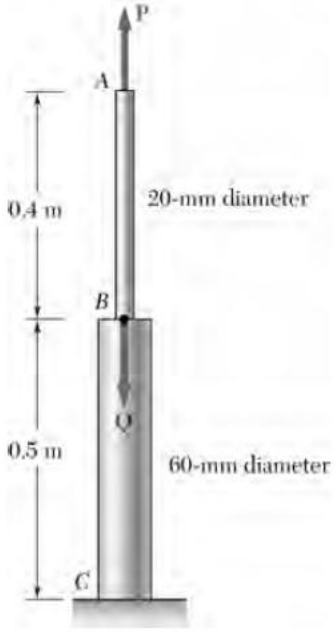
Unit: 2 – Engineering Materials, Stress Analysis, and Power Transmission Dr. MBK

1. Compare and contrast ferrous and nonferrous metals in terms of composition, mechanical properties, corrosion behavior, and industrial applications. Include a discussion on why aluminum alloys are preferred in aerospace over traditional ferrous materials.
2. Analyze the differences between tool steels and stainless steels with respect to alloying elements and performance in high-temperature environments. Explain the selection of these steels for cutting tools and engineering applications respectively.
3. Plastics, ceramics, abrasives, and glass play essential roles in today's industries. Discuss the advantages and limitations of these non-metallic materials and justify their use in at least two engineering applications each (e.g., electronics, construction, biomedical, etc.).
4. Explain how fiber-reinforced composites (FRCs) and metal matrix composites (MMCs) are engineered to overcome the limitations of traditional materials. Compare their mechanical performance, weight efficiency, and cost for use in automotive or aerospace structures.
5. Discuss the working principles and applications of smart materials, specifically piezoelectric materials, shape memory alloys, and rheological fluids.
6. Explain the concept of Factor of Safety (FOS) and its importance in mechanical design.
7. Compare belt and gear drives in terms of efficiency, speed ratio control, maintenance, and suitability for high-torque applications.
8. Define the mechanical properties: strength, stiffness, plasticity, elasticity, toughness, resilience, and hardness. Explain how these properties are represented in the stress–strain diagram obtained from a tensile test, and discuss their relevance in selecting materials for engineering applications.
9. Differentiate between flat belt and V-belt drives. Explain the condition under which an open or crossed belt drive is selected.
10. Explain the classification of gears and define key gear terminologies such as module, pitch circle**,** pressure angle**,** and gear ratio**.**
11. A simple gear train has three gears. Gear A (driver) has 20 teeth, Gear B has 40 teeth, and Gear C (driven) has 60 teeth. Calculate the speed of the driven gear if the driver runs at 600 rpm.
12. A compound gear train consists of two shafts and three gears. Develop the expression for the total speed ratio and solve a problem where Gear A drives Gear B–C (compound), which in turn drives Gear D.
13. An 80-m-long wire of 5-mm diameter is made of a steel with E = 200 GPa and an ultimate tensile strength of 400 MPa. If a factor of safety of 3.2 is desired, determine (a) the largest allowable tension in the wire, (b) the corresponding elongation of the wire.
14. A control rod made of yellow brass must not stretch more than 3 mm when the tension in the wire is 4 kN. Knowing that E =105 GPa and that the maximum allowable normal stress is 180 MPa, determine (a) the smallest diameter that can be selected for the rod, (b) the corresponding maximum length of the rod.

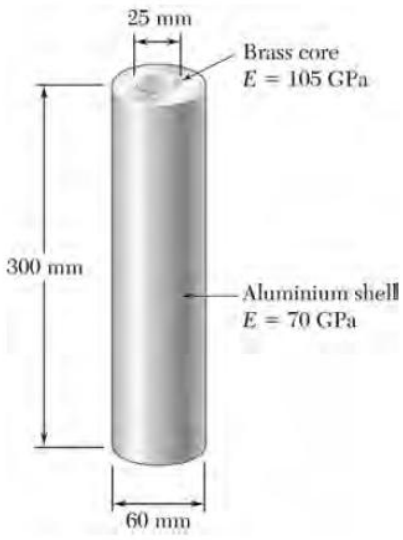
15. Two gage marks are placed exactly 250 mm apart on a 12-mm-diameter aluminum rod with E = 73 GPa and an ultimate strength of 140 MPa. Knowing that the distance between the gage marks is 250.28 mm after a load is applied, determine (a) the stress in the rod, (b) the factor of safety.
16. A single axial load of magnitude P = 58 kN is applied at end C of the brass rod ABC. Knowing that E =105 GPa, determine the diameter d of portion BC for which the deflection of point C will be 3 mm.



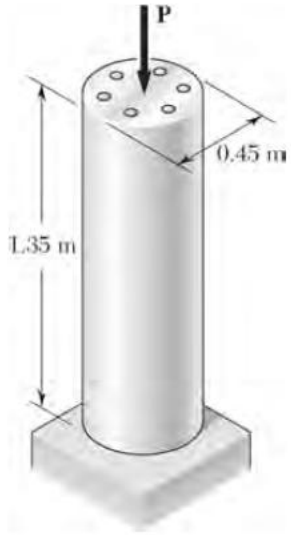
17. Both portions of the rod *ABC* are made of an aluminum for which $E = 70$ GPa. Knowing that the magnitude of **P** is 4 kN, determine (*a*) the value of **Q** so that the deflection at *A* is zero, (*b*) the corresponding deflection of *B*.



18. An axial force of 200 kN is applied to the assembly shown by means of rigid end plates. Determine (*a*) the normal stress in the aluminum shell, (*b*) the corresponding deformation of the assembly.



19. The 1.35 m concrete post is reinforced with six steel bars, each with a 28 mm diameter. Knowing that E_s=200 GPa, E_c = 29 GPa, determine the normal stresses in the steel and in the concrete when a 1560 kN axial centric force **P** is applied to the post.



20. A pinion gear with 22 teeth and a module of 6 mm has a rotational speed of 1200 rpm and drives a gear at 660 rpm. Determine: i) The number of teeth on the gear, and; ii) The theoretical centre distance
21. A pair of gears has been designed with a velocity ratio of 3.20. The pinion has 20 teeth and the circular pitch is 78.54 mm. Determine: i) The number of teeth on the driven gear. ii) The module for the gears. iii) The theoretical centre distance.
22. An engine, running at 150 r.p.m., drives a line shaft by means of a belt. The engine pulley is 750 mm diameter and the pulley on the line shaft being 450 mm. A 900 mm diameter pulley on the line shaft drives a 150 mm diameter pulley keyed to a dynamo shaft. Find the speed of the dynamo shaft, when 1. there is no slip, and 2. there is a slip of 2% at each drive.

23. Two parallel shafts 6 metres apart are provided with 300 mm and 400 mm diameter pulleys and are connected by means of a cross belt. The direction of rotation of the follower pulley is to be reversed by changing over to an open belt drive. How much length of the belt has to be reduced?
24. In an open belt drive, pulleys are 500mm and 1200mm in diameter on parallel shafts 4m apart. The maximum tension in the belt is limited to 1800N and coefficient of friction = 0.3. The driving pulley 1200 mm diameter is running at 210 rpm, calculate power transmitted by the belt drive.
25. Why the slack side of the belt of a horizontal belt drive is preferable to place on the top side?