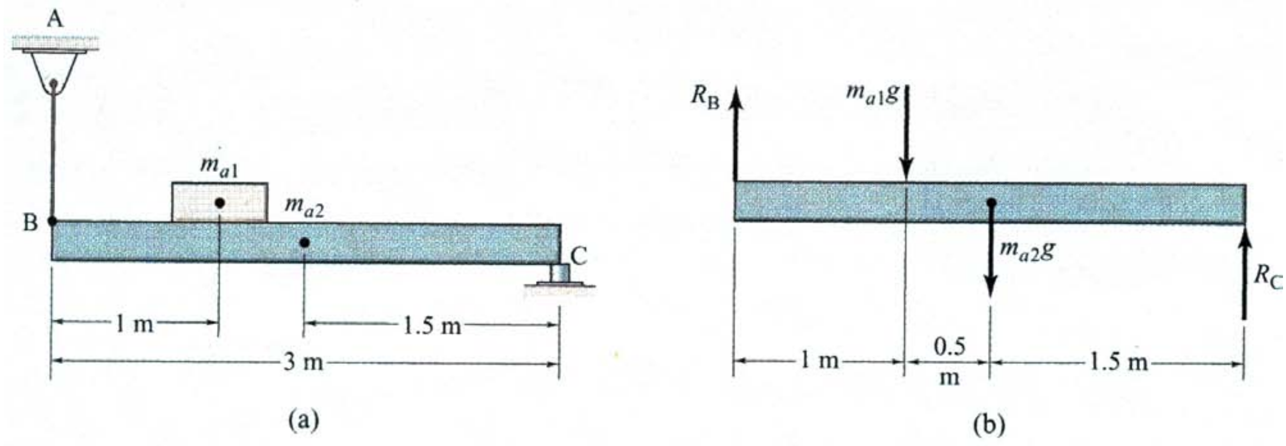
EXAMPLES – INTRODUCTION

Example 1 (Hamrock p.53)

As shown in figure 2.12(a), a 3m long bar is supported at the left end (B) by a 6 ram diameter steel wire and at the right end (C) by a 10mm diameter steel cylinder. The bar carries a mass ma1=200 kg, and the mass of the bar itself is ma2=50 kg.

Find: Determine the stresses in the wire and in the cylinder.



a) Load drawing b) Free-body diagram

Example 2 (Hamrock p.160)

A hollow carbon steel shaft 50 mm long must carry a normal force of 5000 N at a normal stress of 100 MPa. The inside diameter is 0.65 of the outside diameter.

Find: The outside diameter, the axial deformation, and the spring rate.

Example 3 (Hamrock p.160)

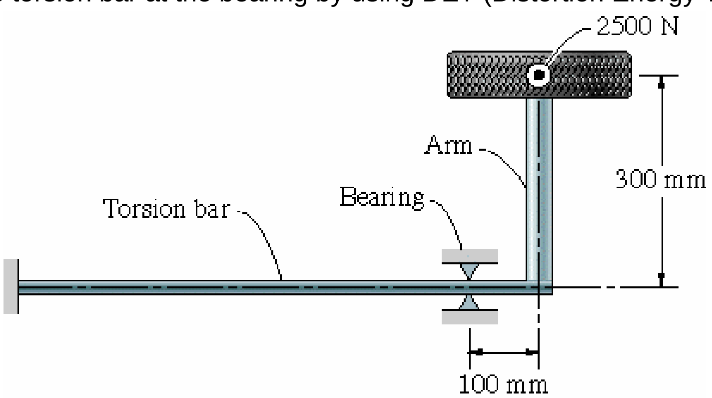
A fisher catches a salmon with a lure fastened to a 0.45 mm diameter nylon line. When the fish bites, the line is 46 m long from the fish to the reel. The modulus of elasticity of the line is 4 GPa, and its ultimate strength is 70 N. The salmon pulls with a force of 50 N.

Find: The elastic elongation of the line, the spring rate, and the tensile stress in the line.

