First Semester Examination
2022/2023 Academic Session

February 2023

# EEM353 – Mechanical Engineering Design
## *(Rekabentuk Kejuruteraan Mekanik)*

Duration : 3 hours
*(Masa : 3 jam)*

Please check that this examination paper consists of **TWELVE (12)** pages of printed material including appendix before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **DUA BELAS (12)** muka surat yang bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini.]*

**Instructions** : This paper consists of **FOUR (4)** questions. Answer **FOUR (4)** questions.

*[**Arahan** : Kertas ini mengandungi **EMPAT (4)** soalan. Jawab **EMPAT (4)** soalan.]*

In the event of any discrepancies, the English version shall be used.

*[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.]*

1. (a) By referring to Figure 1(a), list the seven (7) phases related in generic concept development process and explain briefly the function of each phases?

*Berdasarkan Rajah 1(a), senaraikan tujuh (7) fasa yang berkaitan dengan proses pembangunan produk dan terangkan secara ringkas fungsi setiap fasa?*

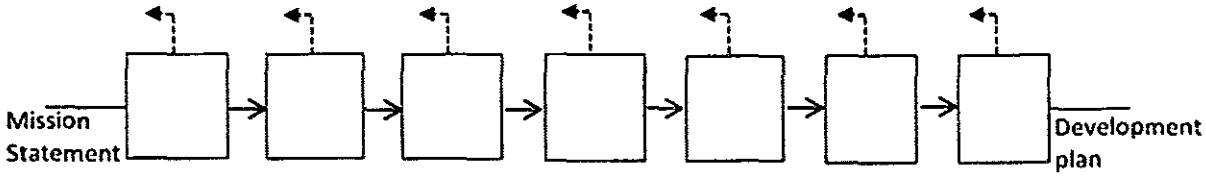


Figure 1(a): Generic Product Development Process form Karl T. Ulrich

*Rajah 1(a): Proses Pembangunan Produk daripada Karl T. Ulrich*

(40 marks/*markah*)

(b) Which of the 4 types of organisations used for product development will be adopting in Proton Holding Bhd. as one of the main automobile manufacturer in Malaysia. Illustrate your answer with organisation structure including statement of its strengths and weakenesses.

*Antara 4 jenis organisasi untuk membangunkan produk manakah yang akan diguna-pakai di Proton Holding Bhd. sebagai salah satu pengeluar automobil utama di Malaysia. Gambarkan jawapan anda dengan struktur organisasi termasuk pernyataan kekuatan dan kelemahannya.*

(60 marks/*markah*)

2. (a) In the situation where a company requested that the product be tailored to the physical capabilities of the elderly. The product to be developed is a reusable syringe with precise dosage control for outpatient use. What are the main criteria on which the choice of a product concept would be based?

*Dalam situasi di mana sebuah syarikat meminta produk tersebut disesuaikan dengan keupayaan fizikal warga emas. Produk yang akan dibangunkan ialah picagari boleh guna semula dengan kawalan dos yang tepat untuk kegunaan pesakit luar. Apakah kriteria-kriteria penting yang menjadi asas pemilihan konsep produk?*

(50 marks/*markah*)

(b) Architecture modularity is that you can replace or add any one component (module) without affecting the rest of the system. What are factors affecting architecture modularity?

*Seni bina modular membolehkan kamu menggantikan atau menambahkan satu komponen (modul) tanpa menjejaskan seluruh sistem. Apakah faktor-faktor yang mempengaruhi seni bina modular?*

(50 marks/*markah*)

3. (a) Explain definition of Screw and Bolts. Sketch both with a diagram.

*Terangkan definisi skru dan bolt. Lakarkan kedua-duanya dengan lukisan gambarajah.*

(15 marks/*markah*)

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(b) A square-thread power screw has a major diameter of 25mm and a thread pitch of 5mm with double threads, and it is to be used in an application to the Figure 3(b). Find the thread depth, the thread width, pitch diameter, minor diameter, and lead. From the answers obtained, determine the torque required to raise and lower the load.

Given: $f = f_c = 0.06$, $d_c = 30$ mm, and $F = 5.2$ kN per screw. Used $n = 2$.

*Bebenang skru segi empat sama mempunyai diameter utama 25mm dan alur bebenang 5mm dengan bebenang berkembar, dan ia akan digunakan dalam aplikasi pada Rajah 3(b). Cari kedalaman bebenang, lebar bebenang, diameter alur, diameter dalaman, dan ketinggian alur. Daripada jawapan yang diperoleh, tentukan daya kilas yang diperlukan untuk menaikkan dan menurunkan beban.*

*Diberi: :* $f = f_c = 0.06$, $d_c = 30$ *mm, dan* $F = 5.2$ *kN per skru. Gunakan* $n = 2$.

