PROBLEM 9-2

Statement: A simply supported shaft is shown in Figure P9-2. A constant magnitude distributed unit load p is applied as the shaft rotates subject to a time-varying torque that varies from T_{min} to T_{max}. For the data in the row(s) assigned from Table P9-1, find the diameter of shaft required to obtain a safety factor of 2 in fatigue loading if the shaft is steel of S_{ut} = 745 MPa and S_y = 427 MPa. The dimensions are in cm, the distributed force in N/cm, and the torque in N-m. Assume no stress concentrations are present.

Assumptions: The finish is machined. Assume a reliability of 99% and room temp.

Table 9-2 Problem 9-2 results for all rows of Table P9-1

Row	Diameter
a	4.864
b	3.339
c	3.193
d	4.864
e	3.641
f	4.371

PROBLEM 9-5

Statement: Determine the maximum deflections in torsion and in bending of the shaft shown in Figure P9-2 for the data in the row(s) assigned in Table P9-1 if the steel shaft diameter is 4 cm.

Table 9-5 Problem 9-5 results for all rows of Table P9-1

Row	y_{min}	y_{max}	θ (deg)
a	−0.0057	0.0	1.267
b	−0.0029	0.0	0.228
c	−0.0111	0.0	0.177
d	−0.0010	0.0	0.507
e	−0.0333	0.0	0.269
f	−0.0292	0.0	1.520

PROBLEM 9-16

Statement: What are the maximum, minimum, and average power values for the shaft shown in Figure P9-2 for the data in the row(s) assigned in Table P9-1 if the shaft speed is 50 rpm?

Table 9-16 Shaft Power Problem 9-16 results for all rows of Table P9-1

Row	P_{min} (kw)	P_{max} (kw)	P_{avg} (kw)
a	0.00	10.5	5.20
b	−0.50	3.1	1.30
c	−1	2.1	0.50
d	0.00	10.5	5.20
e	−1	2.6	0.80
f	5.2	10.5	7.90

PROBLEM 9-20

Statement: A 12-in-long, solid, straight shaft is supported in self-aligning bearings at each end. A gear is attached at the middle of the shaft with a 3/8-in square steel key in a slot. The geometric stress-concentration factor in the keyslot is 2.5 and its corner radius is 0.02 in. The gear drives a fluctuating load which creates a bending moment that varies from +100 lb-in to + 900 lb-in and a torque that varies from −300 lb-in to +1 500 lb-in each cycle. The material chosen is cold-drawn 4140 steel, hardened and tempered to Rockwell C45 (S_{ut} = 180 kpsi). Design the shaft for infinite life and determine the diameter needed for a safety factor of 1.5.

Assumptions: Note that the given magnitudes of the radial forces shown acting on gear(s) in this problem are not necessarily consistent with a load associated with the given torque for any real gear of reasonable pressure angle. Since gears are taken up in a later chapter, these shaft design problems ignore the real gear loadings and use an arbitrary value to provide a shaft design exercise.

12 030.	psi	normal alternating stress
15 037.	psi	normal mean stress
13 533.	psi	shear alternating stress
9 022.	psi	shear mean stress
26 347.	psi	alternating effective stress
21 686.	psi	mean effective stress
0.918	in	shaft diameter