Example 4 (Hamrock p.245)

In the rear wheel suspension of the Volkswagen Beetle, the spring motion is provided by a torsion bar fastened to an arm on which the wheel is mounted. See Figure for more details. The torque in the torsion bar is created by the 2500 N force acting on the wheel from the ground through a 300 mm lever arm. Because of space limitations the bearing holding the torsion bar is situated 100 mm from the wheel shaft. The diameter of the torsion bar is 28 mm.

Find: The stresses in the torsion bar at the bearing by using DET (Distortion Energy Theory)



Rear wheel suspension

Example 5 (Hamrock p.233)

A flat plate made of brittle material and with a major height H of 4.5 mm, a minor height of 2.5 mm, and a fillet radius r of 0.5 mm.

Find: The stress concentration factor and the maximum stress for the following conditions: (a) Axial loading, (b) Pure bending, (c) Axial loading but with fillet radius reduced to 0.25 mm

Example 6 (Hamrock p.234)

A 50 mm wide, 5 mm high rectangular plate has a 5 mm diameter central hole. The allowable stress due to applying a tensile force is 700 MPa.

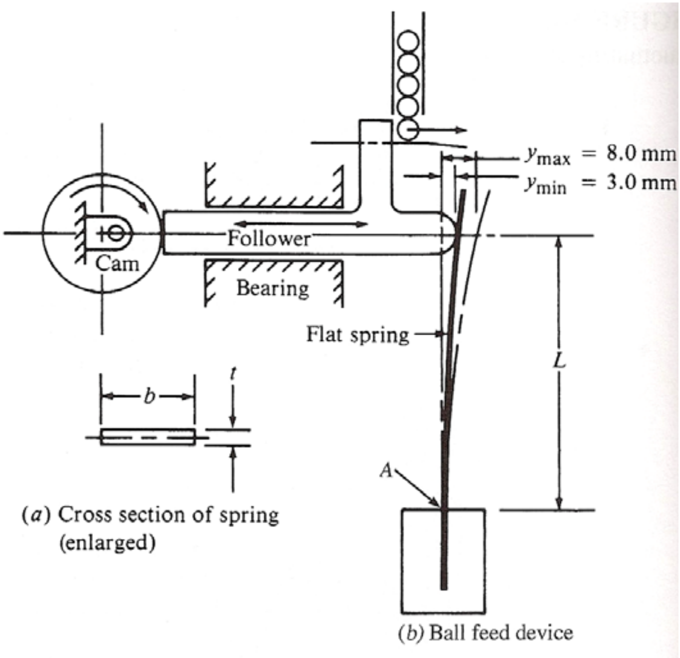
Find: (a) The maximum tensile force that can be applied, (b) The maximum bending moment that can be applied to reach the maximum stress.

Example 7 (Mott p. 170)

For the flat steel spring shown in Figure 5-6, compute the maximum stress, the minimum stress, the mean stress, and the alternating stress. Also compute the stress ratio, R. The length L is 65 mm. The dimensions of the spring cross section are t = 0.80 mm and b = 6.0 mm.

Find: Compute the maximum, minimum, mean, and alternating tensile stresses in the flat spring. Compute the stress ratio, R.

FIGURE 5–6
Example of cyclic loading in which the flat spring is subjected to fluctuating stress



