UTM
UNIVERSITI TEKNOLOGI MALAYSIA

Sekolah Pendidikan Profesional dan
Pendidikan Berterusan
(UTMSPACE)

FINAL EXAMINATION / *PEPERIKSAAN AKHIR*
SEMESTER 2 – SESSION 2017 / 2018
PROGRAM KERJASAMA

COURSE CODE *KOD KURSUS*	:	DDPJ 3532
COURSE NAME *NAMA KURSUS*	:	MECHANICAL ENGINEERING DESIGN *REKABENTUK KEJURUTERAAN MEKANIKAL*
YEAR / PROGRAMME *TAHUN / PROGRAM*	:	3 DDPB
DURATION *TEMPOH*	:	2 HOURS / 2 *JAM*
DATE *TARIKH*	:	APRIL 2018

INSTRUCTION/*ARAHAN* :

i) Answer **FOUR** questions in the answer booklet(s) provided.
*Jawab **EMPAT** soalan di dalam buku jawapan yang disediakan.*

ii) Candidates are required to follow all instruction given out by the examination invigilators.
Calon dikehendaki mematuhi semua arahan daripada penyelia peperiksaan.

(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)

STUDENT'S NAME / *NAMA PELAJAR*	:	....
I.C NO. / *NO. K/PENGENALAN*	:	....
YEAR / PROGRAMME *TAHUN / PROGRAM*	:	....
COLLEGE NAME *NAMA KOLEJ*	:	....
LECTURER'S NAME *NAMA PENSYARAH*	:	....

This examination paper consists of **14** pages including the cover
*Kertas soalan ini mengandungi **14** muka surat termasuk kulit hadapan*

PUSAT PROGRAM KERJASAMA

PETIKAN DARIPADA PERATURAN AKADEMIK
ARAHAN AM - PENYELEWENGAN AKADEMIK

1. SALAH LAKU SEMASA PEPERIKSAAN

1.1 Pelajar tidak boleh melakukan mana-mana salah laku peperiksaan seperti berikut :-

1.1.1 memberi dan/atau menerima dan/atau memiliki sebarang maklumat dalam bentuk elektronik, bercetak atau apa jua bentuk lain yang tidak dibenarkan semasa berlangsungnya peperiksaan sama ada di dalam atau di luar Dewan Peperiksaan melainkan dengan kebenaran Ketua Pengawas; atau

1.1.2 menggunakan makluman yang diperolehi seperti di atas bagi tujuan menjawab soalan peperiksaan; atau

1.1.3 menipu atau cuba untuk menipu atau berkelakuan mengikut cara yang boleh ditafsirkan sebagai menipu semasa berlangsungnya peperiksaan; atau

1.1.4 lain-lain salah laku yang ditetapkan oleh Universiti (seperti membuat bising, mengganggu pelajar lain, mengganggu Pengawas menjalankan tugasnya).

2. HUKUMAN SALAH LAKU PEPERIKSAAN

2.1 Sekiranya pelajar didapati telah melakukan pelanggaran mana-mana peraturan peperiksaan ini, setelah diperakukan oleh Jawatankuasa Peperiksaan Fakulti dan disabitkan kesalahannya, Senat boleh mengambil tindakan dari mana-mana satu yang berikut :-

2.1.1 memberi markah SIFAR (0) bagi keseluruhan keputusan peperiksaan kursus yang berkenaan (termasuk kerja kursus); atau

2.1.2 memberi markah SIFAR (0) bagi semua kursus yang didaftarkan pada semester tersebut.

2.2 Jawatankuasa Akademik Fakulti boleh mencadangkan untuk diambil tindakan tatatertib mengikut peruntukan Akta Universiti dan Kolej Universiti, 1971, Kaedah-kaedah Universiti Teknologi Malaysia (Tatatertib Pelajar-pelajar), 1999 bergantung kepada tahap kesalahan yang dilakukan oleh pelajar.

2.3 Pelajar yang didapati melakukan kesalahan kali kedua akan diambil tindakan seperti di perkara 2.1.2 dan dicadang untuk diambil tindakan tatatertib mengikut peruntukan Akta Universiti dan Kolej Universiti, 1971, Kaedah-kaedah Universiti Teknologi Malaysia (Tatatertib Pelajar-pelajar), 1999.

QUESTION 1 / *SOALAN 1*

A beam having a T section with the dimensions shown in **Figure Q1** is subjected to a bending moment of 1600 Nm, that causes tension at the top surface.

(a) Determine the neutral axis,

(b) find the maximum tensile stress, and

(c) calculate the maximum compressive stress.