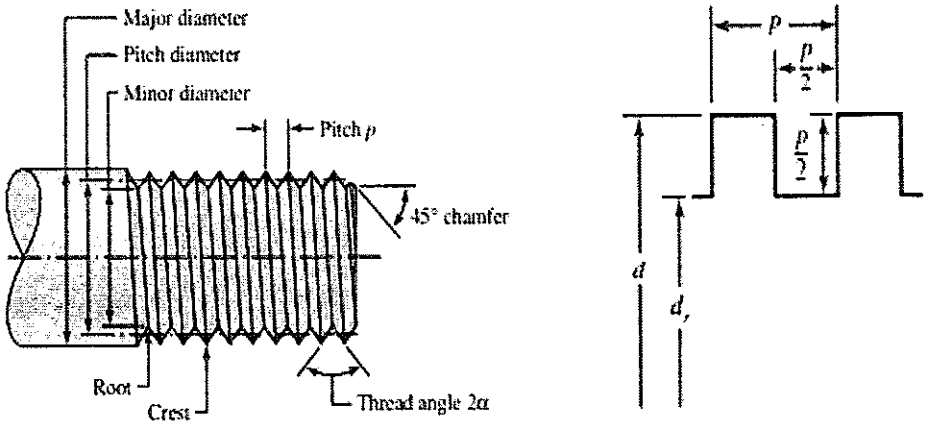


Figure 3(b)

*Rajah 3(b)*

(35 marks/*markah*)

(c) As shown in Figure 3(c), two plates are clamped by washer-faced 16R and bolt type is hexa-head bolt M16 x 2 and E = 207Gpa. Determine the bolt spring rate $K_b$.

*Seperti yang ditunjukkan dalam Rajah 3(c), dua plat diapit oleh muka pelapik 16R dan jenis kepala bolt ialah hexa-bolt, M16 x 2 dan E = 207Gpa. Tentukan kadar spring bolt $K_b$.*

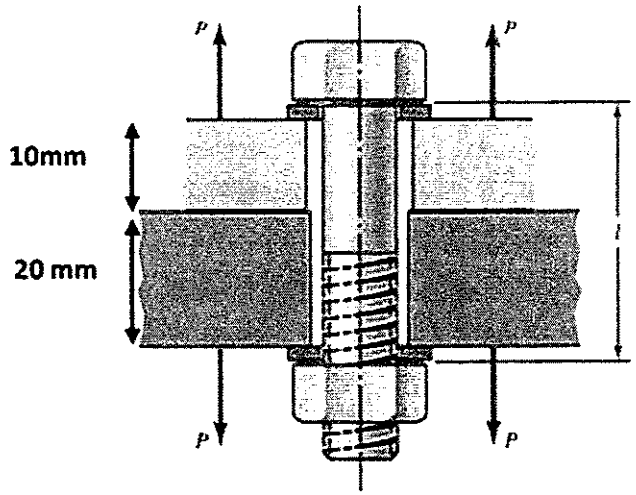


Figure 3(c)

*Rajah 3(c)*

(50 marks/*markah*)

4. (a) What are the differences between Weld symbol and Welding symbol?

*Apakah perbezaan antara simbol kimpalan dan simbol mengimpal?*

(10 marks/*markah*)

(b) Determine the length of weld run for a plate of size 120mm wide and 15mm thick as shown in Figure 4(b), to be welded to another plate by means of:

*Tentukan panjang larian kimpalan untuk plat bersaiz 120mm lebar dan 15mm tebal seperti yang ditunjukkan dalam Rajah 4(b), untuk dikimpal ke plat lain dengan cara:*

(i) A single transverse fillet weld
*Kimpalan fillet melintang tunggal*

(ii) Double parallel fillet weld when the joint is subjected to variable loads.
Take $\sigma_t = 70$ Mpa and $\tau = 56$ Mpa

*Kimpalan fillet selari berganda apabila sambungannya tertakluk kepada beban yang berubah-ubah.*
Ambil $\sigma_t = 70$ Mpa dan $\tau = 56$ Mpa

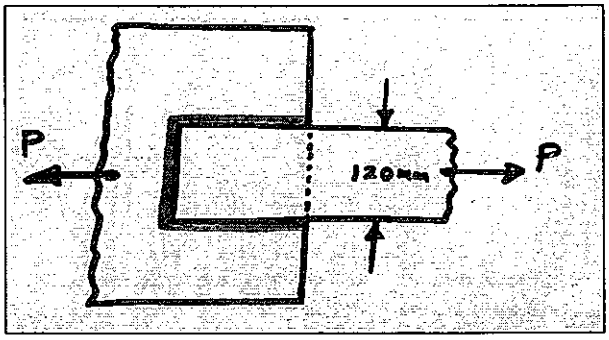


Figure 4(b)
*Rajah 4(b)*

(50 marks/*markah*)

