UNIVERSITI TEKNOLOGI MALAYSIA

Sekolah Pendidikan Profesional dan Pendidikan Berterusan (UTMSPACE)

FINAL EXAMINATION / *PEPERIKSAAN AKHIR*
SEMESTER 1 – SESSION 2016 / 2017
PROGRAM KERJASAMA

COURSE CODE *KOD KURSUS*	:	DDPJ 3532 / DDPJ 3523
COURSE NAME *NAMA KURSUS*	:	MECHANICAL ENGINEERING DESIGN / *REKABENTUK KEJURUTERAAN MEKANIKAL*
YEAR / PROGRAMME *TAHUN / PROGRAM*	:	3 / DDPB
DURATION *TEMPOH*	:	2 HOURS / 2 *JAM*
DATE *TARIKH*	:	OCTOBER 2016

INSTRUCTION/*ARAHAN* :

1. Answer 3 (THREE) question from section A, and answer all questions from section B .
Jawab 3 (TIGA) soalan dari bahagian A , dan semua soalan dari bahagian B.

(You are required to write your name and your lecturer's name on your answer script)
(Pelajar dikehendaki tuliskan nama dan nama pensyarah pada skrip jawapan)

NAME / *NAMA*	:	....
I.C NO. / *NO. K/PENGENALAN*	:	....
YEAR / COURSE *TAHUN / KURSUS*	:	....
COLLEGE NAME *NAMA KOLEJ*	:	....
LECTURER'S NAME *NAMA PENSYARAH*	:	....

This examination paper consists of ...17...pages including the cover
Kertas soalan ini mengandungi ......17....... muka surat termasuk kulit hadapan

Part A/*Bahagian A*

Answer 3 questions only/*Jawab 3 soalan sahaja*

Q1. A round cantilever bar is subjected to torsion plus a transverse load at the free end as shown in Figure Q1. The bar is made of a ductile material having a yield strength of 345 MPa. The transverse force (P) is 2 kN and the torque is 100 kNm. The bar is 127 mm long (*l*) and a safety factor of 2 is assumed. If, transverse shear can be neglected, determine

i. stress element at A

ii. the minimum diameter to avoid yielding using distortion energy theory (DET) criteria.

Satu bar bulat tergantung ditindaki kilasan dan daya melintang pada hujung bebas seperti yang ditunjukkan dalam Rajah Q1. Bar diperbuat dari bahan rapuh dengan kekuatan alah 345 MPa. Daya melintang (P) adalah 2 kN dan kilasan adalah 100 kNm. Panjang bar ialah 127 mm (l) dan andaian faktor keselamatan adalah 2. Sekiranya, tegasan melintang di abaikan, tentukan

i. elemen tegasan di A

ii. minimum diameter untuk mengelakkan alah menggunakan kretaria teori tenaga herotan (DET).

(25 marks/*markah*)

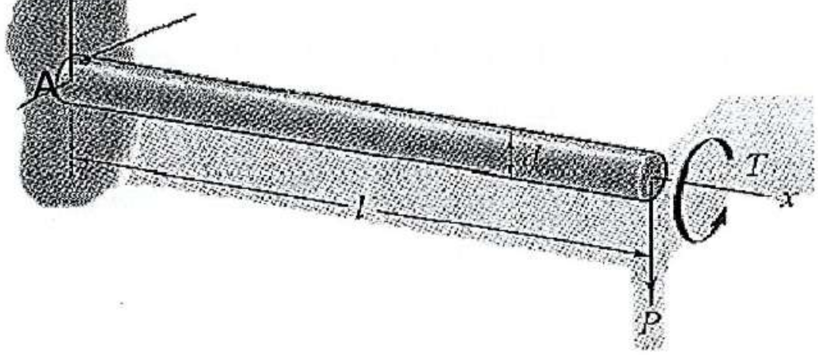


Figure Q1/*Rajah Q1*

Q2. A rotating circular shaft, machined from AISI 1095 Q&T steel, is subjected to a fluctuating bending moment that varies from a value of -100 to 300 Nm as shown in Figure Q2 . Find the factor of safety of the element for an infinite operation life assuming the reliability as 0.999. Use Modified Goodman diagram (Take: S_{ut} = 1260 MPa and S_y = 813 MPa).