Satu rasuk mempunyai keratan rentas berbentuk T dengan dimensi ditunjukkan dalam ***Rajah S1*** *dibebani momen lentur bernilai 1600 Nm, yang menyebabkan tegangan berlaku dipermukaan bahagian atas rasuk.*

(a) Tentukan kedudukan paksi neutral

(b) dapatkan tegasan tegangan maksimum, dan

(c) kirakan tegasan mampatan maksimum.

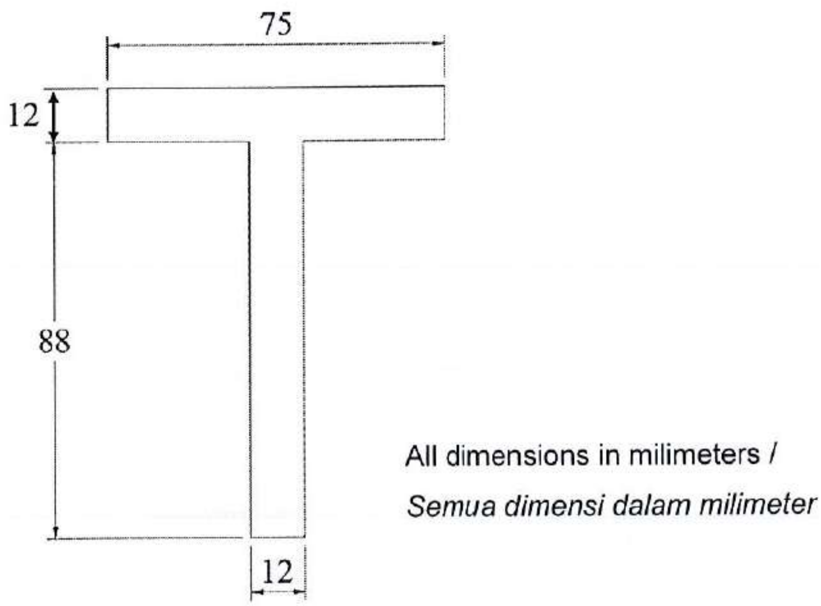


Figure Q1 / *Rajah S1*

(25 Marks/*Markah*)

QUESTION 2 / *SOALAN 2*

The rotating steel shaft is simply supported by bearings at points B and C, and it driven by a gear (not shown) which meshes with the spur gear at D, which has a 150 mm pitch diameter. The force F from the drive gear acts at a pressure angle of 20° as shown in the **Figure Q2**. The shaft is machined from steel with yield stress S_y = 420 MPa and ultimate tensile stress S_{ut} = 560 MPa. Using a factor of safety of 2.5, determine the minimum allowable diameter of the 250 mm section of the shaft based on a static yield analysis using the distortion energy theory.
Given, stress concentration factor for bending K_t = 2.7 and torsional K_{ts} = 2.2; Notch sensitivity q = 0.8 and q_{shear} = 0.9

Aci berputar keluli adalah disokong mudah dengan galas pada B dan C, dan ia dipacu dengan gear (tidak ditunjukkan) yang dirangkaikan dengan gear taji di D, yang mempunyai diameter pic 150 mm. Daya F daripada gear pemacu bertindak pada sudut 20° seperti ditunjukkan dalam ***Rajah S2****. Aci dimesin daripada keluli dengan tegasan alah S_y = 420 MPa dan tegasan tegangan muktamad S_{ut} = 560 MPa. Dengan menggunakan faktor keselamatan 2.5, tentukan diameter minimum dibenarkan bagi bahagian 250 mm aci berdasarkan kepada analisis statik menggunakan teori tenaga herotan.*
Diberi, faktor tumpuan tegasan bagi lenturan K_t = 2.7 dan kilasan K_{ts} = 2.2; kepekaan takuk q = 0.8 dan q_{shear} = 0.9

