BITS, PILANI – DUBAI

Dubai International Academic City, Dubai

FIRST SEMESTER 2010 – 2011

COMPREHENSIVE EXAMNATION

Year:	III	Date:	26.12.2010
Course Code:	ME C312	Maximum Marks:	40
Course Title:	Design of Machine Elements	Weightage:	40 %
		Duration:	3 Hours

Note:
Use appropriate charts and tables wherever necessary.

Answer any EIGHT questions: (8 x 5 = 40 Marks)

Q1. Fig. Q1 illustrates the connection of a cylinder head to a pressure vessel using 10 bolts and a confined gasket seal. The effective sealing diameter is 150 mm. A=100, B=200, C=300, D=20, E=20 (all in mm). The cylinder is used to store gas at a pressure of 6 MPa. ISO class 8.8 bolts with a diameter of 12 mm have been selected. Find the load factor n. Take K_{steel} = 4722 MN/m^2 and $K_{cast\text{-}iron}$ = 2248 MN/m^2.

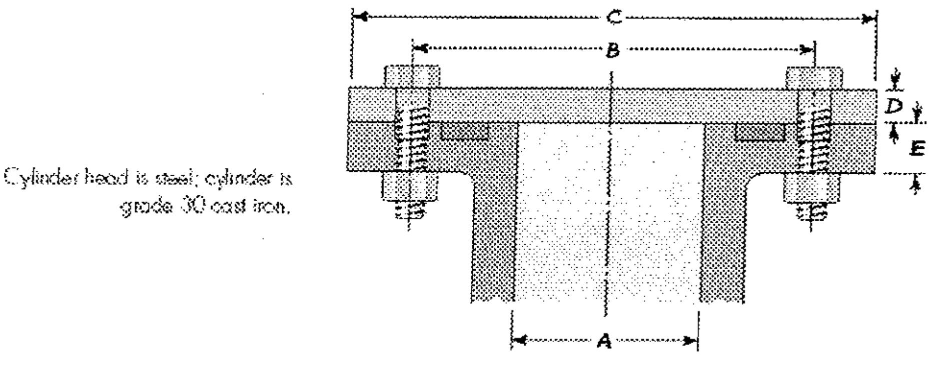


Fig. Q1

Q2. A 10 mm by 100 mm rectangular cross-section bar carries a static load of 107 kN. It is welded to a gusset plate with an 8 mm filet weld on both sides with an E70XX electrode as shown in Fig. Q2. Unsymmetrical weld tracks can compensate for eccentricity such that there is no moment to be resisted by the welds. If the design has a satisfactory weld metal strength, specify the weld track lengths l_1 and l_2 if l_2 is 50% more than l_1. Use the welding code method.

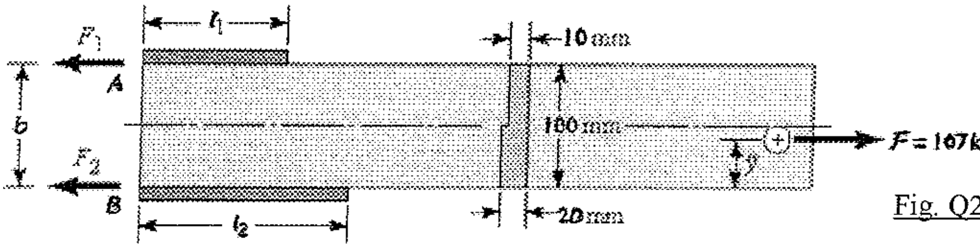


Fig. Q2

Q3. A helical compression spring is needed for food service machinery. The load varies from a minimum of 20 N to 90 N. The outside diameter of spring is 20 mm. Using a wire diameter of 2 mm, determine fatigue design factor n_f and endurance strength using the Gerber-Zimmerli fatigue failure criterion. Material used is A313 stainless steel wire. The spring is unpeened, and squared and ground.

Q4. A certain application requires a ball bearing with an inner ring rotating with a design life of 30000 hours at a speed of 300 rev/min. the radial load is 1.898 kN and application factor of 1.2 is appropriate. The reliability goal is 0.9. Find the multiple of rating life required, x_D, and the catalog rating C_{10} for 02 series deep groove ball bearing and estimate the reliability in use. Make use of Weibull parameters for SKF bearings.

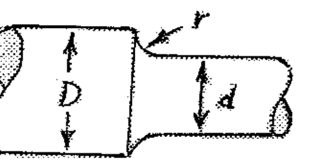
Q5. A full journal bearing has a shaft diameter of 25 mm with a unilateral tolerance of -0.01 mm. The bushing bore has a diameter of 25.04 mm with a unilateral tolerance of 0.03 mm. The l/d ratio is unity. The bushing load is 1.25 kN, and the journal rotates at 1200 rev/min. Analyze the minimum clearance assembly if the average viscosity is 50 mPa-s to find the minimum oil film thickness and the maximum load the bearing can withstand.

Q6. A parallel shaft gearset consists of an 18-tooth helical pinion driving a 32 tooth gear. The pinion has left hand helix angle of 25°, a normal pressure angle of 20°, and a normal module of 3 mm. Find (a) the transverse and axial circular pitches, (b) the transverse module and the transverse pressure angle, (c) the pitch diameters of two gears.

Q7. A stock spur gear is available having a module of 3 mm, a 38-mm face, 16 teeth, and a pressure angle of 20° with full-depth teeth. The material is AISI 1020 steel in as-rolled condition. Use a design factor of $n_d = 3$ to rate power output of the gear corresponding to a speed of 20 rev/s and moderate applications. Take form factor as 0.296.

Q8. **a.** Mention any two types of belt drives used in conveying systems.
b. What is ABS referred to in Automobiles?
c. The allowable gear wear load for a worm gear is 6 kN. Find the worm gear pitch diameter and the effective face width if the ratio of the pitch diameter to the face width is given to be 7. Take the worm-gear load factor as 0.7.

Q9. **a.** A shaft is loaded by a torque of 5 KN-m. The material has a yield point of 350 MPa. Find the shaft diameter using maximum shear stress theory. Take factor of safety as 2.5.
b. Find the maximum stress developed in a stepped shaft shown in fig. Q9 (b) when it is subjected to a bending moment of 150 Nm.



r = 6 mm

d = 30 mm

D = 40 mm

Fig. Q9 (b)

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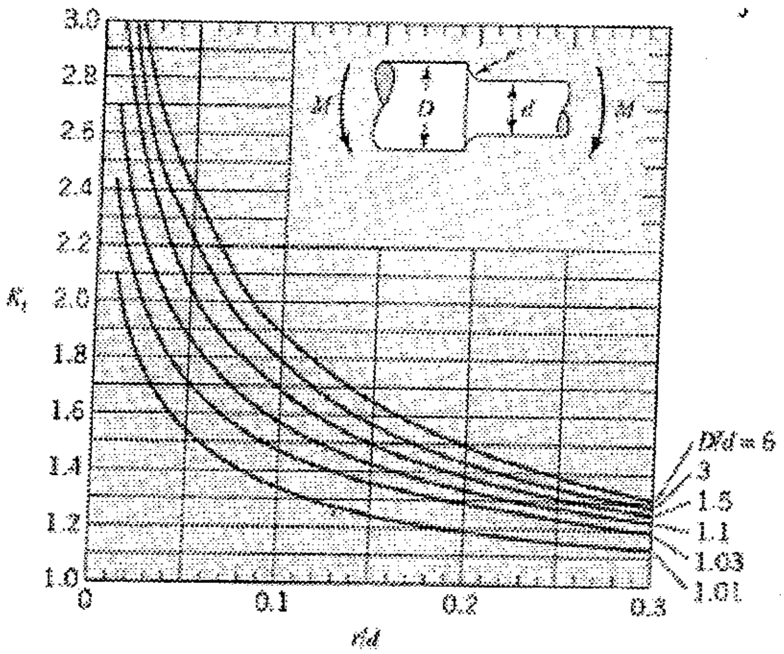
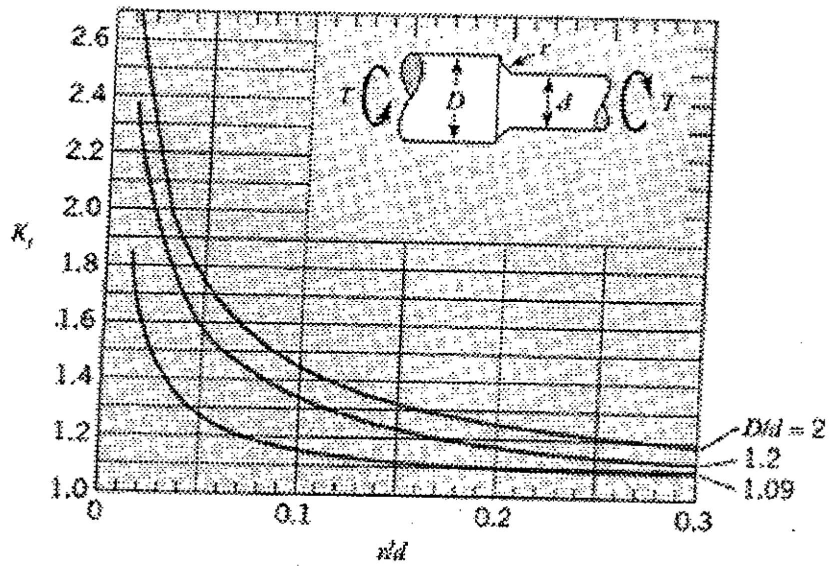
Useful Tables and Charts



Variation of theoretical stress concentration factor with r/d for a stepped shaft subjected to a bending moment



Variation of theoretical stress concentration factor with r/d for a stepped shaft subjected to torsion

Table 8–1

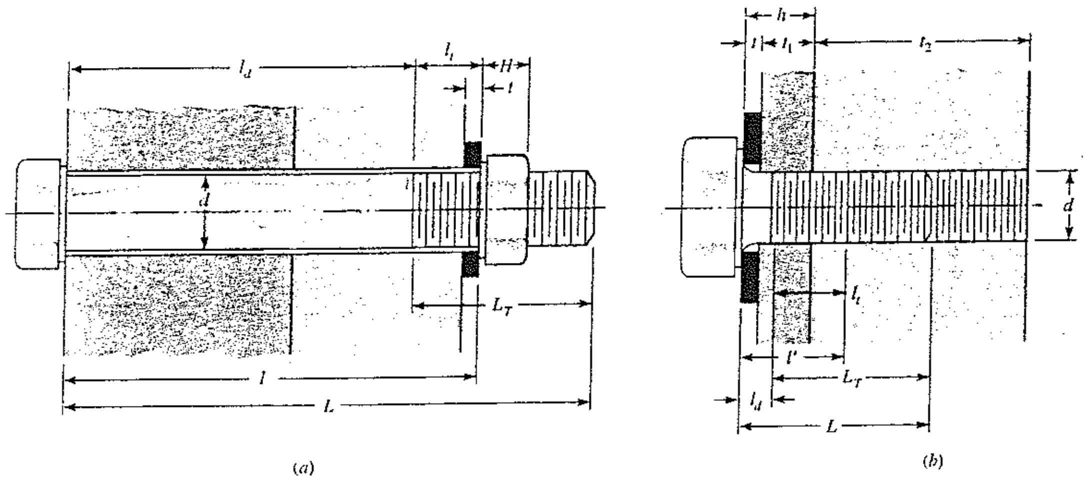
Diameters and Areas of Coarse-Pitch and Fine-Pitch Metric Threads.*