Satu aci berputar, telah di mesin dari keluli AISI 1095 Q&T, ditindaki oleh bebanan momen lenturan dari nilai -100 kepada 300 Nm seperti ditunjukkan dalam Rajah Q2. Carikan faktor keselamatan elemen untuk hayat tak terhingga menggunakan keboleharapan 0.999. Gunakan rajah Goodman Terubahsuai (Ambil: S_{ut} = 1260 MPa dan S_y = 813 MPa)

(25 marks/*markah*)

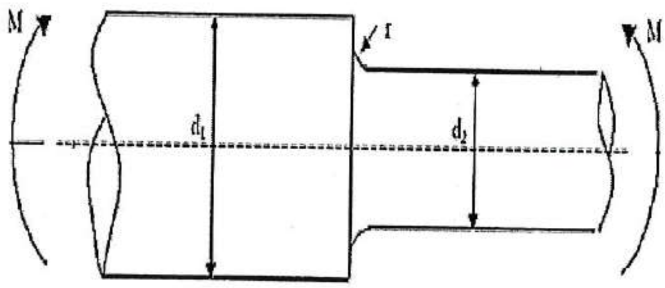


Figure Q2/ *Rajah Q2*

Q3. A welded joint as shown in Figure Q3, is subjected to an eccentric load of 2 kN. Find the size of weld, if the maximum shear stress in the weld is 25 MPa.

Satu sambungan kimpalan ditunjukkan dalam Rajah Q3, ditindaki oleh daya bebanan 2 kN. Tentukan saiz kimpalan sekiranya tegasan ricih maksimum adalah 25 MPa.

(25 marks/*markah*)

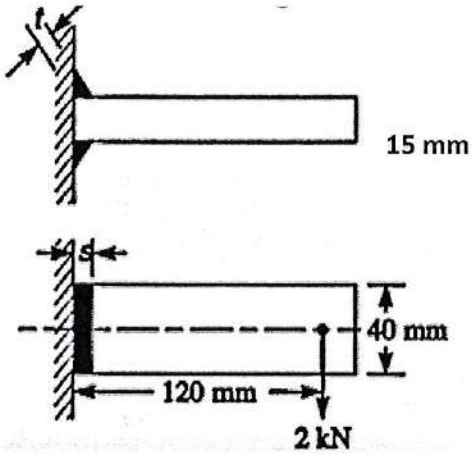


Figure Q3/*Rajah Q3*

Q4. The following particulars of a single reduction spur gear are given: Gear ratio = 10: 1; Distance between centers = 660 mm; pinion transmits 500 kW at 1800 rpm; Involute teeth of standard proportions (addendum = m) with pressure angle of 22.5°; Permissible normal pressure between teeth = 175 N per mm of width. Find:

i. The nearest standard module if no interference is to occur;

ii. The number of teeth on each wheel;

iii. The necessary width of the pinion; and

iv. The load on the bearings of the wheels due to power transmitted.

Maklumat berikut merupakan pengurangan gear taji tunggal diberi : Nisbah gear = 10 : 1; jarak antara pusat-pusat = 660 mm; pinion menmindahkan 500 kW pada 1800 rpm; gigi Involute perkadaran (addendum = m) dengan sudut tekanan 22.5 °; tekanan normal yang dibenarkan di antara gigi = 175 N per mm lebar. Cari:

i. Modul terdekat standard jika tiada gangguan adalah untuk berlaku;

ii. Bilangan gigi pada setiap roda;

iii. Lebar yang perlu bagi pinion; dan

iv. Beban pada galas roda kerana kuasa yang dihantar.