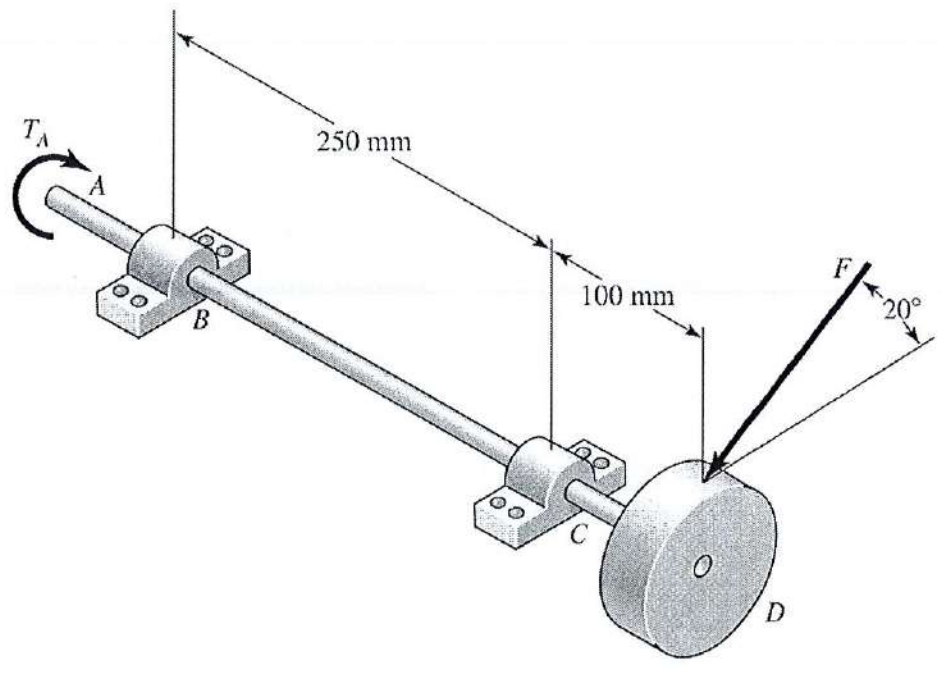


Figure Q2 / *Rajah S2*

(25 Marks/*Markah*)

QUESTION 3 / *SOALAN 3*

Figure Q3(a) shows a rotating shaft simply supported in ball bearing at A and D, and loaded by a nonrotating force F of 6.8 kN. Meanwhile, **Figure Q3(b)** shows bending moment diagram. Estimate the life of the part. All dimensions of shaft in millimeters. Given, fatigue stress-concentration factor K_f = 1.55; all fillets 3 mm radius; the shaft rotates and the load is stationary; material is machined from AISI 1050 cold-drawn steel.

Rajah S3(a) *menunjukkan satu aci keluli berputar yang disokong mudah pada galas di A dan D, dan dibebani dengan daya tidak berputar F bernilai 6.8 kN. Manakala,* ***Rajah S3(b)*** *menunjukkan rajah momen lentur. Anggarkan jangka hayat bagi peralatan tersebut. Semua dimensi bagi aci dalam unit millimeter. Diberi, faktor tumpuan-tegasan lesu K_f = 1.55; semua kekambi berjejari 3 mm; aci berputar dan beban adalah pegun; bahan dimesin daripada keluli penarikan-sejuk AISI 1050.*