Nominal Major Diameter d mm	Coarse-Pitch Series: Pitch p mm	Coarse-Pitch Series: Tensile-Stress Area A_t mm^2	Coarse-Pitch Series: Minor-Diameter Area A_r mm^2	Fine-Pitch Series: Pitch p mm	Fine-Pitch Series: Tensile-Stress Area A_t mm^2	Fine-Pitch Series: Minor-Diameter Area A_r mm^2
1.6	0.35	1.27	1.07			
2	0.40	2.07	1.79			
2.5	0.45	3.39	2.98			
3	0.5	5.03	4.47			
3.5	0.6	6.78	6.00			
4	0.7	8.78	7.75			
5	0.8	14.2	12.7			
6	1	20.1	17.9			
8	1.25	36.6	32.8	1	39.2	36.0
10	1.5	58.0	52.3	1.25	61.2	56.3
12	1.75	84.3	76.3	1.25	92.1	86.0
14	2	115	104	1.5	125	116
16	2	157	144	1.5	167	157
20	2.5	245	225	1.5	272	259
24	3	353	324	2	384	365
30	3.5	561	519	2	621	596
36	4	817	759	2	915	884
42	4.5	1120	1050	2	1260	1230
48	5	1470	1380	2	1670	1630
56	5.5	2030	1910	2	2300	2250
64	6	2680	2520	2	3030	2980
72	6	3460	3280	2	3860	3800
80	6	4340	4140	1.5	4850	4800
90	6	5590	5360	2	6100	6020
100	6	6990	6740	2	7560	7470
110				2	9180	9080

*The equations and data used to develop this table have been obtained from ANSI B1.1-1974 and B18.3.1-1978. The minor diameter was found from the equation $d_r = d - 1.226\ 869p$, and the pitch diameter from $d_p = d - 0.649\ 519p$. The mean of the pitch diameter and the minor diameter was used to compute the tensile-stress area.

Table 8–7

Suggested Procedure for Finding Fastener Stiffness



Given fastener diameter d and pitch p or number of threads

(a)

Grip is thickness l

Washer thickness from Table A–30 or A–29

Threaded length L_T

Inch series:

$$L_T = \begin{cases} 2d + \frac{1}{4} \text{ in}, & L \le 6 \text{ in} \\ 2d + \frac{1}{2} \text{ in}, & L > 6 \text{ in} \end{cases}$$

Metric series:

$$L_T = \begin{cases} 2d + 6 \text{ mm}, & L \le 125, d \le 48 \text{ mm} \\ 2d + 12 \text{ mm}, & 125 < L \le 200 \text{ mm} \\ 2d + 25 \text{ mm}, & L > 200 \text{ mm} \end{cases}$$

Fastener length: $L > l + H$

Round up using Table A–15*

Length of useful unthreaded portion: $l_d = L - L_T$

Length of threaded portion: $l_t = l - l_d$

(b)

Effective grip

$$l' = \begin{cases} h + t_2/2, & t_2 < d \\ h + d/2, & t_2 \ge d \end{cases}$$

Fastener length: $L > h + 1.5d$

Length of useful unthreaded portion: $l_d = L - L_T$

Length of useful threaded portion: $l_t = l' - l_d$

Area of unthreaded portion:

$A_d = \pi d^2/4$

Area of threaded portion:

A_t, Table 8–1 or 8–2

Fastener stiffness:

$$k_b = \frac{A_d A_t E}{A_d l_t + A_t l_d}$$

*Bolts and cap screws may not be available in all the preferred lengths listed in Table A–15. Large fasteners may not be available in fractional inches or in millimeter lengths ending in a nonzero digit. Check with your bolt supplier for availability.

Table 8–11

Metric Mechanical-Property Classes for Steel Bolts, Screws, and Studs*

Property Class	Size Range, Inclusive	Minimum Proof Strength,† MPa	Minimum Tensile Strength,† MPa	Minimum Yield Strength,† MPa	Material	Head Marking
4.6	M5–M36	225	400	240	Low or medium carbon	4.6
4.8	M1.6–M16	310	420	340	Low or medium carbon	4.8
5.8	M5–M24	380	520	420	Low or medium carbon	5.8
8.8	M16–M36	600	830	660	Medium carbon, Q&T	8.8
9.8	M1.6–M16	650	900	720	Medium carbon, Q&T	9.8
10.9	M5–M36	830	1040	940	Low-carbon martensite, Q&T	10.9
12.9	M1.6–M36	970	1220	1100	Alloy, Q&T	12.9

*The thread length for bolts and cap screws is

$$L_T = \begin{cases} 2d + 6 & L \le 125 \\ 2d + 12 & 125 < L \le 200 \\ 2d + 25 & L > 200 \end{cases}$$

where L is the bolt length. The thread length for structural bolts is slightly shorter than given above.

†Minimum strengths are strength exceeded by 99 percent of fasteners.

Table 8–8

Stiffness Parameters of Various Member Materials†

†*Source:* J. Wileman, M. Choudury, and I. Green, "Computation of Member Stiffness in Bolted Connections," *Trans. ASME, J. Mech. Design*, vol. 113, December 1991, pp. 432–437.

Material Used	Poisson Ratio	Elastic Modulus GPa	A	B
Steel	0.291	207	0.787 15	0.628 73
Aluminum	0.334	71	0.796 70	0.638 16
Copper	0.326	119	0.795 68	0.635 53
Gray cast iron	0.211	100	0.778 71	0.616 16
General expression			0.789 52	0.629 14

Table 9–6

Allowable Steady Loads and Minimum Fillet Weld Sizes

Schedule A: Allowable Load for Various Sizes of Fillet Welds

	Strength Level of Weld Metal (EXX)						
	60*	70*	80	90*	100	110*	120
	Allowable shear stress on throat, MPa of fillet weld or partial penetration groove weld						
$\tau =$	124	145	165	186	207	228	248
	Allowable Unit Force on Fillet Weld, N/mm						
$^{\dagger}f =$	$87.67h$	$102.52h$	$116.66h$	$131.5h$	$146.35h$	$161.2h$	$175.34h$
Leg Size h, mm	**Allowable Unit Force for Various Sizes of Fillet Welds N/mm**						
25	2192	2563	2916	3288	3659	4030	4383
22	1929	2255	2566	2893	3220	3546	3857
20	1753	2050	2333	2630	2927	3224	3506
16	1403	1640	1866	2104	2342	2579	2805
12	1052	1230	1400	1578	1756	1934	2104
11	964	1127	1283	1447	1610	1773	1927
10	877	1025	1167	1315	1463	1612	1753
8	701	820	933	1052	1171	1290	1403
6	526	615	700	789	878	967	1052
5	438	513	583	658	732	806	877
3	263	308	350	395	439	484	526
2	175	205	233	263	293	322	351

*Fillet welds actually tested by the joint AISC-AWS Task Committee.

$^{\dagger}f = 0.707h\,\tau_{all}$.

Schedule B: Minimum Fillet Weld Size, h

Material Thickness of Thicker Part Joined, mm		Weld Size, mm
*To 6 incl.		3
Over 6	To 12	5
Over 12	To 20	6
†Over 20	To 38	8
Over 38	To 58	10
Over 58	To 150	12
Over 150		16

Not to exceed the thickness of the thinner part.

*Minimum size for bridge application does not go below 5 mm.

†For minimum fillet weld size, schedule does not go above 8 mm fillet weld for every 20 mm material.

Source: From Omer W. Blodgett (ed.), *Stress Allowables Affect Weldment Design*, D412, The James F. Lincoln Arc Welding Foundation, Cleveland, May 1991, p. 3. Reprinted by permission of Lincoln Electric Company.

Figure 10–2

Types of ends for compression springs: (a) both ends plain; (b) both ends squared; (c) both ends squared and ground; (d) both ends plain and ground.

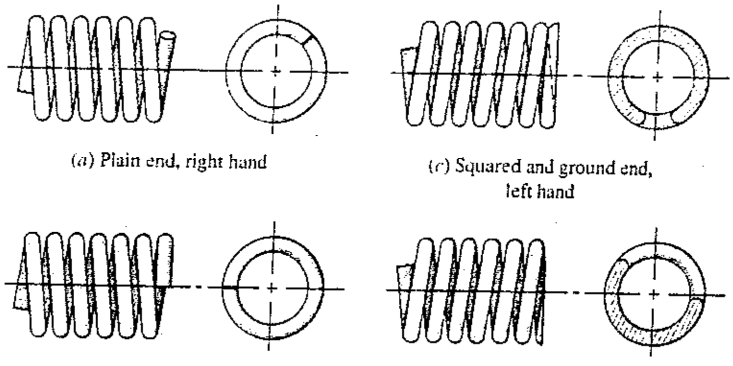


Table 10–1

Formulas for the Dimensional Characteristics of Compression-Springs. (N_a = Number of Active Coils)

Source: From Design Handbook, 1987, p. 32. Courtesy of Associated Spring.

	Type of Spring Ends			
Term	**Plain**	**Plain and Ground**	**Squared or Closed**	**Squared and Ground**
End coils, N_e	0	1	2	2
Total coils, N_t	N_a	$N_a + 1$	$N_a + 2$	$N_a + 2$
Free length, L_0	$pN_a + d$	$p(N_a + 1)$	$pN_a + 3d$	$pN_a + 2d$
Solid length, L_s	$d(N_t + 1)$	dN_t	$d(N_t + 1)$	dN_t
Pitch, p	$(L_0 - d)/N_a$	$L_0/(N_a + 1)$	$(L_0 - 3d)/N_a$	$(L_0 - 2d)/N_a$

Table 10–2

End-Condition Constants α for Helical Compression Springs*

End Condition	Constant α
Spring supported between flat parallel surfaces (fixed ends)	0.5
One end supported by flat surface perpendicular to spring axis (fixed); other end pivoted (hinged)	0.707
Both ends pivoted (hinged)	1
One end clamped; other end free	2

*Ends supported by flat surfaces must be squared and ground.

According to the Zimmerli data, the endurance strength components for infinite life for springs:

Unpeened - S_{sa} = 241 MPa S_{sm} = 379 MPa

Peened - S_{sa} = 398 MPa S_{sm} = 534 MPa

$S_{su} = 0.67 S_{ut}$

Table 10–4

Constants A and m of $S_{ut} = A/d^m$ for Estimating Minimum Tensile Strength of Common Spring Wires

Source: From *Design Handbook,* 1987, p. 19. Courtesy of Associated Spring.