(25 marks/*markah*)

Q5. For supporting the travelling crane in a workshop, the brackets are fixed on steel columns as shown in Figure Q5. The maximum load that comes on the bracket is 12 kN acting vertically at a distance of 400 mm from the face of the column. The vertical face of the bracket is secured to a column by four bolts, in two rows (two in each row) at a distance of 50 mm from the lower edge of the bracket. Determine the size of the bolts if the permissible value of the tensile stress for the bolt material is 84 MPa. Also find the cross-section of the arm of the bracket which is rectangular.

Untuk menyokong kren gerak di bengkel, pendakap tetap dipasang pada tiang keluli seperti yang ditunjukkan dalam Rajah Q5 . Beban maksimum pada pendakap ialah 12 kN bertindak secara menegak pada jarak 400 mm dari muka tiang. Permukaan menegak pada pendakap diikat oleh empat bolt, dalam dua baris (dua dalam setiap baris) pada jarak 50 mm dari tepi bawah pendakap. Tentukan saiz bolt yang sesuai digunakan jika tekanan tegangan dibenarkan untuk bahan bolt ialah 84 MPa. Juga tentukan keratan rentas lengan pendakap yang berbentuk segi empat tepat.

(25 marks/*markah*)

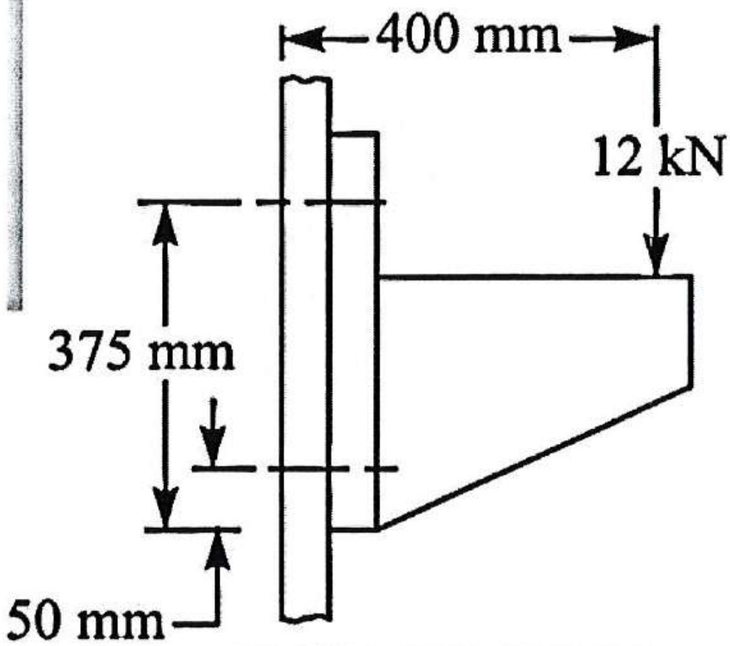


Figure Q5/*Rajah Q5*

PART B: Answer all question

BAHAGIAN B: Jawab semua soalan

Q 1. Select suitable material for the following cases, indicating the reason;

i.. A shaft subjected to variable torsional and bending load ;

ii. Spring used in a spring loaded safety.

Pilih bahan yang sesuai bagi kes-kes berikut, berikan alasan pemilihan ;

i. Aci ditindaki oleh kilasan berubah-ubah dan beban lentur ;

ii. Spring digunakan dalam spring dimuatkan keselamatan.

(3 marks/markah)

Q2. Explain the following terms in connection with design of machine members subjected to variable loads:

i. Endurance limit,

ii. Size factor,

iii. Surface finish factor, and

Terangkan istilah berikut yang berkaitan dengan reka bentuk anggota mesin tertakluk kepada beban berubah-ubah:

i. Had ketahanan,

ii. Faktor saiz,

iii. Permukaan faktor akhir, dan

(6 marks/markah)

Q3. Label the following of gear nomenclature as shown in Figure Q3.