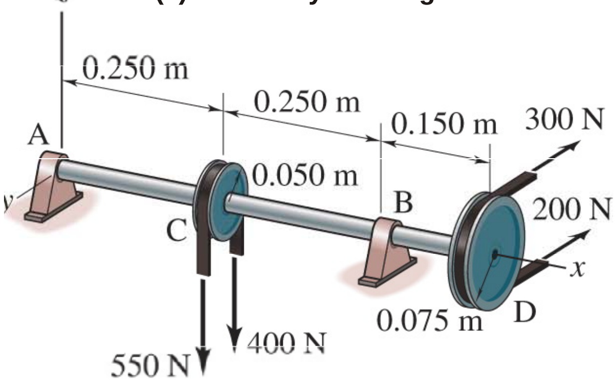
EXAMPLES – SHAFTS

Example 1 (Hamrock p. 426) ***Computer Demonstration***

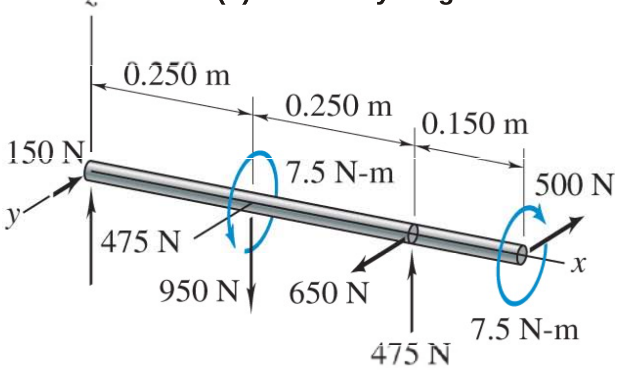
An assembly of belts has tensile forces applied as shown in Figure and friction-less journal bearings at locations A and B. The yield strength of the shaft material is 500 MPa, and the safety factor is 2.

Find: Determine the smallest safe shaft diameter by using both the DET and the MSST. Also, provide a free-body diagram as well as moment and torque diagrams.

(a) Assembly drawing



(b) Free-body diagram

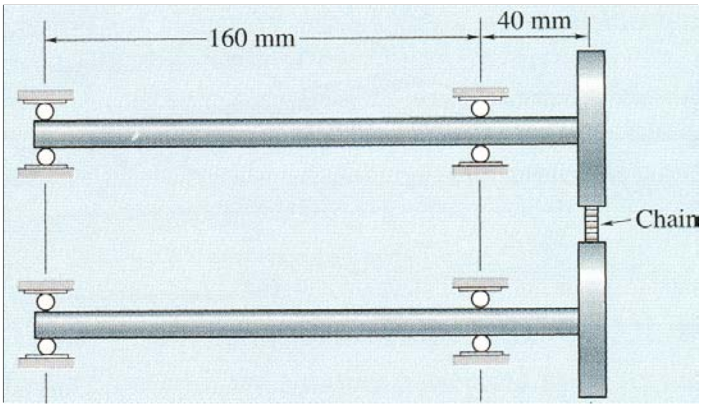


Example 2 (Hamrock p. 426)

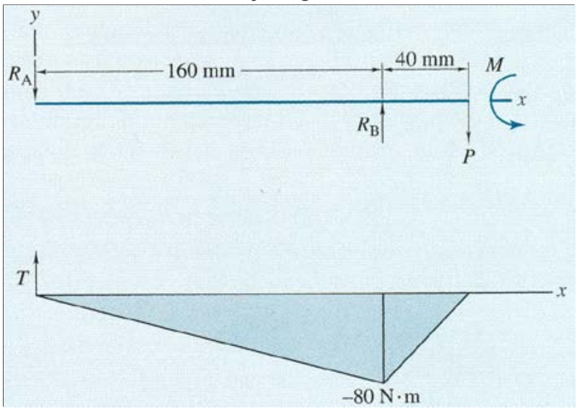
The power from the motor of a front-wheel-drive car is transmitted to the gearbox by a chain drive. The two chain wheels are the same size. The chain is not prestressed, so the loose chain exerts no force. The safety factor is 4. The shaft is to be made of AISI1080 steel. The chain transmits 100 kW of power at the chain speed of 50 m/s when the motor speed is 6000 rpm.

Find: The appropriate shaft diameter by using the DET.