Material	ASTM No.	Exponent m	Diameter, mm	A, $MPa \cdot mm^m$	Relative Cost of wire
Music wire*	A228	0.145	0.10–6.5	2211	2.6
OQ&T wire†	A229	0.187	0.5–12.7	1855	1.3
Hard-drawn wire‡	A227	0.190	0.7–12.7	1783	1.0
Chrome-vanadium wire§	A232	0.168	0.8–11.1	2005	3.1
Chrome-silicon wire‖	A401	0.108	1.6–9.5	1974	4.0
302 Stainless wire#	A313	0.146	0.3–2.5	1867	7.6–11
		0.263	2.5–5	2065	
		0.478	5–10	2911	
Phosphor-bronze wire**	B159	0	0.1–0.6	1000	8.0
		0.028	0.6–2	913	
		0.064	2–7.5	932	

*Surface is smooth, free of defects, and has a bright, lustrous finish.

†Has a slight heat-treating scale which must be removed before plating.

‡Surface is smooth and bright with no visible marks.

§Aircraft-quality tempered wire, can also be obtained annealed.

‖Tempered to Rockwell C49, but may be obtained untempered.

#Type 302 stainless steel.

**Temper CA510.

Table 10–8

Maximum Allowable Stresses for ASTM A228 and Type 302 Stainless Steel Helical Extension Springs in Cyclic Applications

Source: From *Design Handbook,* 1987, p. 52. Courtesy of Associated Spring.

Number of Cycles	Percent of Tensile Strength: In Torsion, Body	In Torsion, End	In Bending, End
10^5	36	34	51
10^6	33	30	47
10^7	30	28	45

This information is based on the following conditions: not shot-peened, no surging and ambient environment with a low temperature heat treatment applied. Stress ratio = 0.

Table 11-2

Dimensions and Load Ratings for Single-Row 02-Series Deep-Groove and Angular-Contact Ball Bearings

Bore, mm	OD, mm	Width, mm	Fillet Radius, mm	Shoulder Diameter, mm d_S	Shoulder Diameter, mm d_H	Load Ratings, kN Deep Groove C_{10}	Deep Groove C_0	Angular Contact C_{10}	Angular Contact C_0
10	30	9	0.6	12.5	27	5.07	2.24	4.94	2.12
12	32	10	0.6	14.5	28	6.89	3.10	7.02	3.05
15	35	11	0.6	17.5	31	7.80	3.55	8.06	3.65
17	40	12	0.6	19.5	34	9.56	4.50	9.95	4.75
20	47	14	1.0	25	41	12.7	6.20	13.3	6.55
25	52	15	1.0	30	47	14.0	6.95	14.8	7.65
30	62	16	1.0	35	55	19.5	10.0	20.3	11.0
35	72	17	1.0	41	65	25.5	13.7	27.0	15.0
40	80	18	1.0	46	72	30.7	16.6	31.9	18.6
45	85	19	1.0	52	77	33.2	18.6	35.8	21.2
50	90	20	1.0	56	82	35.1	19.6	37.7	22.8
55	100	21	1.5	63	90	43.6	25.0	46.2	28.5
60	110	22	1.5	70	99	47.5	28.0	55.9	35.5
65	120	23	1.5	74	109	55.9	34.0	63.7	41.5
70	125	24	1.5	79	114	61.8	37.5	68.9	45.5
75	130	25	1.5	86	119	66.3	40.5	71.5	49.0
80	140	26	2.0	93	127	70.2	45.0	80.6	55.0
85	150	28	2.0	99	136	83.2	53.0	90.4	63.0
90	160	30	2.0	104	146	95.6	62.0	106	73.5
95	170	32	2.0	110	156	108	69.5	121	85.0

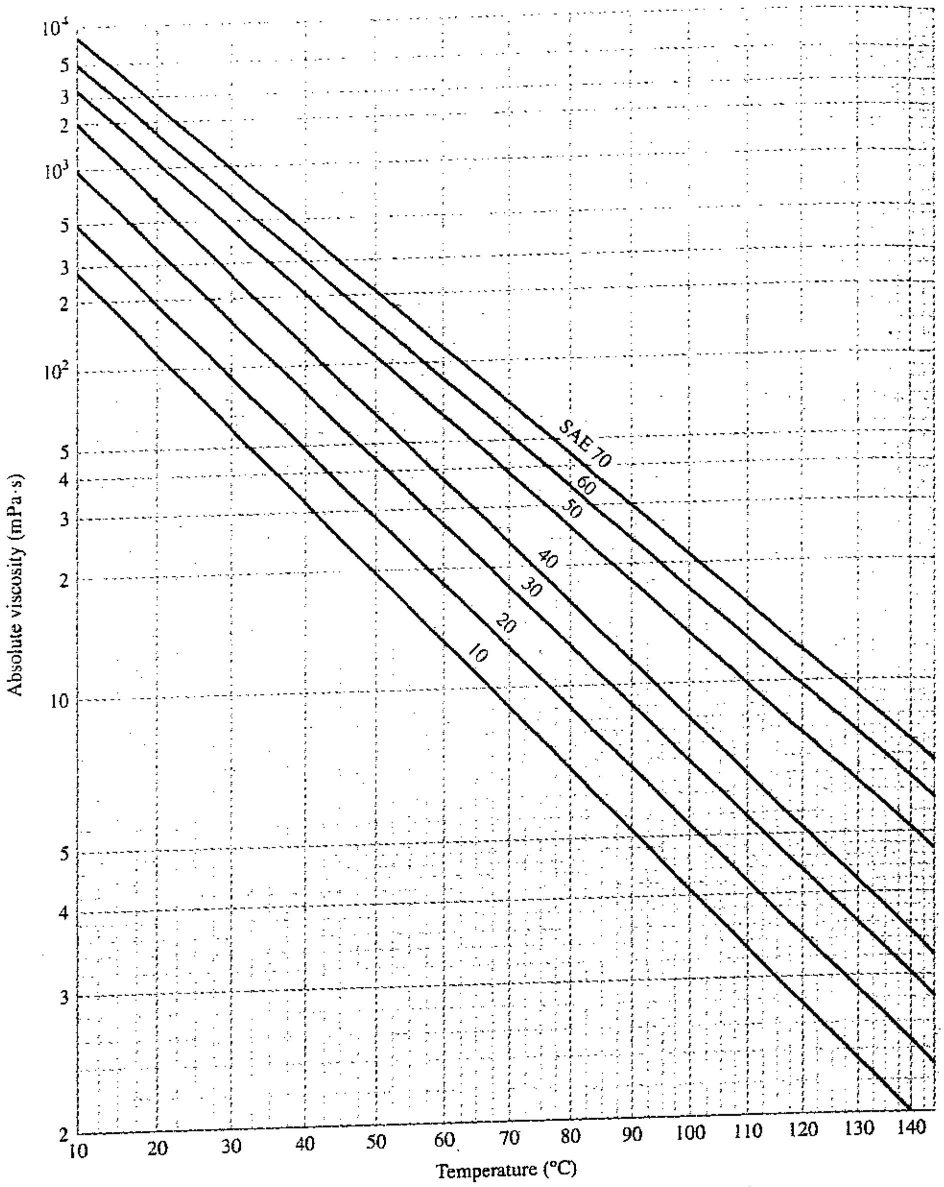
Table 11-3

Dimensions and Basic Load Ratings for Cylindrical Roller Bearings

Bore, mm	02-Series OD, mm	02-Series Width, mm	02-Series Load Rating, kN C_{10}	02-Series Load Rating, kN C_0	03-Series OD, mm	03-Series Width, mm	03-Series Load Rating, kN C_{10}	03-Series Load Rating, kN C_0
25	52	15	16.8	8.8	62	17	28.6	15.0
30	62	16	22.4	12.0	72	19	36.9	20.0
35	72	17	31.9	17.6	80	21	44.6	27.1
40	80	18	41.8	24.0	90	23	56.1	32.5
45	85	19	44.0	25.5	100	25	72.1	45.4
50	90	20	45.7	27.5	110	27	88.0	52.0
55	100	21	56.1	34.0	120	29	102	67.2
60	110	22	64.4	43.1	130	31	123	76.5
65	120	23	76.5	51.2	140	33	138	85.0
70	125	24	79.2	51.2	150	35	151	102
75	130	25	93.1	63.2	160	37	183	125
80	140	26	106	69.4	170	39	190	125
85	150	28	119	78.3	180	41	212	149
90	160	30	142	100	190	43	242	160
95	170	32	165	112	200	45	264	189
100	180	34	183	125	215	47	303	220
110	200	38	229	167	240	50	391	304
120	215	40	260	183	260	55	457	340
130	230	40	270	193	280	58	539	408
140	250	42	319	240	300	62	682	454