Labelkan tatanama gear seperti yang ditunjukkan Rajah Q3

(4 marks/*markah*)

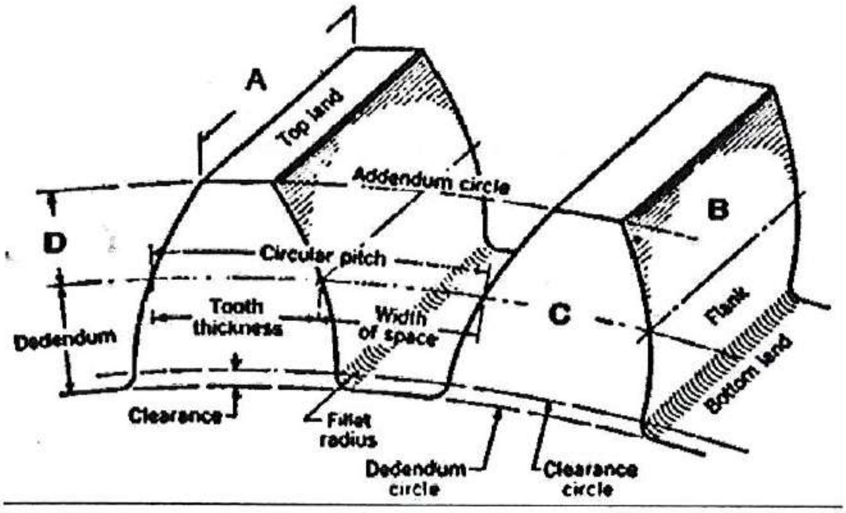


Figure Q3/*Rajah Q3*

Q4. Explain how the following factors influence the life of a bearing:

i. Load

ii. Speed

iii. Temperature

Terangkan bagaimana faktor-faktor berikut mempengaruhi kehidupan galas:

i. Beban

ii. Kelajuan

iii. Suhu

(12 marks/*markah*)

-LAMPIRAN-

STATIC LOADING THEOREM

Maximum Shear Theory

p. 220
$$\tau_{\max} = \frac{\sigma_1 - \sigma_3}{2} = \frac{S_y}{2n} \quad (5\text{–}3)$$

Distortion-Energy Theory

Von Mises stress, p. 223
$$\sigma' = \left[\frac{(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2}{2}\right]^{1/2} \quad (5\text{–}12)$$

p. 223
$$\sigma' = \frac{1}{\sqrt{2}}\left[(\sigma_x - \sigma_y)^2 + (\sigma_y - \sigma_z)^2 + (\sigma_z - \sigma_x)^2 + 6(\tau_{xy}^2 + \tau_{yz}^2 + \tau_{zx}^2)\right]^{1/2} \quad (5\text{–}14)$$

Plane stress, p. 223
$$\sigma' = (\sigma_A^2 - \sigma_A\sigma_B + \sigma_B^2)^{1/2} \quad (5\text{–}13)$$

p. 223
$$\sigma' = (\sigma_x^2 - \sigma_x\sigma_y + \sigma_y^2 + 3\tau_{xy}^2)^{1/2} \quad (5\text{–}15)$$

Yield design equation, p. 224

$$\sigma' = \frac{S_y}{n} \qquad (5\text{–}19)$$

Shear yield strength, p. 225

$$S_{sy} = 0.577\, S_y \qquad (5\text{–}21)$$

Coulomb-Mohr Theory

p. 225

$$\frac{\sigma_1}{S_t} - \frac{\sigma_3}{S_c} = \frac{1}{n} \qquad (5\text{–}26)$$

where S_t is tensile yield (ductile) or ultimate tensile (brittle), and S_t is compressive yield (ductile) or ultimate compressive (brittle) strengths.