a. Chain drive assembly

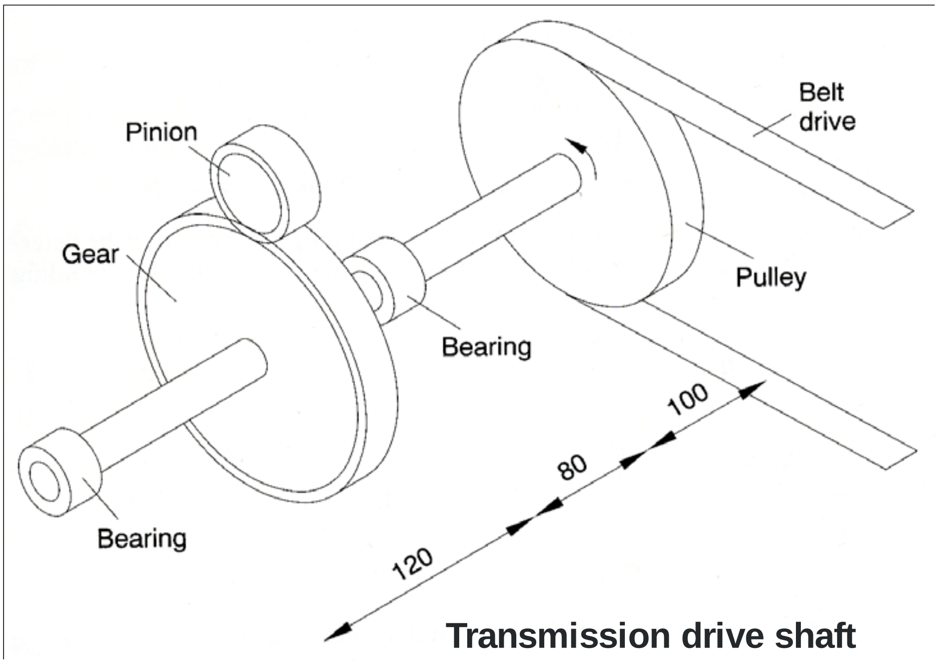


b. Free body diagram of forces



Example 3 (Shilds p. 57)

Determine a sensible minimum nominal diameter for the drive shaft illustrated in Fig. consisting of a mid-mounted spur gear and overhung pulley wheel. The shaft is to be manufactured using 817M40 hot-rolled alloy steel, with σuts =1000 MPa, σy=770 MPa and Brinell hardness approximately 220 BHN. The radius of the fillets at the gear and pulley shoulders is 3 mm. The power to be transmitted is 8000 W at 900 rpm. The pitch circle diameter of the 20° pressure angle spur gear is 192 mm and the pulley diameter is 250 mm. The masses of the gear and pulley are 8 kg and 10 kg respectively. The ratio of belt tensions should be taken as 2.5. Profiled keys are used to transmit torque through the gear and pulley. The safety factor is 2. A shaft nominal reliability of 90 per cent is desired. Assume the shaft is of constant diameter for the calculation.



Transmission drive shaft

Example 4

Figure shows a simply supported shaft arrangement. A solid shaft of 50mm diameter made of low-carbon steel is used. The following are given: x1=750 mm, x2=1000 mm, FA=350N. (E=210.000 MPa)

Find: Determine the first critical speed by using the Dunkerley method.

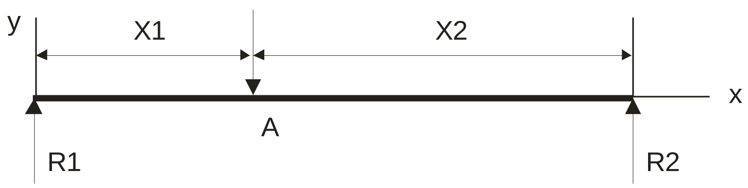


Figure: Simply supported shaft

Example 5 (Hamrock p. 455) *Computer Demonstration*

Figure 11.9 shows a simply supported shaft arrangement. A solid shaft of 50mm diameter made of low-carbon steel is used. The following are given: x1=750 mm, x2=1000 mm, x3=500 mm, $P_A=F_A$=350N, and $P_B=F_B$=550 N.

Find: Determine the first critical speed by using тhe Dunkerley method.

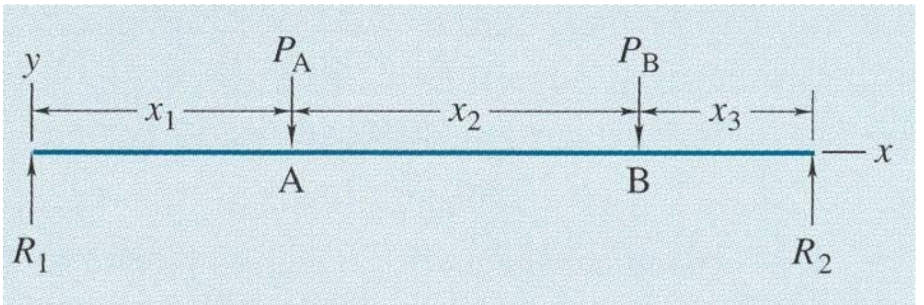


Figure 11.9 Simply supported shaft arrangement for Example 11.5.