Figure 12–13

Viscosity–temperature chart in SI units. *(Adapted from Fig. 12–12.)*



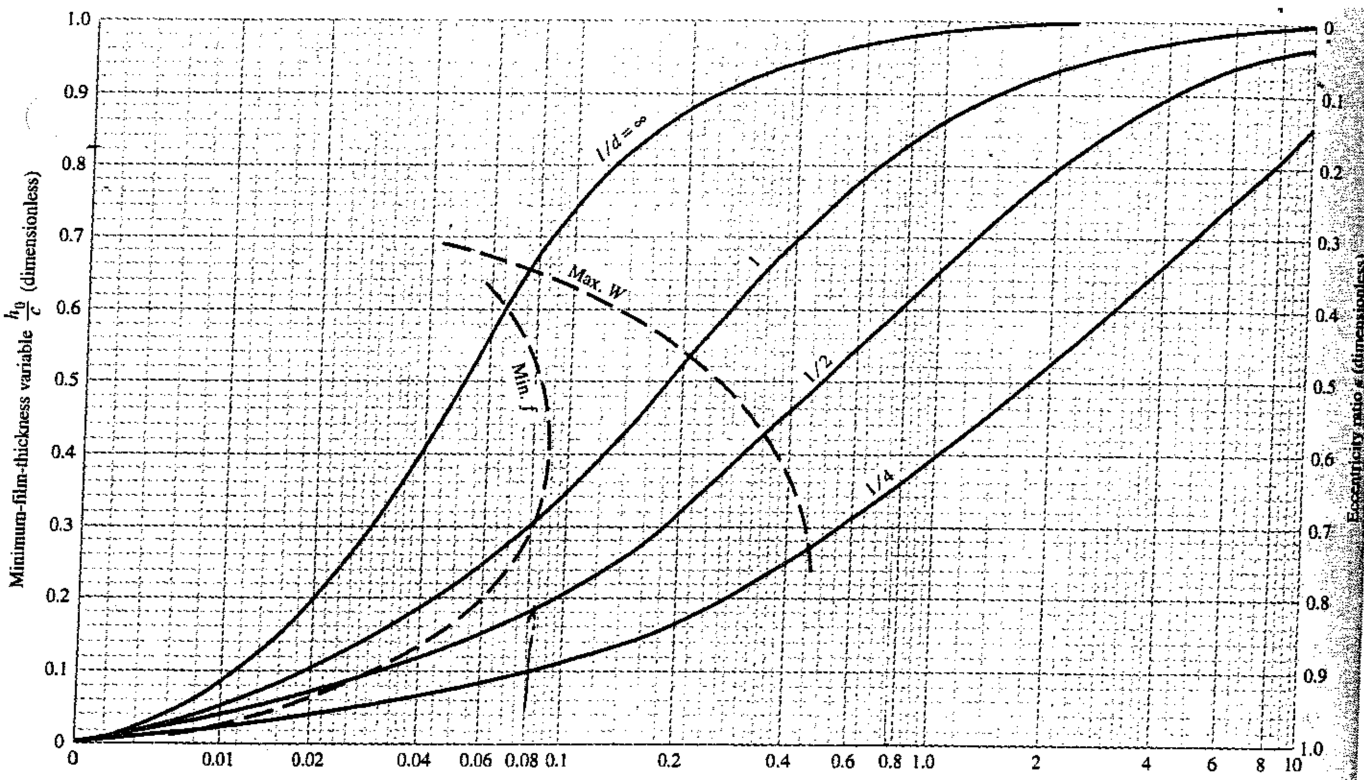
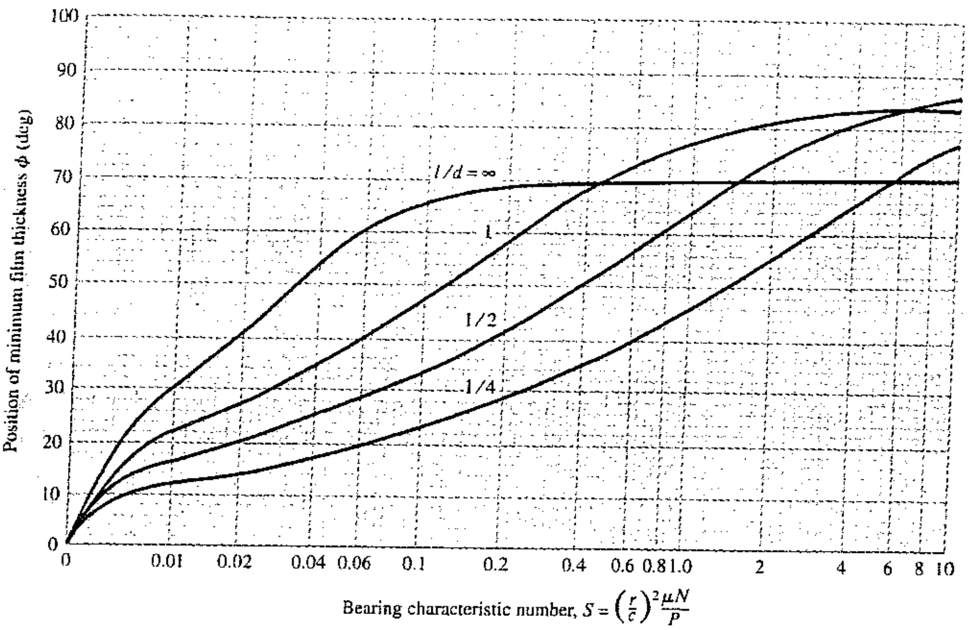


Figure 12–16

Chart for minimum film-thickness variable and eccentricity ratio. The left boundary of the zone defines the optimal h_0 for minimum friction;

Figure 12-17

Chart for determining the position of the minimum film thickness h_0. *(Raimondi and Boyd.)*



Lubrication and Journal Bearings

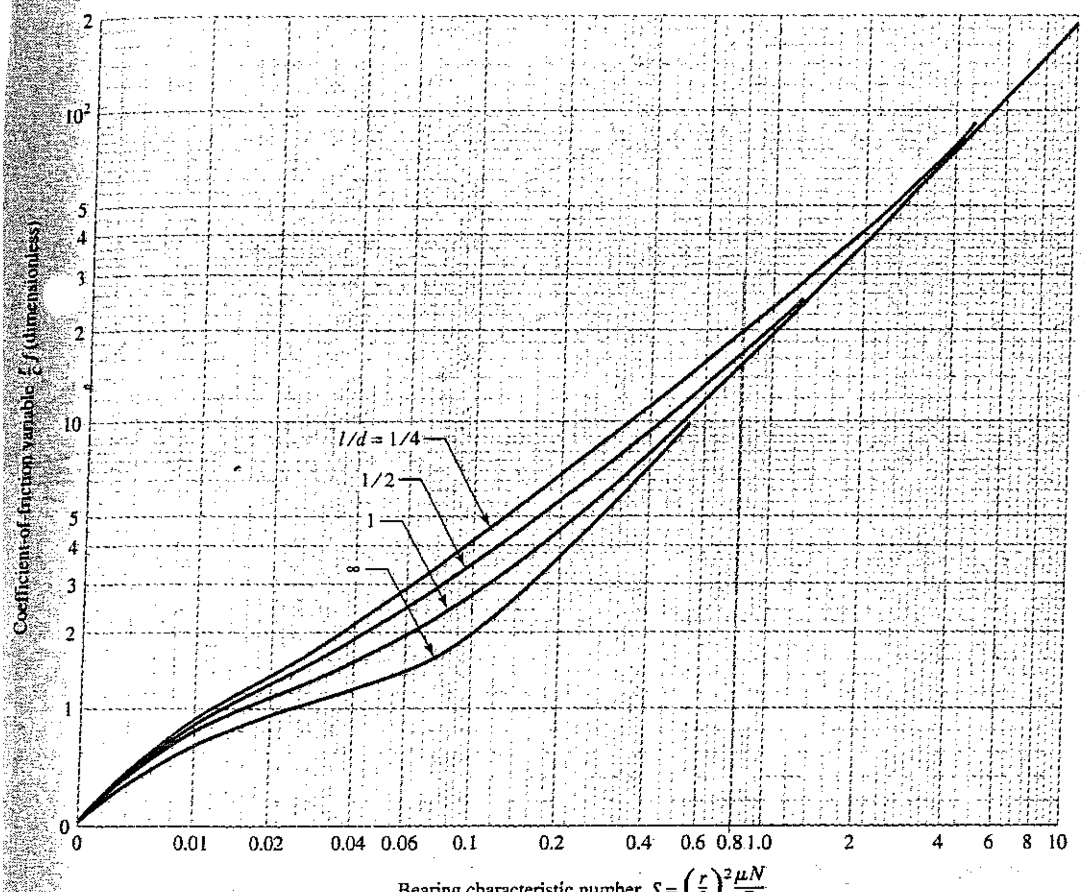


Figure 12-18

Chart for coefficient-of-friction variable; note that Petroff's equation is the asymptote. *(Raimondi and Boyd.)*

Figure 12–19

Chart for flow variable. *Note:* Not for pressure-fed bearings. (Raimondi and Boyd.)

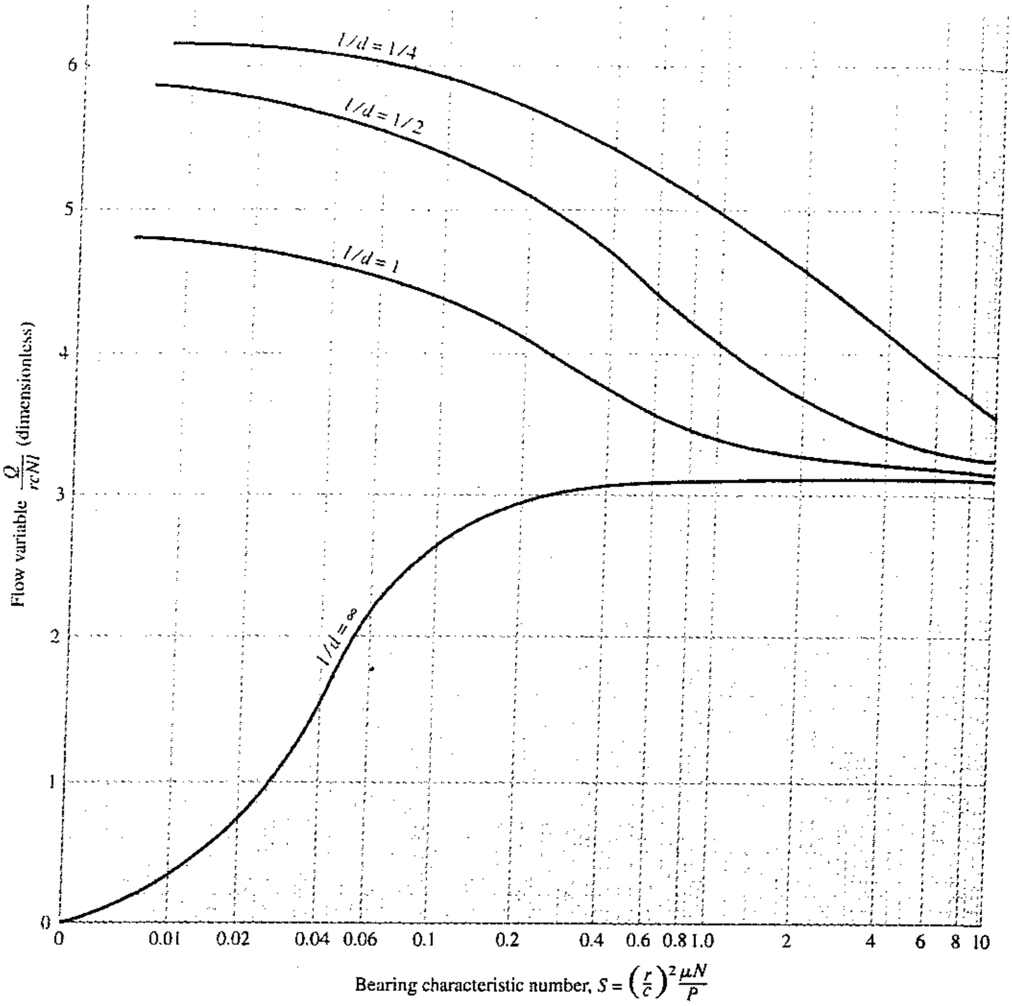


Figure 12–20

Chart for determining the ratio of side flow to total flow. (Raimondi and Boyd.)