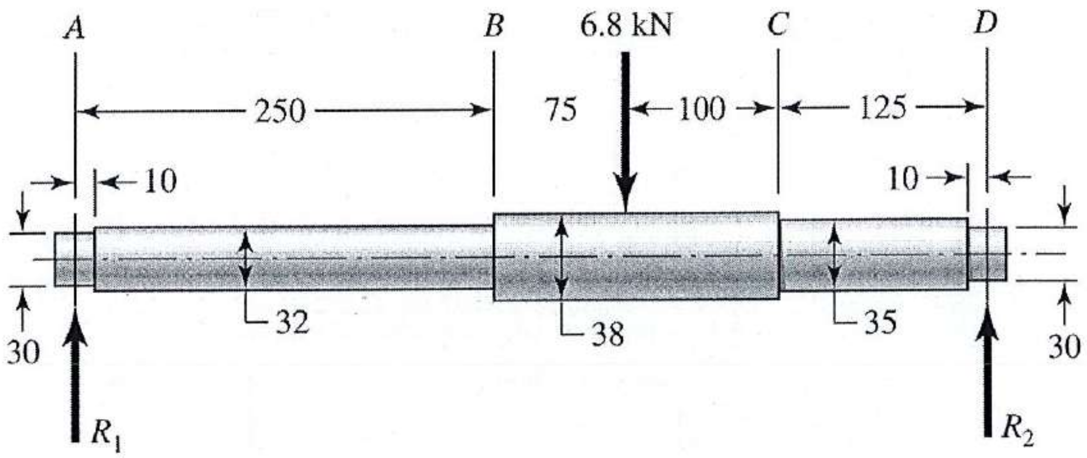


Figure Q3(a) / ***Rajah S3(a)***

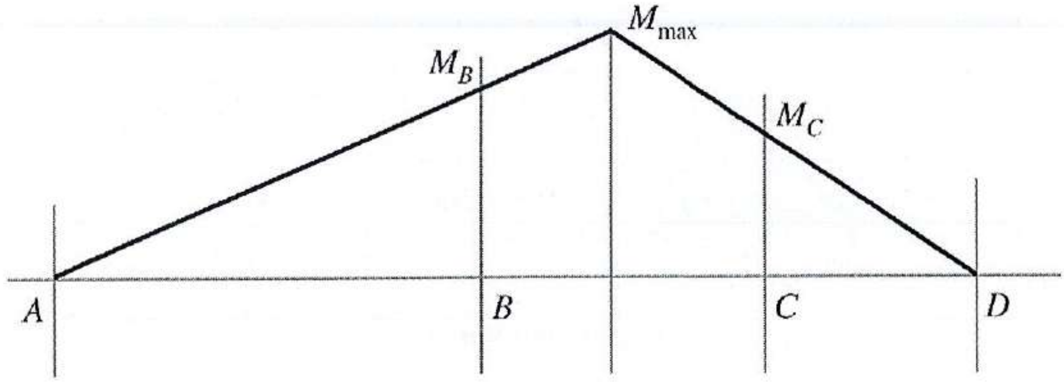


Figure Q3(b) / ***Rajah S3(b)***

(25 Marks/*Markah*)

QUESTION 4 / *SOALAN 4*

A rectangular steel bar shown in the **Figure Q4** is cantilevered to a 250 mm steel channel using four tightly fitted bolts located at A, B, C and D. All dimensions in millimeters. For the F = 16 kN load shown, find;

(a) the resultant load on each bolt
(b) the maximum shear stress in each bolt
(c) the maximum bearing stress

Bar keluli segiempat tepat ditunjukkan dalam ***Rajah S4*** *adalah dijulur kepada satu alur keluli berukuran 250 mm menggunakan empat bolt yang dipasang dengan ketat terletak di A, B, C dan D. Semua dimensi dalam unit milimeter. Bagi beban F = 16 kN ditunjukkan, dapatkan;*

(a) beban paduan pada setiap bolt.
(b) tegasan ricih maksimum dalam setiap bolt
(c) tegasan galas maksimum

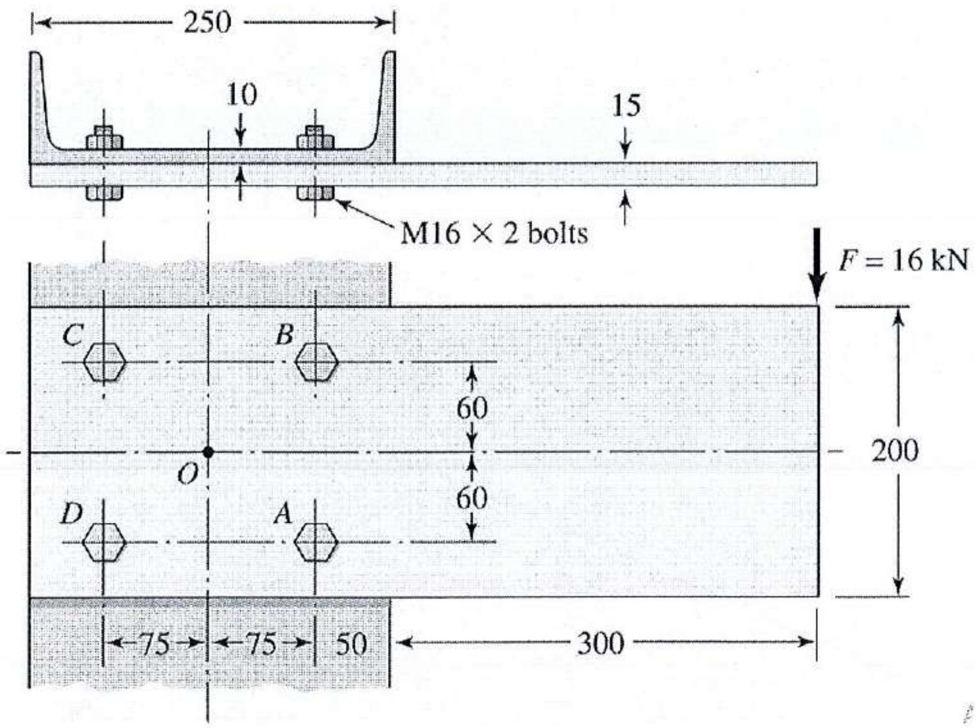


Figure Q4 / *Rajah S4*

(25 Marks/*Markah*)

QUESTION 5 / *SOALAN 5*

Figure Q5 shows a steel bar of thickness h is subjected to a bending force *F*. The vertical support is stepped such that the horizontal welds are b_1 dan b_2 long. Determine force *F* if the maximum allowable shear stress τ_{allow} = 140 MPa. Given b_1 = 30 mm, b_2 = 50 mm, *c* = 150 mm, *d* = 50 mm and *h* = 5 mm.