Modified Mohr (Plane Stress)

$$\sigma_A = \frac{S_{ut}}{n} \qquad \sigma_A \geq \sigma_B \geq 0$$

$$\sigma_A \geq 0 \geq \sigma_B \quad \text{and} \quad \left|\frac{\sigma_B}{\sigma_A}\right| \leq 1 \qquad (5\text{–}32a)$$

p. 236

$$\frac{(S_{uc} - S_{ut})\sigma_A}{S_{uc}S_{ut}} - \frac{\sigma_B}{S_{uc}} = \frac{1}{n} \qquad \sigma_A \geq 0 \geq \sigma_B \quad \text{and} \quad \left|\frac{\sigma_B}{\sigma_A}\right| > 1 \qquad (5\text{–}32b)$$

$$\sigma_B = -\frac{S_{uc}}{n} \qquad 0 \geq \sigma_A \geq \sigma_B \qquad (5\text{–}32c)$$

FATIQUE

Completely Reversing Simple Loading

1 Determine S'_e either from test data or

p. 282

$$S'_e = \begin{cases} 0.5S_{ut} & S_{ut} \leq 200 \text{ kpsi } (1400 \text{ MPa}) \\ 100 \text{ kpsi} & S_{ut} > 200 \text{ kpsi} \\ 700 \text{ MPa} & S_{ut} > 1400 \text{ MPa} \end{cases} \qquad (6\text{–}8)$$

2 Modify S'_e to determine S_e.

p. 287

$$S_e = k_a k_b k_c k_d k_e k_f S'_e \qquad (6\text{-}18)$$

$$k_a = a S_{ut}^b \qquad (6\text{-}19)$$

Surface Finish	Factor a S_{ut}, kpsi	Factor a S_{ut}, MPa	Exponent b
Ground	1.34	1.58	−0.085
Machined or cold-drawn	2.70	4.51	−0.265
Hot-rolled	14.4	57.7	−0.718
As-forged	39.9	272.	−0.995

Rotating shaft. For bending or torsion,

p. 288

$$k_b = \begin{cases} (d/0.3)^{-0.107} = 0.879d^{-0.107} & 0.11 \le d \le 2 \text{ in} \\ 0.91d^{-0.157} & 2 < d \le 10 \text{ in} \\ (d/7.62)^{-0.107} = 1.24d^{-0.107} & 2.79 \le d \le 51 \text{ mm} \\ 1.51d^{-0.157} & 51 < 254 \text{ mm} \end{cases} \qquad (6\text{-}20)$$

For axial,

$$k_b = 1 \qquad (6\text{-}21)$$

Nonrotating member. Use Table 6–3, p. 290, for d_e and substitute into Eq. (6–20) for d.

p. 290

$$k_c = \begin{cases} 1 & \text{bending} \\ 0.85 & \text{axial} \\ 0.59 & \text{torsion} \end{cases} \qquad (6\text{-}26)$$

p. 291 Use Table 6–4 for k_d, or

$$k_d = 0.975 + 0.432(10^{-3})T_F - 0.115(10^{-5})T_F^2 + 0.104(10^{-8})T_F^3 - 0.595(10^{-12})T_F^4 \qquad (6\text{-}27)$$

pp. 292–293, k_e

Reliability, %	Transformation Variate z_a	Reliability Factor k_e
50	0	1.000
90	1.288	0.897
95	1.645	0.868
99	2.326	0.814
99.9	3.091	0.753
99.99	3.719	0.702
99.999	4.265	0.659
99.9999	4.753	0.620

pp. 293–294, k_f

3 Determine fatigue stress-concentration factor, K_f or K_{fs}. First, find K_t or K_{ts} from Table A–15.

p. 295 $$K_f = 1 + q(K_t - 1) \quad \text{or} \quad K_{fs} = 1 + q(K_{ts} - 1) \qquad (6\text{–}32)$$

Obtain q from either Fig. 6–20 or 6–21, pp. 295–296.