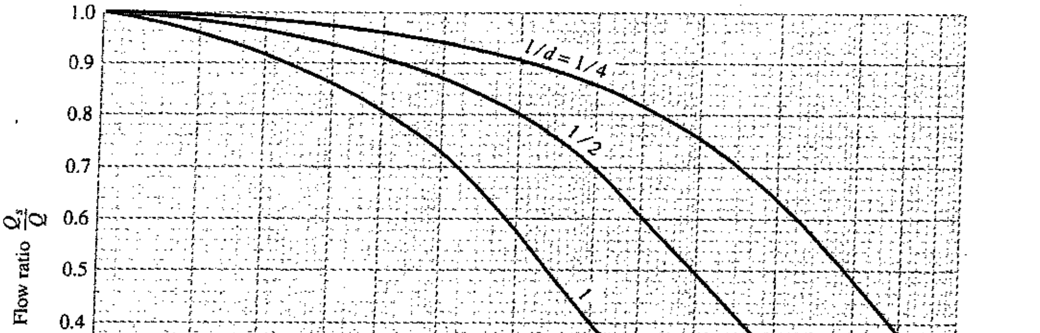
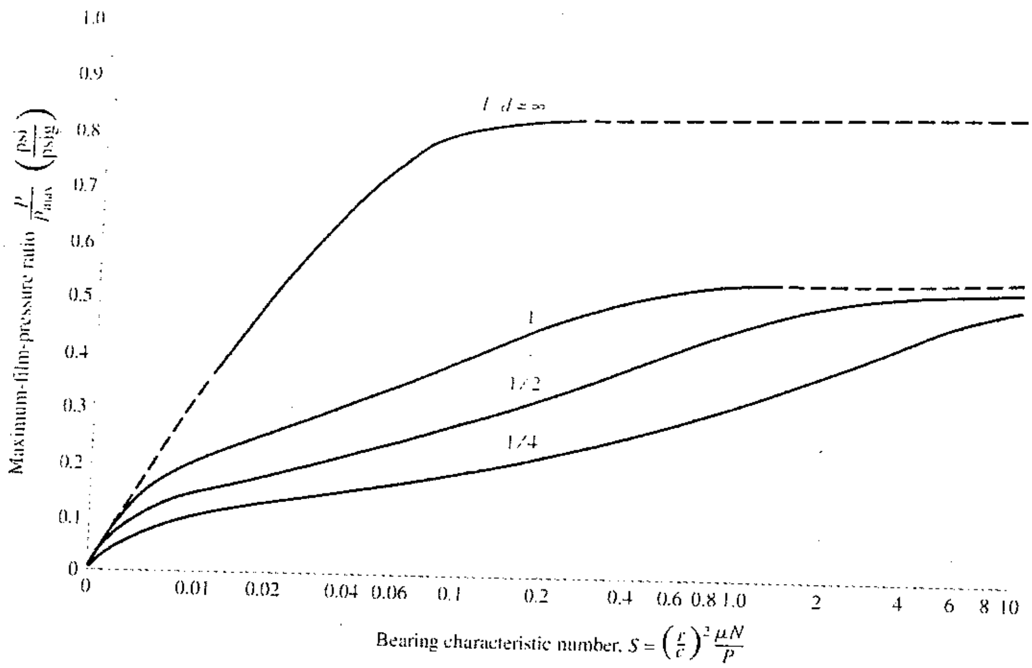


Figure [illegible]

[illegible] determining the [illegible] pressure. Note: [illegible] bearings. ([illegible] and Boyd.)



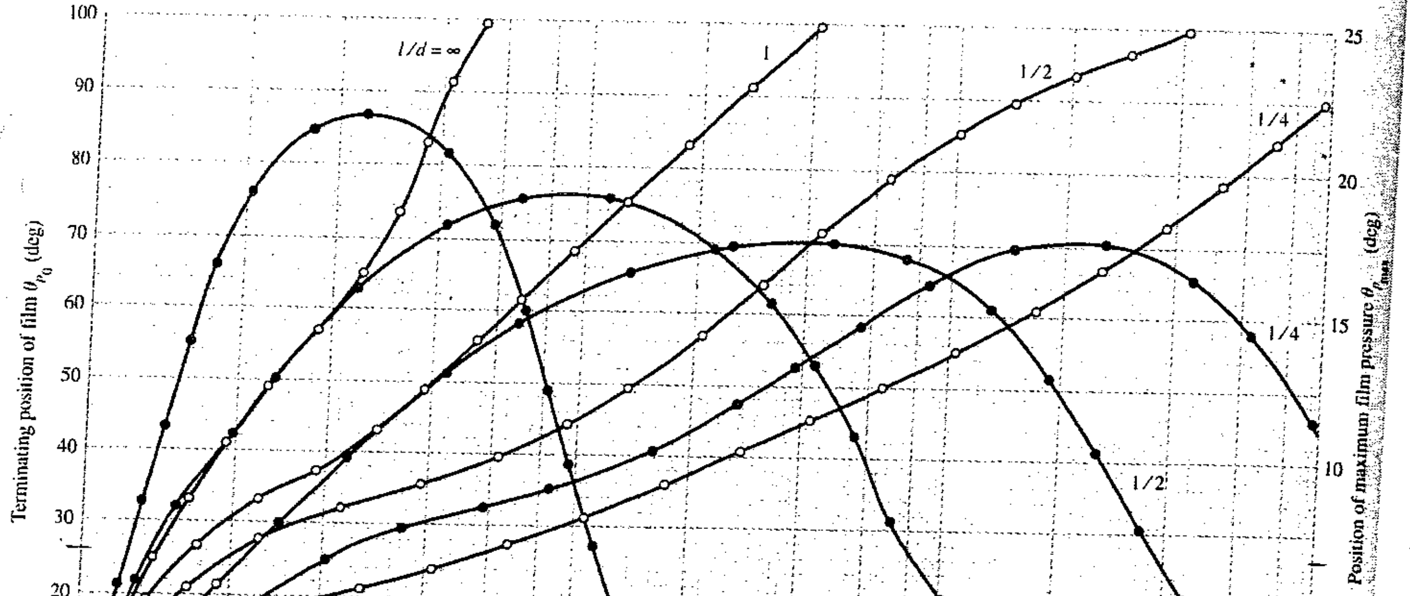


Figure 12–22

Chart for finding the terminating position of the lubricant film and the position of maximum film pressure. *(Raimondi and Boyd.)*

Table A–18

Deterministic ASTM Minimum Tensile and Yield Strengths for Some Hot-Rolled (HR) and Cold-Drawn (CD) Steels [The strengths listed are estimated ASTM minimum values in the size range 18 to 32 mm ($\frac{3}{4}$ to $1\frac{1}{4}$ in). These strengths are suitable for use with the design factor defined in Sec. 1–10, provided the materials conform to ASTM A6 or A568 requirements or are required in the purchase specifications. Remember that a numbering system is not a specification.] *Source:* 1986 SAE Handbook, p. 2.15.

1 UNS No.	2 SAE and/or AISI No.	3 Processing	4 Tensile Strength, MPa (kpsi)	5 Yield Strength, MPa (kpsi)	6 Elongation in 2 in, %	7 Reduction in Area, %	8 Brinell Hardness
G10060	1006	HR	300 (43)	170 (24)	30	55	86
		CD	330 (48)	280 (41)	20	45	95
G10100	1010	HR	320 (47)	180 (26)	28	50	95
		CD	370 (53)	300 (44)	20	40	105
G10150	1015	HR	340 (50)	190 (27.5)	28	50	101
		CD	390 (56)	320 (47)	18	40	111
G10180	1018	HR	400 (58)	220 (32)	25	50	116
		CD	440 (64)	370 (54)	15	40	126
G10200	1020	HR	380 (55)	210 (30)	25	50	111
		CD	470 (68)	390 (57)	15	40	131
G10300	1030	HR	470 (68)	260 (37.5)	20	42	137
		CD	520 (76)	440 (64)	12	35	149
G10350	1035	HR	500 (72)	270 (39.5)	18	40	143
		CD	550 (80)	460 (67)	12	35	163
G10400	1040	HR	520 (76)	290 (42)	18	40	149
		CD	590 (85)	490 (71)	12	35	170
G10450	1045	HR	570 (82)	310 (45)	16	40	163
		CD	630 (91)	530 (77)	12	35	179
G10500	1050	HR	620 (90)	340 (49.5)	15	35	179
		CD	690 (100)	580 (84)	10	30	197
G10600	1060	HR	680 (98)	370 (54)	12	30	201
G10800	1080	HR	770 (112)	420 (61.5)	10	25	229
G10950	1095	HR	830 (120)	460 (66)	10	25	248

Table A-29

Dimensions of Hexagonal Nuts

Nominal Size, in.	Width W	Height H: Regular Hexagonal	Height H: Thick or Slotted	Height H: JAM
$\frac{1}{4}$	$\frac{7}{16}$	$\frac{7}{32}$	$\frac{9}{32}$	$\frac{5}{32}$
$\frac{5}{16}$	$\frac{1}{2}$	$\frac{17}{64}$	$\frac{21}{64}$	$\frac{3}{16}$
$\frac{3}{8}$	$\frac{9}{16}$	$\frac{21}{64}$	$\frac{13}{32}$	$\frac{7}{32}$
$\frac{7}{16}$	$\frac{11}{16}$	$\frac{3}{8}$	$\frac{29}{64}$	$\frac{1}{4}$
$\frac{1}{2}$	$\frac{3}{4}$	$\frac{7}{16}$	$\frac{9}{16}$	$\frac{5}{16}$
$\frac{9}{16}$	$\frac{7}{8}$	$\frac{31}{64}$	$\frac{39}{64}$	$\frac{5}{16}$
$\frac{5}{8}$	$\frac{15}{16}$	$\frac{35}{64}$	$\frac{23}{32}$	$\frac{3}{8}$
$\frac{3}{4}$	$1\frac{1}{8}$	$\frac{41}{64}$	$\frac{13}{16}$	$\frac{27}{64}$
$\frac{7}{8}$	$1\frac{5}{16}$	$\frac{3}{4}$	$\frac{29}{32}$	$\frac{31}{64}$
1	$1\frac{1}{2}$	$\frac{55}{64}$	1	$\frac{35}{64}$
$1\frac{1}{8}$	$1\frac{11}{16}$	$\frac{31}{32}$	$1\frac{5}{32}$	$\frac{39}{64}$
$1\frac{1}{4}$	$1\frac{7}{8}$	$1\frac{1}{16}$	$1\frac{1}{4}$	$\frac{23}{32}$
$1\frac{3}{8}$	$2\frac{1}{16}$	$1\frac{11}{64}$	$1\frac{3}{8}$	$\frac{25}{32}$
$1\frac{1}{2}$	$2\frac{1}{4}$	$1\frac{9}{32}$	$1\frac{1}{2}$	$\frac{27}{32}$
Nominal Size, mm				
M5	8	4.7	5.1	2.7
M6	10	5.2	5.7	3.2
M8	13	6.8	7.5	4.0
M10	16	8.4	9.3	5.0
M12	18	10.8	12.0	6.0
M14	21	12.8	14.1	7.0
M16	24	14.8	16.4	8.0
M20	30	18.0	20.3	10.0
M24	36	21.5	23.9	12.0
M30	46	25.6	28.6	15.0
M36	55	31.0	34.7	18.0

Table A-15

Preferred Sizes and Renard (R-Series) Numbers

(When a choice can be made, use one of these sizes; however, not all parts or items are available in all the sizes shown in the table.)