Rajah S5 *menunjukkan satu keluli bar berketebalan h dikenakan beban lenturan F. Sokongan menegak dilangkah sedemikian rupa agar kimpalan mendatar berukuran* b_1 *dan* b_2 *panjang. Tentukan daya F jika tegasan ricih maksimum dibenarkan* τ_{allow} *= 140 MPa. Diberi* b_1 *= 30 mm,* b_2 *= 50 mm, c = 150 mm, d = 50 mm dan h = 5 mm.*

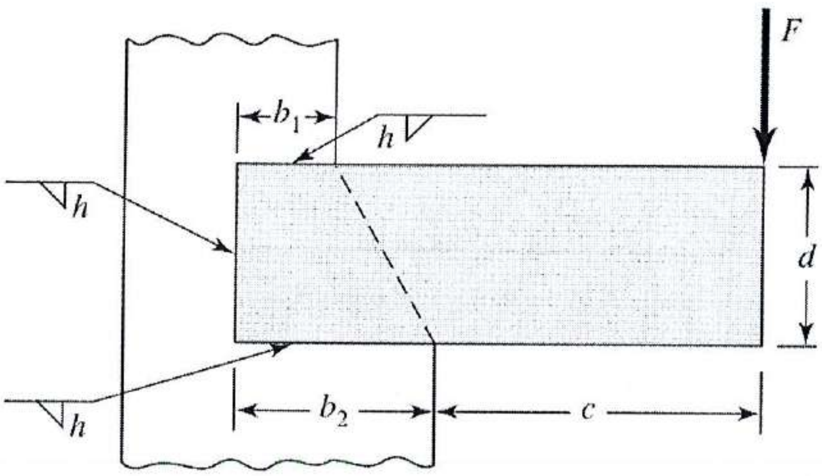


Figure Q5 / *Rajah S5*

(25 Marks/*Markah*)

APPENDIX 1 / *LAMPIRAN 1*

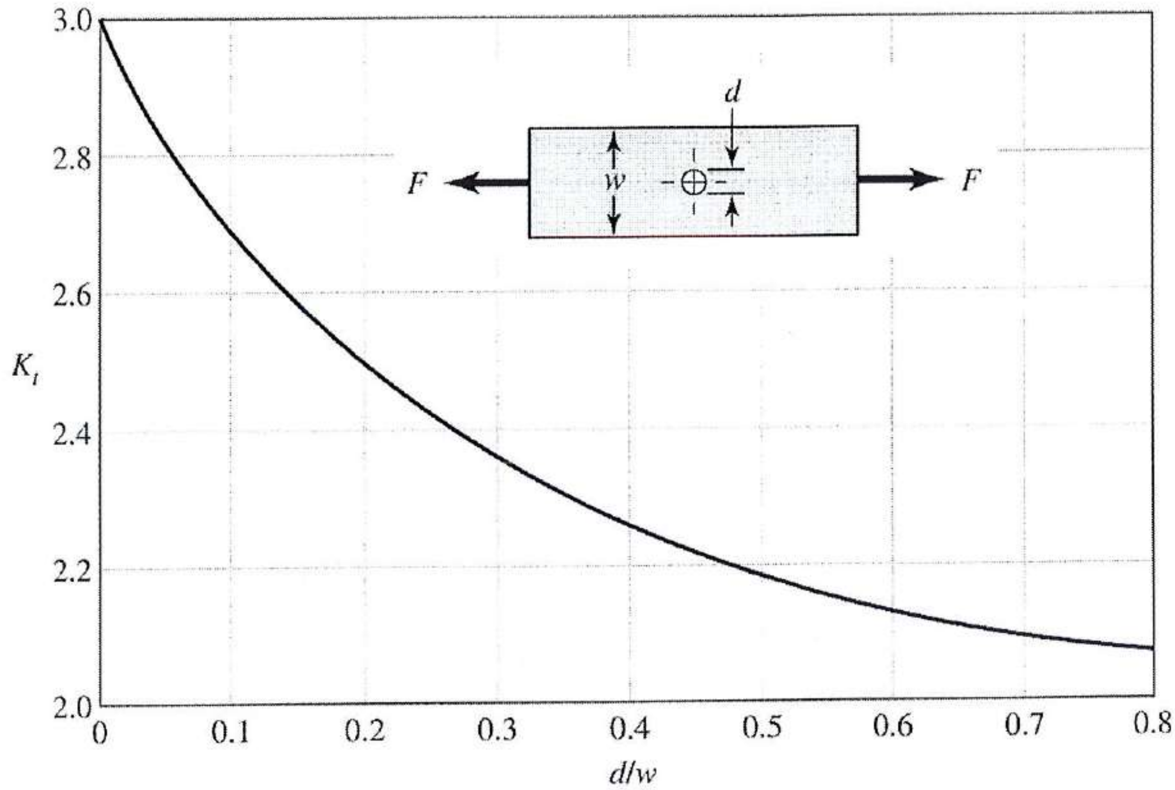


Figure 1 : Bar in tension or simple compression with a transverse hole. $\sigma_o = F/A$, where $A = (\omega - d)t$ and t is the thickness.