Example 6 (Flywheels)

The output, or load torque, of a flywheel used in a punch press for each revolution of the shaft is 12Nm from 0 to π and from 3π/2 to 2π and 144 Nm from π to 3π/2. The coefficient of fluctuation is 0.05 about an average speed of 600 rpm. Assume that the flywheel's solid disk is made of low-carbon steel of constant 25.4 mm thickness.

Determine the following:

(a) The average load or output torque, (b) The locations $\Theta_{\omega max}$ and $\Theta_{\omega min}$, (c) The energy required

(d) The outside diameter of the flywheel

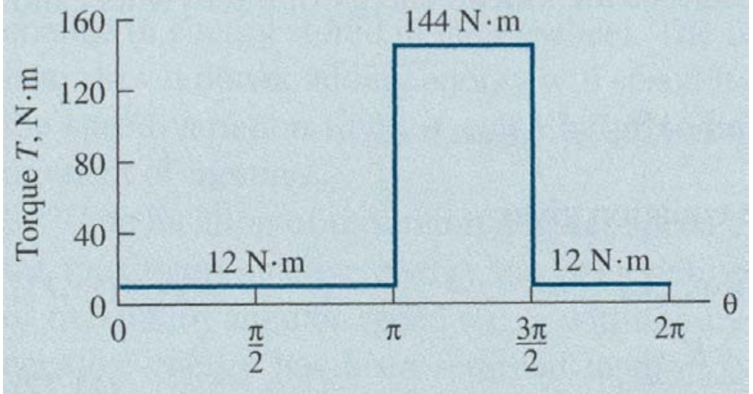


Figure 11.12 Load or output torque variation

EXAMPLES – BEARINGS

A. SLIDING BEARINGS

Example 1 (Childs 2nd p. 46)

A bearing is to be designed to carry a radial load of 700 N for a shaft of diameter 25 mm running at a speed of 75 rpm (see Fig. 2.7).

Calculate the PV value and by comparison with the value in table 4.2 determine a suitable bearing material.

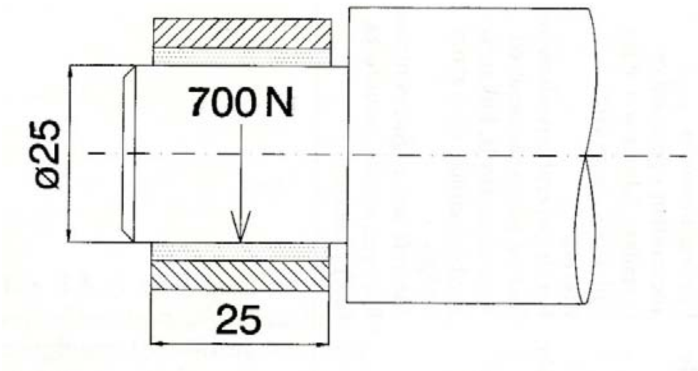


Fig. 2.7 Boundary lubricated bearing design example.

Example 2 (Childs 2nd p. 57)

A full journal bearing has a nominal diameter of 50 mm and a bearing length of 25mm (see Fig. 2.12). The bearing supports a load of 3000 N, and the journal design speed is 3000 rpm. The radial clearance has been specified as 0.04mm. A SAE 10 oil has been chosen and the lubricant supply temperature is 50°C.

Find the temperature rise of the lubricant, the lubricant flow rate, the minimum film thickness, the torque required to overcome friction and the heat generated in the bearing.