Millimeters
0.05, 0.06, 0.08, 0.10, 0.12, 0.16, 0.20, 0.25, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, 1.0, 1.1, 1.2, 1.4, 1.5, 1.6, 1.8, 2.0, 2.2, 2.5, 2.8, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 8.0, 9.0, 10, 11, 12, 14, 16, 18, 20, 22, 25, 28, 30, 32, 35, 40, 45, 50, 60, 80, 100, 120, 140, 160, 180, 200, 250, 300
Renard Numbers*
1st choice, R5: 1, 1.6, 2.5, 4, 6.3, 10
2d choice, R10: 1.25, 2, 3.15, 5, 8
3d choice, R20: 1.12, 1.4, 1.8, 2.24, 2.8, 3.55, 4.5, 5.6, 7.1, 9
4th choice, R40: 1.06, 1.18, 1.32, 1.5, 1.7, 1.9, 2.12, 2.36, 2.65, 3, 3.35, 3.75, 4.25, 4.75, 5.3, 6, 6.7, 7.5, 8.5, 9.5

*May be multiplied or divided by powers of 10.

BITS, PILANI – DUBAI

Dubai International Academic City, Dubai

FIRST SEMESTER 2010 – 2011

TEST – 2 (Open Book)

Year:	**III**	Date:	**21.11.2010**
Course Code:	**ME C312**	Maximum Marks:	**20**
Course Title:	**Design of Machine Elements**	Weightage:	**20 %**
		Duration:	**50 minutes**

Note:
1. *Answer all the questions.*
2. *Use appropriate charts and tables from the text book wherever necessary.*
3. *Prescribed text book and handwritten class notes are allowed.*

Q1. A 15 mm by 50 mm rectangular cross-section bar carries a static load of 100 kN. It is welded to a gusset plate with an 8 mm filet weld 50 mm long on both sides with an E80XX electrode as shown in Fig. Q1. Use the welding code method and check if the design has a satisfactory weld metal strength. **[4 M]**

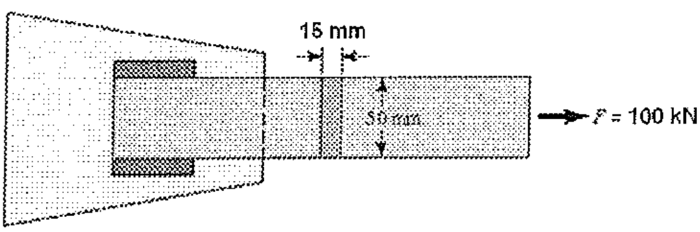


Fig. Q1

Q2. A helical compression spring is made of music wire 2mm in diameter and has an outside diameter of 24 mm. The ends are squared and ground, and there are 10.5 total coils. The spring is to be used with a static load of 65 N. Perform a design assessment if the spring closed to solid height. Find free length, pitch, force required to compress the spring to solid length and spring rate. **[5 M]**

Q3. Fig. Q3 shows a geared countershaft. Select an angular contact ball bearing at O and a straight roller bearing at B. The shaft is to run at 500 rpm. Forces at the bearings are: R_O=1698j + 2127k N, R_B = 1702j - 7286k N. Use an application factor of 1.2, a desired life of 60000 h and an individual reliability goal of 0.94. Use SKF rating. **[6 M]**

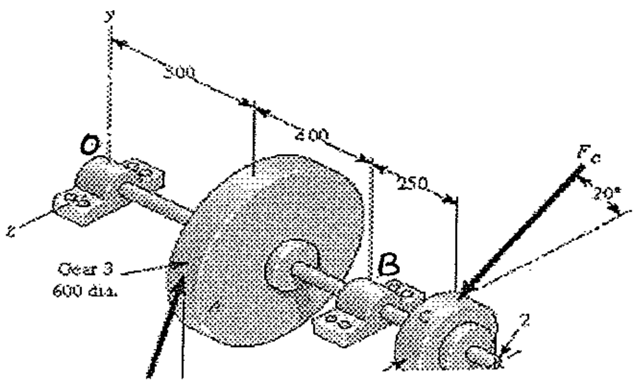


Fig. Q3

Q4. A full journal bearing has a shaft diameter of 35 mm with a unilateral tolerance of -0.01 mm. The bushing bore has a diameter of 35.06 mm with a unilateral tolerance of 0.03 mm. The l/d ratio is unity. The bushing load is 2.15 kN, and the journal rotates at 1800 rev/min. Analyze the minimum clearance assembly if the average viscosity is 50 mPa-s to find the minimum oil film thickness, power loss and side flow rate. **[5 M]**

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BITS, PILANI – DUBAI

Dubai International Academic City, Dubai

FIRST SEMESTER 2010 – 2011

<u>TEST – 1 (Closed Book)</u>

Year:	III	Date:	10.10.2010
Course Code:	ME C312	Maximum Marks:	25
Course Title:	Design of Machine Elements	Weightage:	25 %
		Duration:	50 minutes

Note:

1. *Answer all the questions.*
2. *Refer to the appropriate charts and tables attached with the question paper wherever necessary.*

Q1. Among the decisions a design engineer must make is selection of the failure criteria that is applicable to the material and its static loading. A hot rolled metal rod, has a yield strength of 225 MPa and true strain at fracture $\varepsilon_f = 0.45$. The load on the rod consists of an axial pull of 10 kN together with a transverse shear force of 5 kN. Find the diameter of the rod taking factor of safety as 2.5. Given below are two failure theories. Select the appropriate failure theory, citing proper justification based on the material properties for your design calculations: **[8 M]**

a. Distortion energy theory
b. Maximum principal stress theory

Q2. A stepped steel shaft is shown in figure Q2. The tensile axial stress on the shaft fluctuates between 25 MPa to 100 MPa. The ultimate tensile strength and yield strength for the material are 450 MPa and 350 MPa respectively and the component has a machine finish. Find the factor of safety. For the fatigue failure analysis use Soderberg criterion. Take the reliability goal as 0.998. **[9 M]**

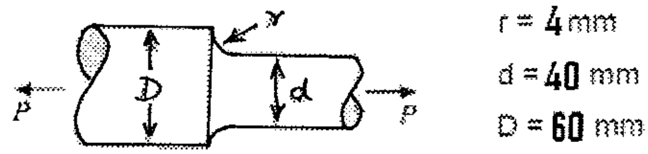


Figure Q2

Q3. A single threaded power screw as shown in figure Q3 is 30 mm in diameter with a pitch of 6 mm. A vertical load on the screw reaches a maximum of 9 kN. The coefficients of friction are 0.04 for collar and 0.08 for the threads. The frictional diameter of collar is 45 mm. Find the following: **[8 M]**

a. torque required to raise the load
b. torque required to lower the load
c. overall efficiency
d. power input for a speed of 60 rpm

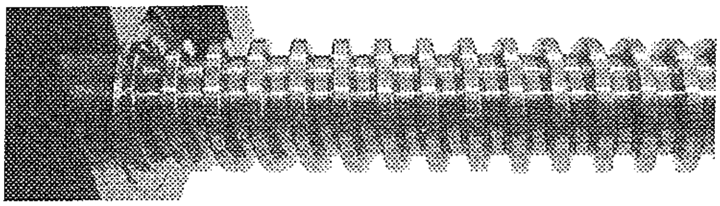
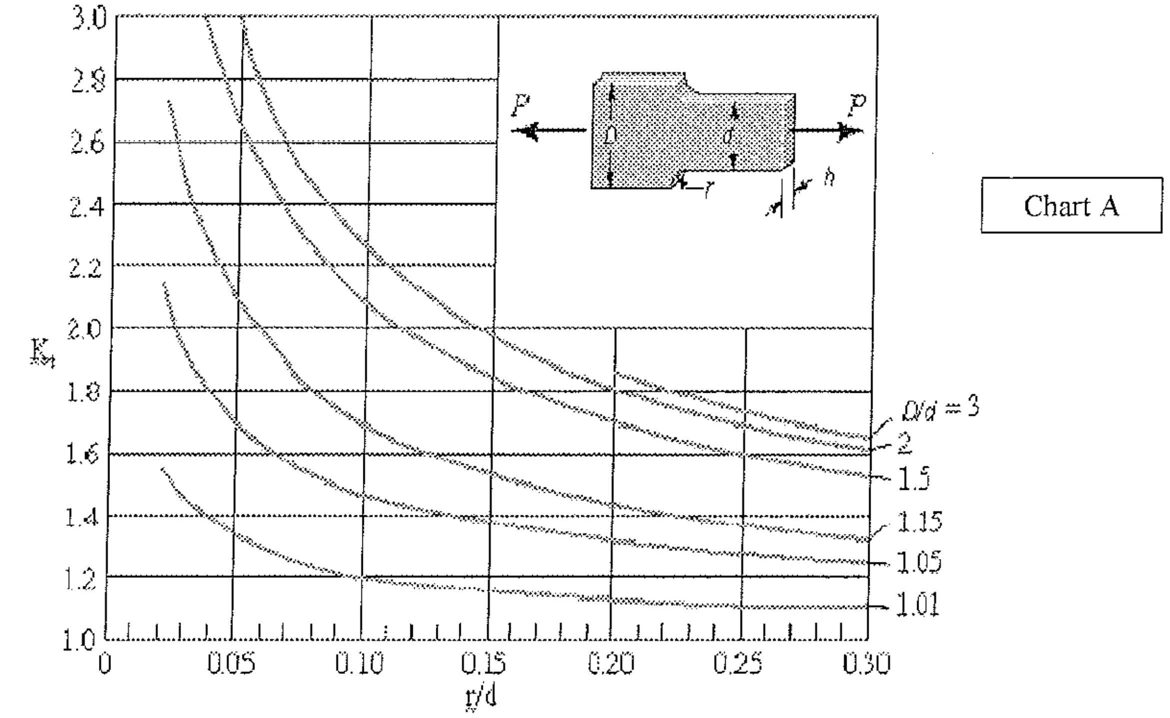
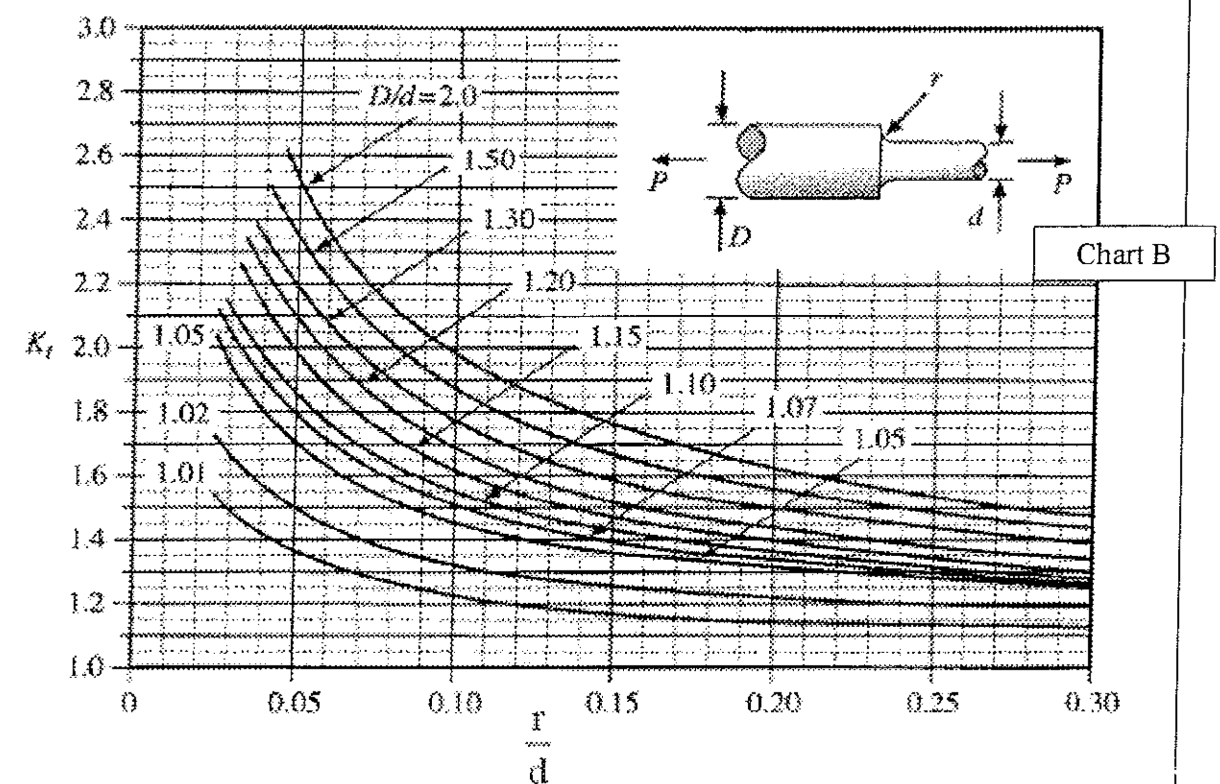