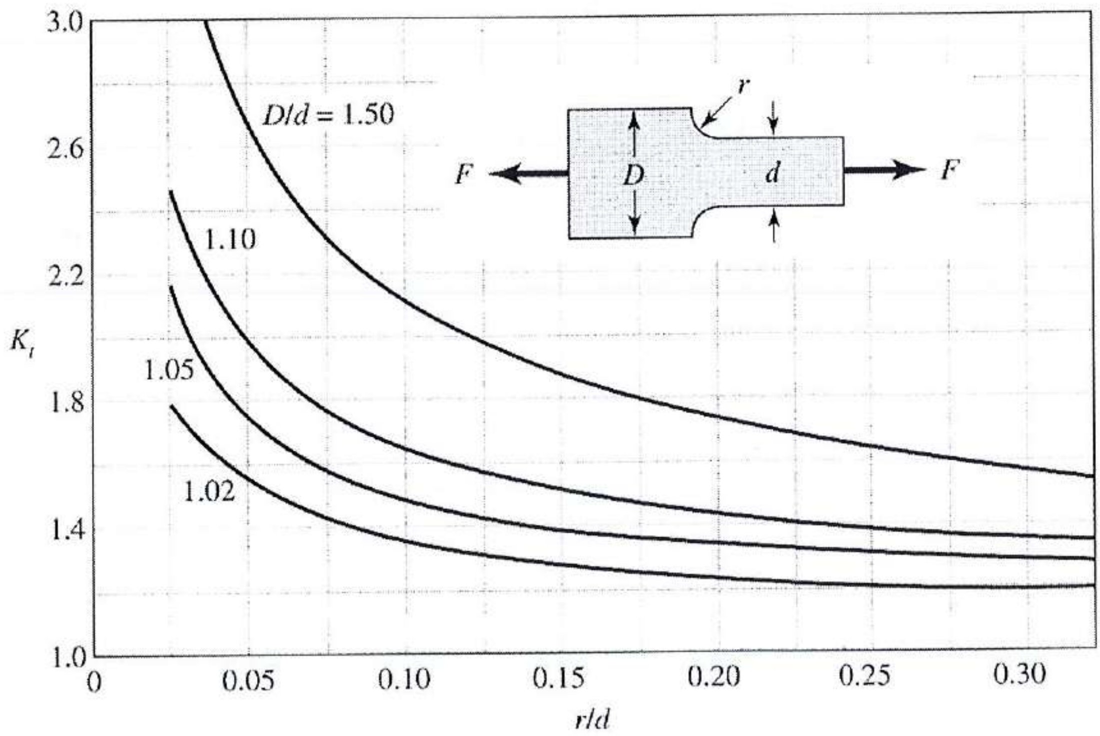


Figure 2 : Rectangular filleted bar in tension or simple compression. $\sigma_o = F/A$, where $A = dt$ and t is the thickness.