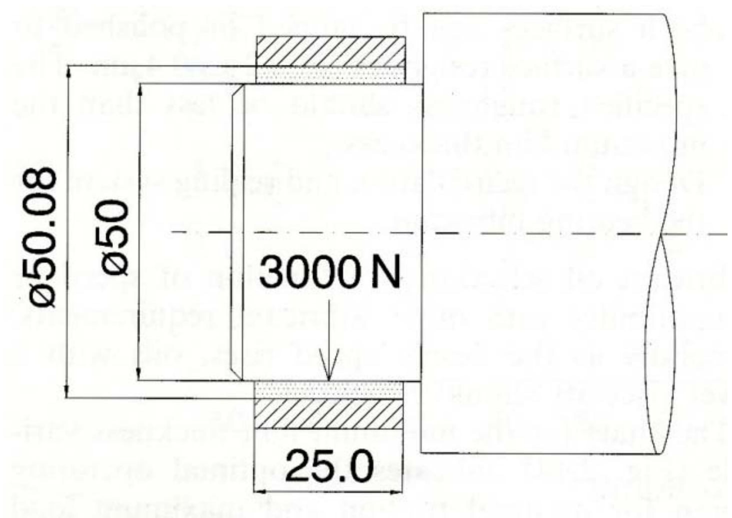


Fig. 2.12 Bearing design example.

B. ROLLING BEARINGS

Example 1 (Childs 2nd p. 65)

A straight cylindrical roller bearing operates with a load of 7.5 kN. The required life is 8760 hours at 1000 rpm. What load rating should be used for selection from the catalogue?

Example 2 (Childs)

A catalogue lists the basic dynamic load rating for a ball bearing to be 33800 N for a rated life of 1 million revolutions. What would be the expected L10 life of the bearing if it were subjected to 15000N and determine the life in hours that this corresponds to if the speed of rotation is 2000 rpm.

Example 3 (Childs)

A ball bearing for an industrial grinder is chosen to withstand a radial load of 1300N and have an L10 life of 3600 hours at 3000 rpm. The manufacturer's catalogue rating is based on an L10 life of 3800 hours at 1000 rpm. What load should be used to enter into the catalogue for selection?

Example 4 (Childs)

A bearing is required to carry a radial load of 2.8 kN and provide axial location for a shaft of 30 mm diameter rotating at 1500 rpm. An L10 life of 10 000 hours is required. Select and specify an appropriate bearing.

Example 5 (Childs)

A radial load F1=3.2 kN acts for 2 hours on a rolling bearing and then reduces to F2 = 2.9 kN for 1 hour. The cycle repeats itself. The shaft rotates at 430 rpm. Calculate the mean cubic load Fm, which should be used in rating the bearing for 9000 hours life.

Example 6 (Childs)

A small fan application requires a bearing to last for 2100 hours with a reliability of 95%. What should the rated life of the bearing be?

Example 7 (Bearing calculation)

The bearing (inner race rotate) is subjected to the loads as shown in the following figure. The shaft diameter is 30 mm. Select ball bearing for 655 rpm. For X use 0.75 and Y 1.85.

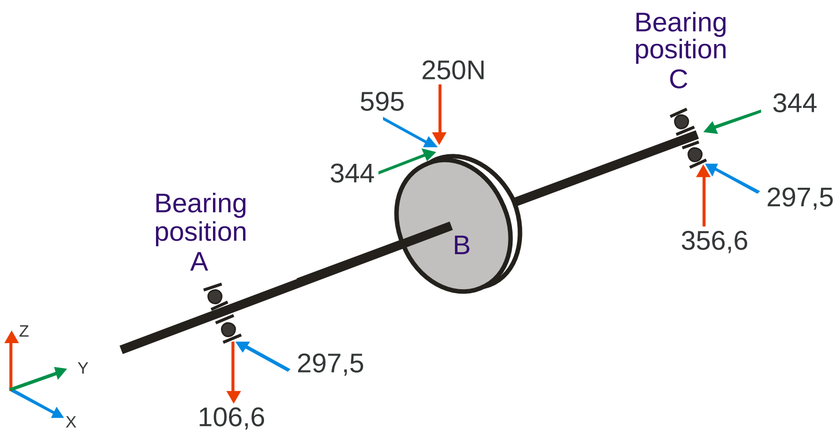


Fig. 1: Shaft supported with bearings