Figure Q3



Variation of theoretical stress concentration factor with r/d for a plate with fillets subjected to a uni-axial loading



Variation of theoretical stress concentration factor with r/d of a stepped shaft for different values of D/d subjected to uni-axial loading

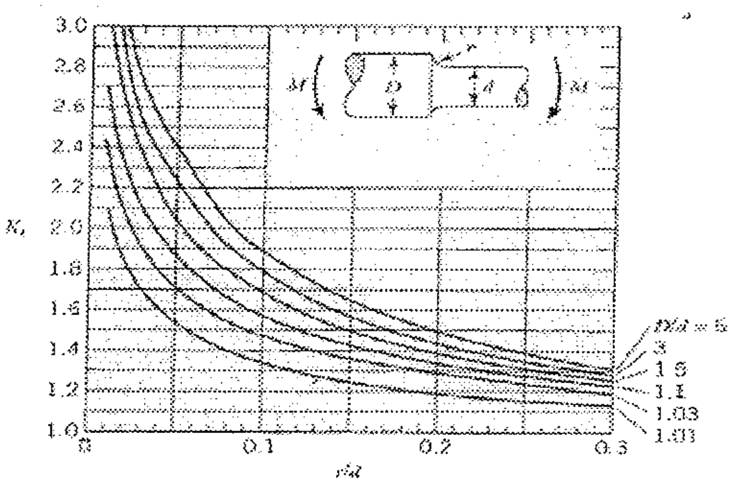


Chart C

Variation of theoretical stress concentration factor with r/d for a stepped shaft subjected to a bending moment

Reliability %	C_5
50	1
90	0.897
99.99	0.702

$C_2 = 1$ (reversed bending load)
$= 0.85$ (reversed axial load)
$= 0.78$ (reversed torsional load)

$C_1 = 1$ ($d \leq 7.6$mm)
$= 0.85$ ($7.6 \leq d \leq 50$mm)
$= 0.75$ ($d \geq 50$mm)

Table 1

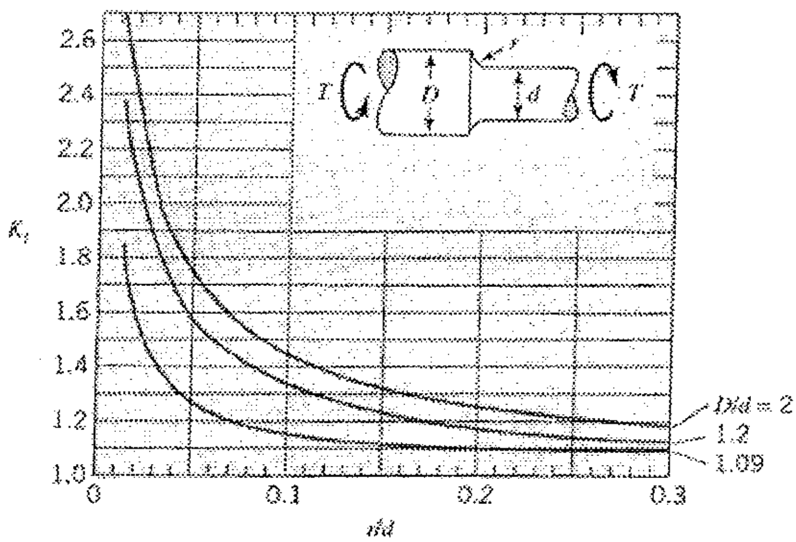


Chart D

Variation of theoretical stress concentration factor with r/d for a stepped shaft subjected to torsion

<u>Steel</u>

$\sigma_e = 0.5\ \sigma_{ut}$ $\quad\sigma_{ut} < 1400$ MPa

$\sigma_e = 700$ MPa $\quad\sigma_{ut} > 1400$ MPa

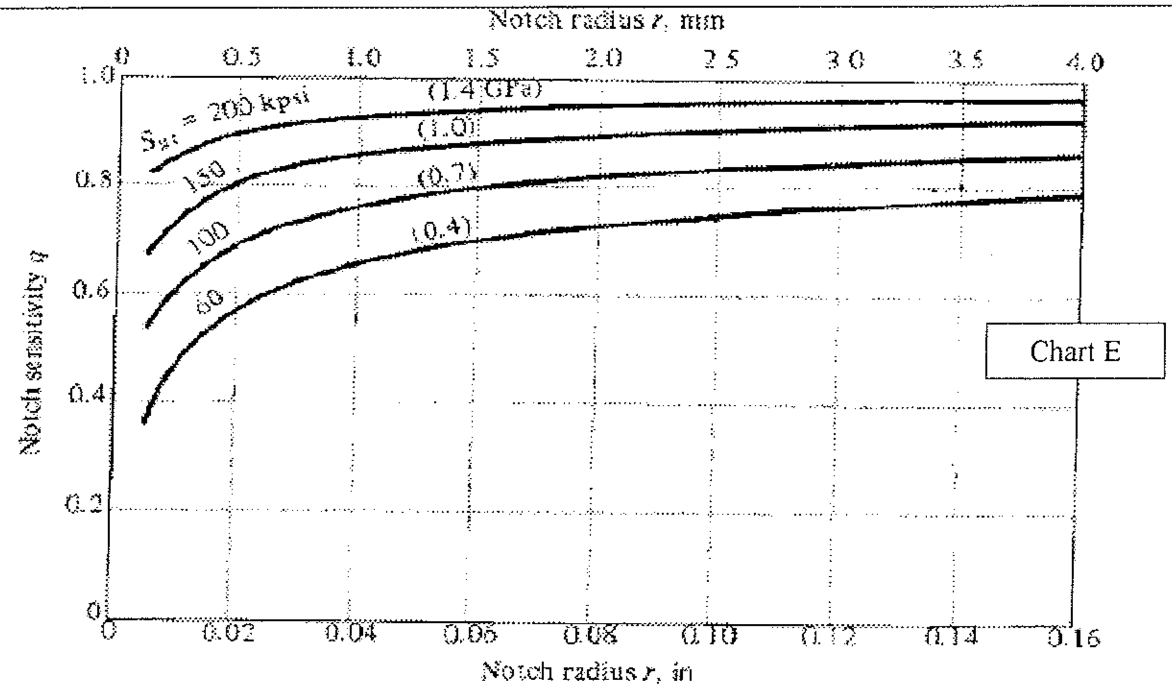
<u>Cast Iron</u>

$\sigma_e = 0.35\ \sigma_{ut}$

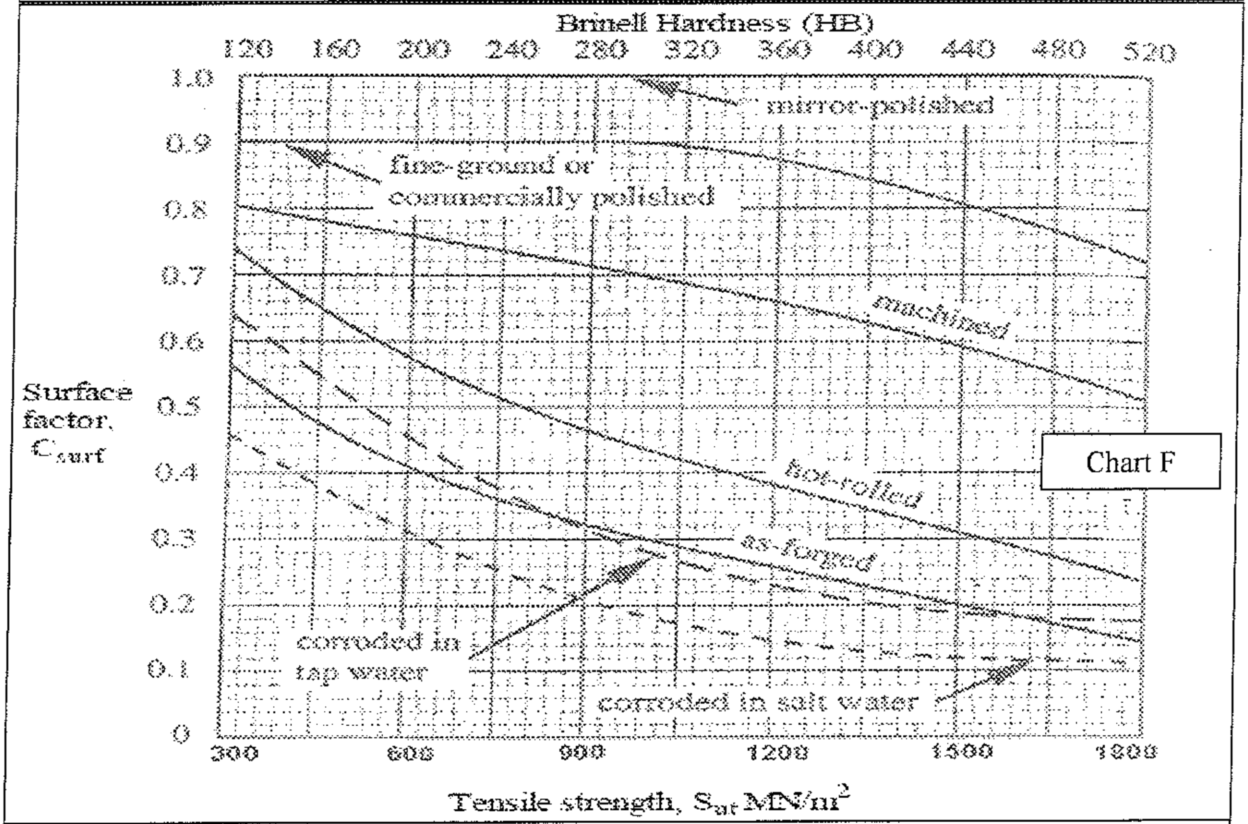
<u>Non Ferrous metals and alloys</u>

$\sigma_e = 0.3\ \sigma_{ut}$

Table 2



Variation of notch sensitivity with notch radius for steels of different ultimate tensile strength