(c) A stock helical gear as shown in Figure 4(c), has a normal pressure angle of 200, a helix angle of 250, and a transverse module of 4mm, and has 18 teeth. Find:

*Gear heliks stok seperti yang ditunjukkan dalam Rajah 4(c), mempunyai sudut tekanan normal 200, sudut heliks 250, dan modul melintang 4mm, dan mempunyai 18 gigi. Cari:*

(i) The pitch diameter
*Diameter alur*

(ii) The transverse, the normal, and the axial pitches
*Alur melintang, alur normal, dan alur paksi*

(iii) The normal diametral pitch
*Diameter alur normal*

(iv) The transverse pressure angle
*Sudut tekanan melintang.*

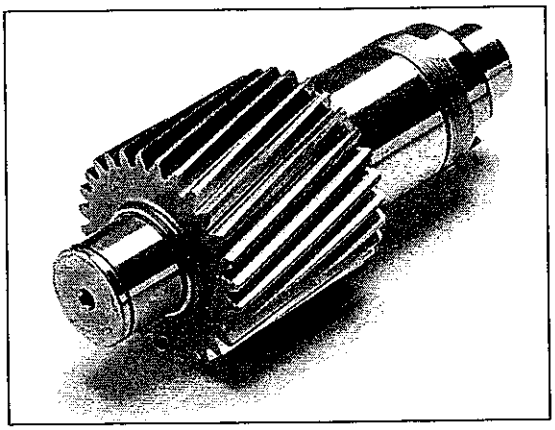

Figure 4(c)
*Rajah 4(c)*

(40 marks/*markah*)

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## Appendix

## *Lampiran*

## List of Formula and Tables

$$T_R = \frac{F d_m}{2}\left(\frac{l + \pi f d_m}{\pi d_m - f l}\right) + \frac{F f_c d_c}{2}$$

$$T_L = \frac{F d_m}{2}\left(\frac{\pi f d_m - l}{\pi d_m + f l}\right) + \frac{F f_c d_c}{2}$$

**For Inch Series Bolts**

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

**For Metric Series Bolts**

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

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## Table 1

**Table 8–1**

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

| Nominal Major Diameter $d$ mm | Coarse-Pitch Series | | | Fine-Pitch Series | | |
|---|---|---|---|---|---|---|
| | Pitch $p$ mm | Tensile-Stress Area $A_t$ mm$^2$ | Minor-Diameter Area $A_r$ mm$^2$ | Pitch $p$ mm | Tensile-Stress Area $A_t$ mm$^2$ | 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.

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## Table 2

**Table A–33**

Dimensions of Metric Plain Washers (All Dimensions in Millimeters)

| Washer Size* | Minimum ID | Maximum OD | Maximum Thickness | Washer Size* | Minimum ID | Maximum OD | Maximum Thickness |
|---|---|---|---|---|---|---|---|
| 1.6 N | 1.95 | 4.00 | 0.70 | 10 N | 10.85 | 20.00 | 2.30 |
| 1.6 R | 1.95 | 5.00 | 0.70 | 10 R | 10.85 | 28.00 | 2.80 |
| 1.6 W | 1.95 | 6.00 | 0.90 | 10 W | 10.85 | 39.00 | 3.50 |
| 2 N | 2.50 | 5.00 | 0.90 | 12 N | 13.30 | 25.40 | 2.80 |
| 2 R | 2.50 | 6.00 | 0.90 | 12 R | 13.30 | 34.00 | 3.50 |
| 2 W | 2.50 | 8.00 | 0.90 | 12 W | 13.30 | 44.00 | 3.50 |
| 2.5 N | 3.00 | 6.00 | 0.90 | 14 N | 15.25 | 28.00 | 2.80 |
| 2.5 R | 3.00 | 8.00 | 0.90 | 14 R | 15.25 | 39.00 | 3.50 |
| 2.5 W | 3.00 | 10.00 | 1.20 | 14 W | 15.25 | 50.00 | 4.00 |
| 3 N | 3.50 | 7.00 | 0.90 | 16 N | 17.25 | 32.00 | 3.50 |
| 3 R | 3.50 | 10.00 | 1.20 | 16 R | 17.25 | 44.00 | 4.00 |
| 3 W | 3.50 | 12.00 | 1.40 | 16 W | 17.25 | 56.00 | 4.60 |
| 3.5 N | 4.00 | 9.00 | 1.20 | 20 N | 21.80 | 39.00 | 4.00 |
| 3.5 R | 4.00 | 10.00 | 1.40 | 20 R | 21.80 | 50.00 | 4.60 |
| 3.5 W | 4.00 | 15.00 | 1.75 | 20 W | 21.80 | 66.00 | 5.10 |
| 4 N | 4.70 | 10.00 | 1.20 | 24 N | 25.60 | 44.00 | 4.60 |
| 4 R | 4.70 | 12.00 | 1.40 | 24 R | 25.60 | 56.00 | 5.10 |
| 4 W | 4.70 | 16.00 | 2.30 | 24 W | 25.60 | 72.00 | 5.60 |
| 5 N | 5.50 | 11.00 | 1.40 | 30 N | 32.40 | 56.00 | 5.10 |
| 5 R | 5.50 | 15.00 | 1.75 | 30 R | 32.40 | 72.00 | 5.60 |
| 5 W | 5.50 | 20.00 | 2.30 | 30 W | 32.40 | 90.00 | 6.40 |
| 6 N | 6.65 | 13.00 | 1.75 | 36 N | 38.30 | 66.00 | 5.60 |
| 6 R | 6.65 | 18.80 | 1.75 | 36 R | 38.30 | 90.00 | 6.40 |
| 6 W | 6.65 | 25.40 | 2.30 | 36 W | 38.30 | 110.00 | 8.50 |
| 8 N | 8.90 | 18.80 | 2.30 | | | | |
| 8 R | 8.90 | 25.40 | 2.30 | | | | |
| 8 W | 8.90 | 32.00 | 2.80 | | | | |