Alternatively,

p. 296 $$K_f = 1 + \frac{K_t - 1}{1 + \sqrt{a}/\sqrt{r}} \qquad (6\text{–}33)$$

For $\sqrt{a}$ in units of $\sqrt{\text{in}}$, and S_{ut} in kpsi

Bending or axial: $\sqrt{a} = 0.246 - 3.08(10^{-3})S_{ut} + 1.51(10^{-5})S_{ut}^2 - 2.67(10^{-8})S_{ut}^3$ (6–35a)

Torsion: $\sqrt{a} = 0.190 - 2.51(10^{-3})S_{ut} + 1.35(10^{-5})S_{ut}^2 - 2.67(10^{-8})S_{ut}^3$ (6–35b)

4 Apply K_f or K_{fs} by *either* dividing S_e by it *or* multiplying it with the purely reversing stress, *not* both.

5 Determine fatigue life constants a and b. If $S_{ut} \geq 70$ kpsi, determine f from Fig. 6–18, p. 285. If $S_{ut} < 70$ kpsi, let $f = 0.9$.

p. 285 $$a = (f\,S_{ut})^2/S_e \qquad (6\text{–}14)$$

$$b = -[\log(f\,S_{ut}/S_e)]/3 \qquad (6\text{–}15)$$

6 Determine fatigue strength S_f at N cycles, or, N cycles to failure at a reversing stress σ_{rev}

(*Note*: this only applies to purely reversing stresses where $\sigma_m = 0$).

p. 285 $$S_f = aN^b \qquad (6\text{–}13)$$

$$N = (\sigma_{rev}/a)^{1/b} \qquad (6\text{–}16)$$

Fluctuating Simple Loading

For S_e, K_f or K_{fs}, see previous subsection.

1 Calculate σ_m and σ_a. Apply K_f to both stresses.

p. 301 $$\sigma_m = (\sigma_{max} + \sigma_{min})/2 \qquad \sigma_a = |\sigma_{max} - \sigma_{min}|/2 \qquad (6\text{–}36)$$

2 Apply to a fatigue failure criterion, p. 306

$\sigma_m \geq 0$

Soderburg	$\sigma_a/S_e + \sigma_m/S_y = 1/n$	(6–45)
mod-Goodman	$\sigma_a/S_e + \sigma_m/S_{ut} = 1/n$	(6–46)
Gerber	$n\sigma_a/S_e + (n\sigma_m/S_{ut})^2 = 1$	(6–47)
ASME-elliptic	$(\sigma_a/S_e)^2 + (\sigma_m/S_y)^2 = 1/n^2$	(6–48)

$\sigma_m < 0$

p. 305 $$\sigma_a = S_e/n$$

Figure 6–20

Notch-sensitivity charts for steels and UNS A92024-T wrought aluminum alloys subjected to reversed bending or reversed axial loads. For larger notch radii, use the values of q corresponding to the $r = 0.16$-in (4-mm) ordinate. *(From George Sines and J. L. Waisman (eds.),* Metal Fatigue, *McGraw-Hill, New York. Copyright © 1969 by The McGraw-Hill Companies, Inc. Reprinted by permission.)*