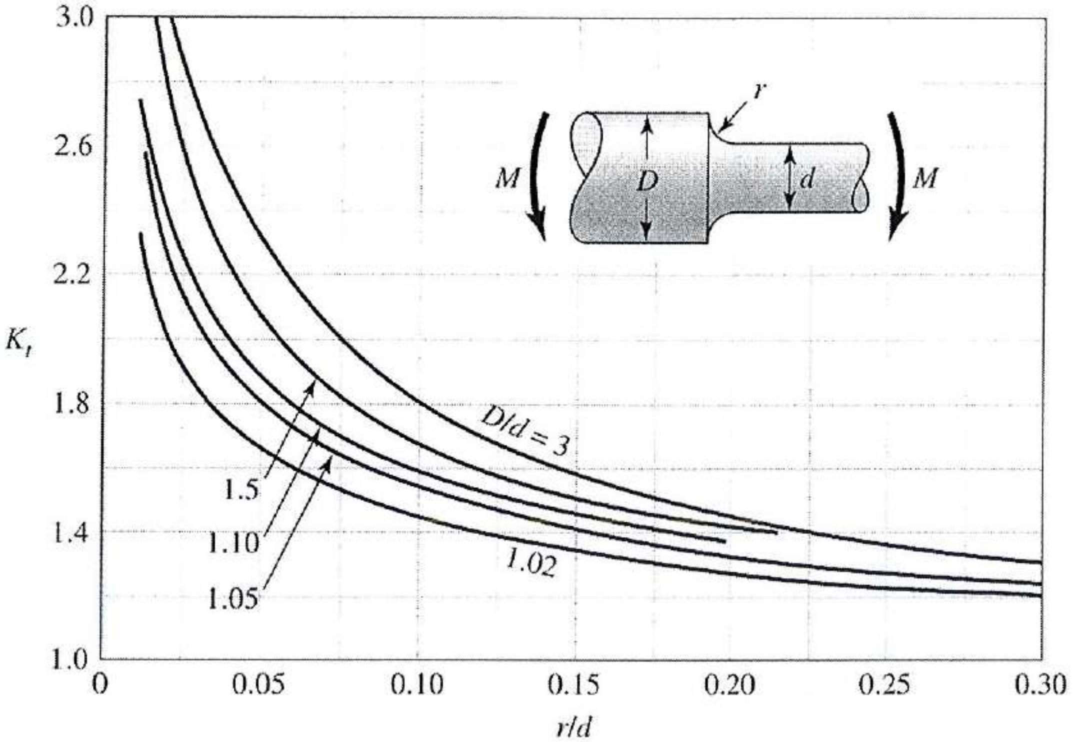


Figure 3 : Round shaft with shoulder fillet in bending. $\sigma_o = Mc/I$, where $c = d/2$ and $I = \pi d^4/64$.

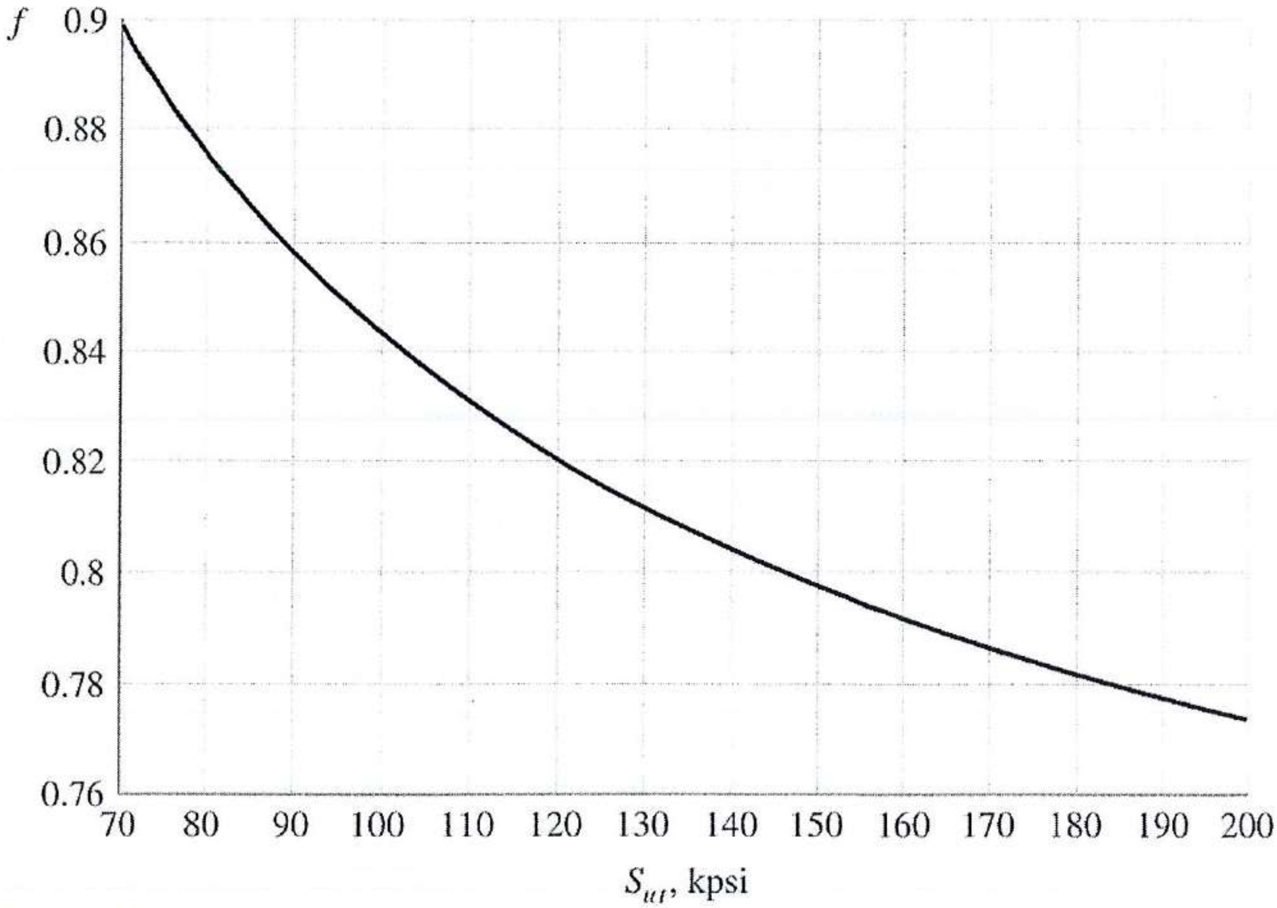
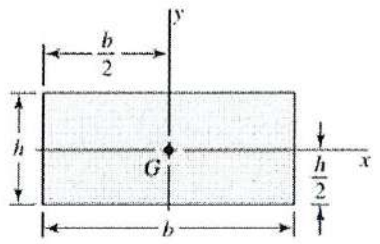