N = narrow; R = regular; W = wide.
*Same as screw or bolt size.

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Table 3

**Table A–31**

Dimensions of Hexagonal Nuts

| Nominal Size, in | Width W | Height H | | |
|---|---|---|---|---|
| | | Regular Hexagonal | Thick or Slotted | 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 |

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## Table 4

**Table A–17**

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.)

**Fraction of Inches**

$\frac{1}{64}$, $\frac{1}{32}$, $\frac{1}{16}$, $\frac{3}{32}$, $\frac{1}{8}$, $\frac{5}{32}$, $\frac{3}{16}$, $\frac{1}{4}$, $\frac{5}{16}$, $\frac{3}{8}$, $\frac{7}{16}$, $\frac{1}{2}$, $\frac{9}{16}$, $\frac{5}{8}$, $\frac{11}{16}$, $\frac{3}{4}$, $\frac{7}{8}$, 1, $1\frac{1}{4}$, $1\frac{1}{2}$, $1\frac{3}{4}$, 2, $2\frac{1}{4}$, $2\frac{1}{2}$, $2\frac{3}{4}$, 3, $3\frac{1}{4}$, $3\frac{1}{2}$, $3\frac{3}{4}$, 4, $4\frac{1}{4}$, $4\frac{1}{2}$, $4\frac{3}{4}$, 5, $5\frac{1}{4}$, $5\frac{1}{2}$, $5\frac{3}{4}$, 6, $6\frac{1}{2}$, 7, $7\frac{1}{2}$, 8, $8\frac{1}{2}$, 9, $9\frac{1}{2}$, 10, $10\frac{1}{2}$, 11, $11\frac{1}{2}$, 12, $12\frac{1}{2}$, 13, $13\frac{1}{2}$, 14, $14\frac{1}{2}$, 15, $15\frac{1}{2}$, 16, $16\frac{1}{2}$, 17, $17\frac{1}{2}$, 18, $18\frac{1}{2}$, 19, $19\frac{1}{2}$, 20

**Decimal Inches**

0.010, 0.012, 0.016, 0.020, 0.025, 0.032, 0.040, 0.05, 0.06, 0.08, 0.10, 0.12, 0.16, 0.20, 0.24, 0.30, 0.40, 0.50, 0.60, 0.80, 1.00, 1.20, 1.40, 1.60, 1.80, 2.0, 2.4, 2.6, 2.8, 3.0, 3.2, 3.4, 3.6, 3.8, 4.0, 4.2, 4.4, 4.6, 4.8, 5.0, 5.2, 5.4, 5.6, 5.8, 6.0, 7.0, 7.5, 8.5, 9.0, 9.5, 10.0, 10.5, 11.0, 11.5, 12.0, 12.5, 13.0, 13.5, 14.0, 14.5, 15.0, 15.5, 16.0, 16.5, 17.0, 17.5, 18.0, 18.5, 19.0, 19.5, 20

**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.

## Table 5

**Table 9–5**

Fatigue Stress-Concentration Factors, $K_{fs}$

| Type of Weld | $K_{fs}$ |
|---|---|
| Reinforced butt weld | 1.2 |
| Toe of transverse fillet weld | 1.5 |
| End of parallel fillet weld | 2.7 |
| T-butt joint with sharp corners | 2.0 |