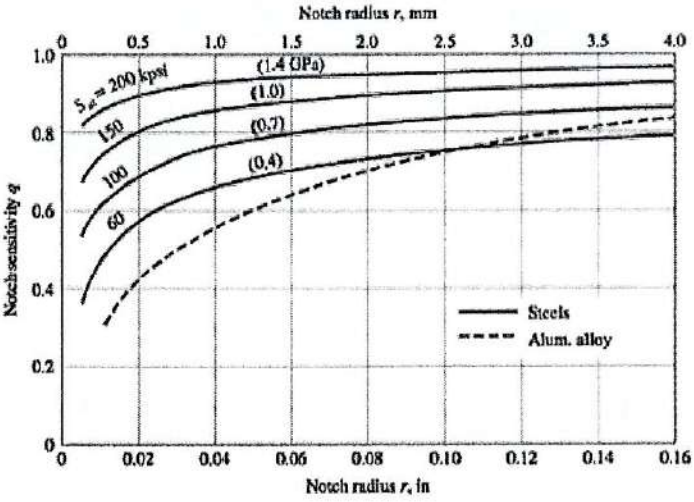
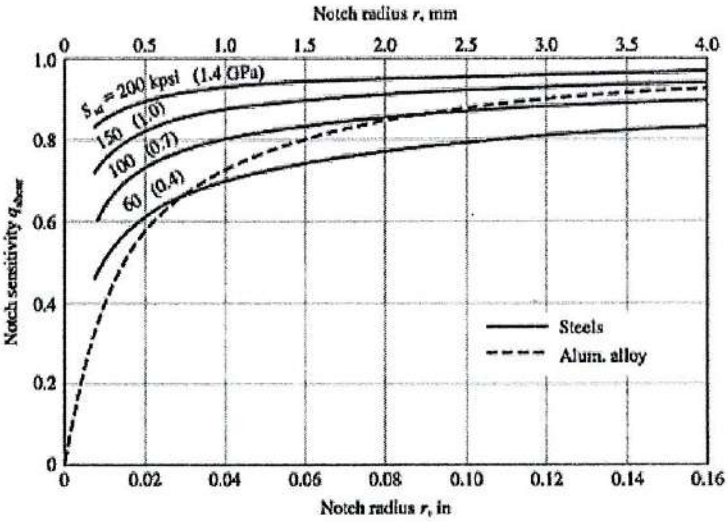
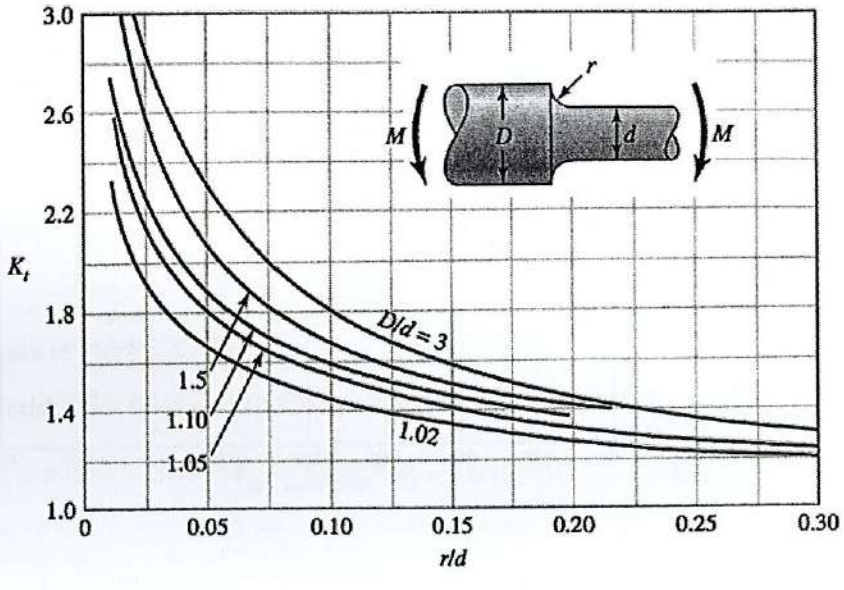
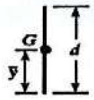
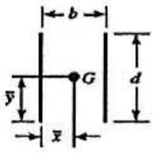
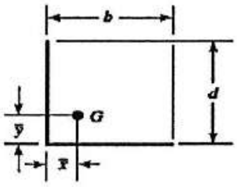
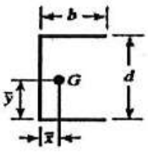
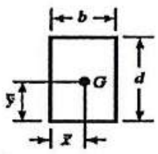