Variation of surface factor with tensile strength and Brinell hardness for steels with different surface conditions

A

BITS, Pilani – Dubai

Dubai International Academic City, Dubai

III Year – I Semester 2010– 2011

QUIZ- 2

Course No.	: ME C312	Weightage	: 7 %
Course Title	: Design of Machine Elements	Max. Marks	: 7
Date	: 15-12-2010	Duration	: 20 minutes

NAME: **ID. No:**

1. Spur gears have teeth ____________ to the axis of rotation. **[0.5 M]**
   a. Offset at 14.5°
   b. Inclined at 20°
   c. Parallel
   d. Inclined

2. ___________is the larger of the two mating gears. **[0.5 M]**
   a. Gear
   b. Pinion
   c. Worm
   d. All of the above

3. All the calculations of gears are based on the ______________. **[0.5 M]**
   a. Circular pitch
   b. Pitch circle
   c. Pitch diameter
   d. Base circle

4. Bevel gears are used to transmit motion between ____________ shafts. **[0.5 M]**
   a. Non-intersecting
   b. Intersecting
   c. Parallel
   d. None of the above

5. Diametral pitch is defined as the __________. **[0.5 M]**
   a. ratio of number of teeth on gear to the pitch diameter
   b. ratio of the pitch diameter to the number of teeth
   c. ratio of tooth thickness to the width of space
   d. ratio of clearance to the fillet radius

6. ______________ is the radial distance between top land and the pitch circle. **[0.5 M]**

a. Dedendum
b. Pitch
c. Clearance
d. Addendum

7. ______________ is the amount by which the width of a tooth space exceeds the thickness of the engaging tooth measured on the pitch circle. **[0.5 M]**

a. Backlash
b. Module
c. Filet radius
d. Bottom land

8. For a 20° pressure angle full-depth tooth the smallest number of pinion teeth to mesh with a rack is ______________. **[0.5 M]**

a. 14
b. 16
c. 18
d. 22

9. Thermoplastic gears are manufactured by ______________. **[0.5 M]**

a. Injection molding
b. Sand casting
c. Powder metallurgy
d. Cold rolling

10. The AGMA allowable bending stress equation is ______________. **[0.5 M]**

a. $\sigma_{all} = \frac{S_t}{S_F}\frac{Y_N}{Y_\theta Y_Z}$

b. $\sigma_{all} = \frac{S_t}{S_F}\frac{Z_N Z_W}{Y_\theta Y_Z}$

c. $\sigma_{all} = \frac{S_t}{S_F}\frac{Y_{NT}}{K_\theta Y_Z}$

d. $\sigma_{all} = \frac{S_t}{S_F}\frac{Y_\theta}{Y_N Y_Z}$

11. A stock gear having a pitch diameter of 50 mm runs at a speed of 1000 rpm transmitting a load of 2.5 kN. The power that can be obtained by this gear is ____________. **[1 M]**

a. 392700 W

b. 261800 W

c. 15700 W

d. 6550 W

12. For the following data of a steel worm gear: worm gear load factor = 35, gear pitch diameter = 200 mm, worm gear effective face width = 30 mm, the allowable gear wear load $(W^t_G)_{all}$ is __________. **[1 M]**

a. 525 kN

b. 233 kN

c. 210 kN

d. 172 kN

A

BITS, Pilani – Dubai

Dubai International Academic City, Dubai

III Year – I Semester 2010– 2011

QUIZ- I

Course No.	: ME C312	Weightage	: 8 %
Course Title	: Design of Machine Elements	Max. Marks	: 8
Date	: 03-11-2010	Duration	: 20 minutes

NAME: **ID. No:**

Q1. When a nut is tightened by placing a washer below it, the bolt will be subjected to ______________________________ stress. **[0.5 M]**

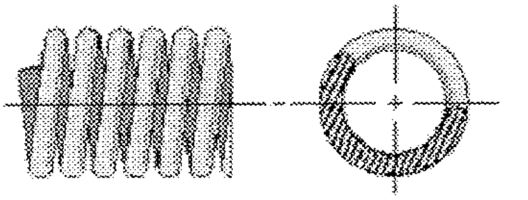
Q2. A helical compression spring is wound using 3 mm diameter wire. The spring has an outside diameter of 30 mm with plain ground ends and 12 total coils. What force is required to compress this spring to closure? **[1.5 M]**

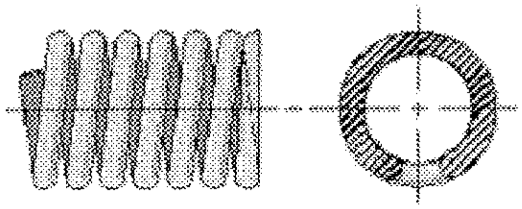
Q3. An extension spring has 84 coils and is close wound with preload of 80 N. The shear modulus and the elastic modulus are 80 GPa and 200 GPa respectively. If the normal force on the hook is 350 N find the spring deflection. Take d = 3 mm and D = 25 mm. **[1.5 M]**

A

Q4. A screw is specified by its ______________________ diameter. **[0.5 M]**

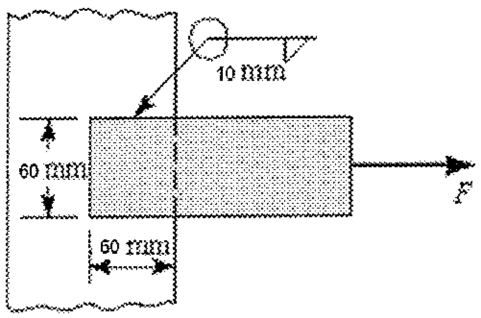
Q5. Identify the type of ends for the two compression springs shown below: **[1 M]**

a.  Ans: ______________________

b.  Ans: ______________________

Q6. A cylinder head is connected to a pressure vessel using 12 bolts. The effective sealing diameter is 150 mm. The cylinder is used to store gas at a pressure of 7 MPa. ISO class 8.8 bolts with a diameter of 12 mm have been selected. Determine the load factor of the bolt. Take the proof strength of 600 MPa and the thread area of 85 mm^2. The clamping force is 40 kN and the percentage of external load carried by the bolt is 20% **[1.5 M]**

Q7. A steel bar is welded to a vertical support as shown. What is the shear stress in the throat of the welds if the force F is 1770 kN? **[1.5 M]**



B

BITS, Pilani – Dubai

Dubai International Academic City, Dubai

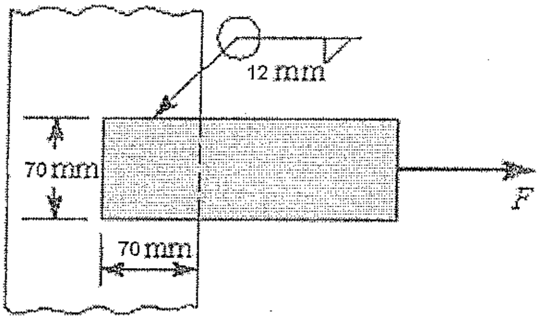
III Year – I Semester 2010– 2011

QUIZ- I

Course No.	: ME C312	Weightage	: 8 %
Course Title	: Design of Machine Elements	Max. Marks	: 8
Date	: 03-11-2010	Duration	: 20 minutes

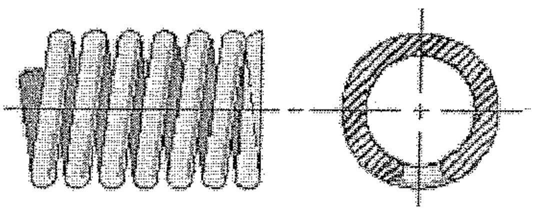
NAME: **ID. No:**

Q1. A steel bar is welded to a vertical support as shown. What is the shear stress in the throat of the welds if the force F is 770 kN? **[1.5 M]**



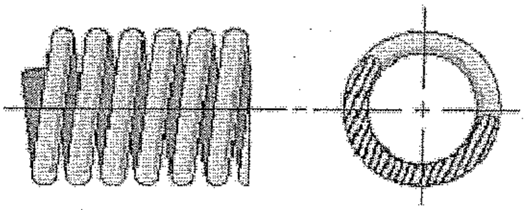
Q2. Identify the type of ends for the two compression springs shown below: **[1 M]**

a.



Ans: ______________________________

b.



Ans: ______________________________

Q3. A screw is specified by its ________________________ diameter. **[0.5 M]**

Q4. When a nut is tightened by placing a washer below it, the bolt will be subjected to ________________________ stress. **[0.5 M]**

B

Q5. A helical compression spring is wound using 3 mm diameter wire. The spring has an outside diameter of 33 mm with shear yield strength of 800 MPa. What force is required to compress this spring to closure? [1.5 M]

Q6. An extension spring has 85 coils and is close wound with preload of 80 N. The shear modulus and the elastic modulus are 80 GPa and 200 GPa respectively. If the normal force on the hook is 300 N find the spring deflection. Take d = 3 mm and D = 25 mm. [1.5 M]

Q7. A cylinder head is connected to a pressure vessel using 14 bolts. The effective sealing diameter is 150 mm. The cylinder is used to store gas at a pressure of 7 MPa. ISO class 8.8 bolts with a diameter of 12 mm have been selected. Determine the load factor of the bolt. Take the proof strength of 800 MPa and the thread area of 85 mm^2. The clamping force is 40 kN and the percentage of external load carried by the bolt is 20% [1.5 M]