Figure 4 : Fatigue strength fraction, *f*

APPENDIX 2 / *LAMPIRAN 2*

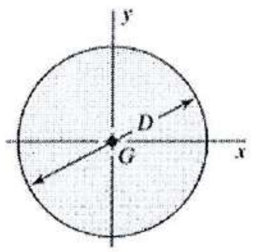
Table 1 : Properties of sections.

Rectangle



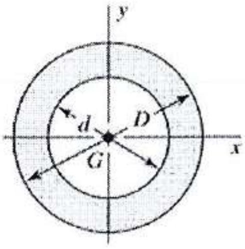
$A = bh \qquad I_x = \frac{bh^3}{12} \qquad I_y = \frac{b^3h}{12} \qquad I_{xy} = 0$

Circle



$A = \frac{\pi D^2}{4} \qquad I_x = I_y = \frac{\pi D^4}{64} \qquad I_{xy} = 0 \qquad J_G = \frac{\pi D^4}{32}$

Hollow circle



$A = \frac{\pi}{4}(D^2 - d^2) \qquad I_x = I_y = \frac{\pi}{64}(D^4 - d^4) \qquad I_{xy} = 0 \qquad J_G = \frac{\pi}{32}(D^4 - d^4)$

A = area
G = location of centroid
$I_x = \int y^2\, dA$ = second moment of area about x axis
$I_y = \int x^2\, dA$ = second moment of area about y axis
$I_{xy} = \int xy\, dA$ = mixed moment of area about x and y a
$J_G = \int r^2\, dA = \int (x^2 + y^2)\, dA = I_x + I_y$
= second polar moment of area about axis through C
$k_x^2 = I_x/A$ = squared radius of gyration about x axis

Table 2 : Parameters for surface modification factor.

Surface Finish	Factor a S_{ut}, kpsi	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

Table 3 :

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 4 :

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 strengths exceeded by 99 percent of fasteners.

APPENDIX 3 / *LAMPIRAN 3*

$$q = \frac{K_f - 1}{K_t - 1} \qquad \text{or} \qquad q_{\text{shear}} = \frac{K_{fs} - 1}{K_{ts} - 1}$$

$$\sigma_a = K_f \frac{32M_a}{\pi d^3} \qquad \sigma_m = K_f \frac{32M_m}{\pi d^3}$$

$$\tau_a = K_{fs} \frac{16T_a}{\pi d^3} \qquad \tau_m = K_{fs} \frac{16T_m}{\pi d^3}$$

$$\sigma'_{\max} = \left[(\sigma_m + \sigma_a)^2 + 3(\tau_m + \tau_a)^2\right]^{1/2}$$

$$= \left[\left(\frac{32K_f(M_m + M_a)}{\pi d^3}\right)^2 + 3\left(\frac{16K_{fs}(T_m + T_a)}{\pi d^3}\right)^2\right]^{1/2}$$

$$n_y = \frac{S_y}{\sigma'_{\max}}$$

DE-ASME Elliptic

$$\frac{1}{n} = \frac{16}{\pi d^3}\left[4\left(\frac{K_f M_a}{S_e}\right)^2 + 3\left(\frac{K_{fs} T_a}{S_e}\right)^2 + 4\left(\frac{K_f M_m}{S_y}\right)^2 + 3\left(\frac{K_{fs} T_m}{S_y}\right)^2\right]^{1/2}$$

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

$$S_e = k_a k_b k_c k_d k_e k_f S'_e$$

$$k_a = a S_{ut}^b$$

For axial loading, there is no size effect, so

$$k_b = 1$$

For bending and torsion,

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

$$k_c = \begin{cases} 1 & \text{bending} \\ 0.85 & \text{axial} \\ 0.59 & \text{torsion} \end{cases}$$

$$n_f = \frac{S_e}{K_f \sigma_{\text{rev}}}$$

The reversing bending stress,

$$\sigma_{rev} = K_f \left(\frac{M}{I/c}\right)$$

$$S_f = a\, N^b$$

$$a = \frac{(f\, S_{ut})^2}{S_e}$$

$$b = -\frac{1}{3} \log\left(\frac{f\, S_{ut}}{S_e}\right)$$

$$N = \left(\frac{\sigma_{\text{rev}}}{a}\right)^{1/b}$$

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