Figure 6–21

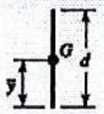
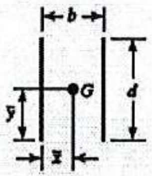
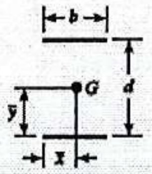
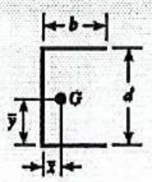
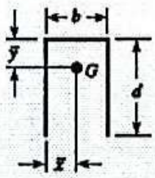
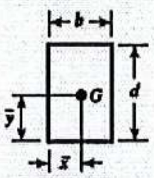
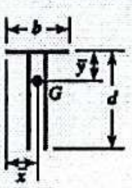
Notch-sensitivity curves for materials in reversed torsion. For larger notch radii, use the values of q_{shear} corresponding to $r = 0.16$ in (4 mm).

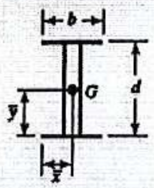



3.0
2.6
2.2
1.8
1.4
1.0
K_t
0
0.05
0.10
0.15
0.20
0.25
0.30
r/d
r
M
D
d
M
D/d = 3
1.5
1.10
1.05
1.02

Weld	Throat Area	Location of G	Unit Second Polar Moment of Area
	$A = 0.70\,hd$	$\bar{x} = 0$ $\bar{y} = d/2$	$J_u = d^3/12$
	$A = 1.41\,hd$	$\bar{x} = b/2$ $\bar{y} = d/2$	$J_u = \frac{d(3b^2 + d^2)}{6}$
	$A = 0.707h(2b + d)$	$\bar{x} = \frac{b^2}{2(b+d)}$ $\bar{y} = \frac{d^2}{2(b+d)}$	$J_u = \frac{(b+d)^4 - 6b^2d^2}{12(b+d)}$
	$A = 0.707h(2b + d)$	$\bar{x} = \frac{b^2}{2b+d}$ $\bar{y} = d/2$	$J_u = \frac{8b^3 + 6bd^2 + d^3}{12} - \frac{b^4}{2b+d}$
	$A = 1.414h(b + d)$	$\bar{x} = b/2$ $\bar{y} = d/2$	$J_u = \frac{(b+d)^3}{6}$
	$A = 1.414\,\pi hr$		$J_u = 2\pi r^3$

Bending Properties of Fillet Welds*

Weld	Throat Area	Location of G	Unit Second Moment of Area
	$A = 0.707hd$	$\bar{x} = 0$ $\bar{y} = d/2$	$I_u = \frac{d^3}{12}$
	$A = 1.414hd$	$\bar{x} = b/2$ $\bar{y} = d/2$	$I_u = \frac{d^3}{6}$
	$A = 1.414hd$	$\bar{x} = b/2$ $\bar{y} = d/2$	$I_u = \frac{bd^2}{2}$
	$A = 0.707h(2b + d)$	$\bar{x} = \frac{b^2}{2b+d}$ $\bar{y} = d/2$	$I_u = \frac{d^2}{12}(6b+d)$
	$A = 0.707h(b + 2d)$	$\bar{x} = b/2$ $\bar{y} = \frac{d^2}{b+2d}$	$I_u = \frac{2d^3}{3} - 2d^2\bar{y} + (b+2d)\bar{y}^2$
	$A = 1.414h(b + d)$	$\bar{x} = b/2$ $\bar{y} = d/2$	$I_u = \frac{d^2}{6}(3b+d)$
	$A = 0.707h(b + 2d)$	$\bar{x} = b/2$ $\bar{y} = \frac{d^2}{b+2d}$	$I_u = \frac{2d^3}{3} - 2d^2\bar{y} + (b+2d)\bar{y}^2$

Weld	Throat Area	Location of G	Unit Second Moment of Area
	$A = 1.414h(b + d)$	$\bar{x} = b/2$ $\bar{y} = d/2$	$I_u = \frac{d^2}{6}(3b + d)$
	$A = 1.414\pi hr$		$I_u = \pi r^3$