UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Pertama
Sidang Akademik 2006/2007

Oktober/November 2006

EEM 221 – PRINSIP DAN MEKANIK BAHAN

Masa: 3 jam

Sila pastikan bahawa kertas peperiksaan ini mengandungi **SEMBILAN** muka surat dan **LIMA** muka surat LAMPIRAN bercetak sebelum anda memulakan peperiksaan ini.

Kertas soalan ini mengandungi ENAM soalan.

Jawab **LIMA** soalan. Jika calon menjawab lebih daripada lima soalan hanya lima soalan pertama mengikut susunan dalam skrip jawapan akan diberi markah.

Mulakan jawapan anda untuk setiap soalan pada muka surat yang baru.

Agihan markah bagi setiap soalan diberikan di sudut sebelah kanan soalan berkenaan.

Jawab semua soalan dalam Bahasa Malaysia.

...2/-

1. (a) Kira ketumpatan satah (110) bagi FCC

Calculate the planar density of (110) plane for FCC

(20 markah)

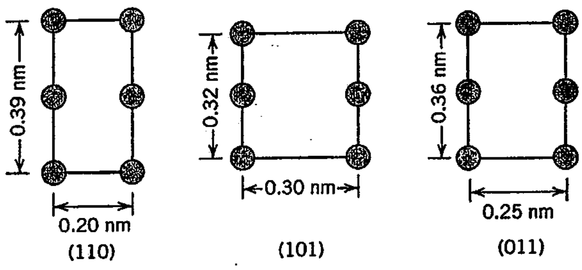
(b) Kira ketumpatan linear [100] bagi BCC

Calculate the linear density of the [100] direction for BCC

(20 markah)

(c) Rajah 1 menunjukkan tiga satah kristalografi yang berbeza bagi satu unit sel satu logam (**andaian**); bulatan mewakili atom:

*Figure 1 shows three different crystallographic planes for a unit cell of some **hypothetical** metal; the circle represents atoms:*



Rajah 1
Figure 1

(i) Apakah sistem kristal bagi unit sel ini?

Which crystal system does the unit cell belong to?

(ii) Apakah nama struktur kristal ini?

What would this crystal structure be called?

(iii) Sekiranya ketumpatan logam ini ialah 18.91 g/cm^3, tentukan berat atom bagi logam ini.

If the density of this metal is 18.91 g/cm^3, determine its atomic weight.

(40 markah)

(d) Terangkan tentang sistem kordinat empat-paksi atau Miller-Bravais bagi kristal yang mempunyai simetri heksagon.

Explain on a four-axis, or Miller-Bravais coordinate system for crystals having hexagonal symmetry.

(20 markah)

2. (a) Satu tegasan regangan akan dikenakan sepanjang paksi bagi satu rod aluminum yang mempunyai garis pusat 10 mm. Tentukan magnitud beban yang diperlukan untuk menghasilkan perubahan garis pusat sebanyak 2.5×10^{-3} mm dan ubah bentuk adalah elastik sepenuhnya. Nilai nisbah Poisson ialah 0.33 dan modulus kenyal ialah 69 GPA bagi aluminum.

A tensile stress is to be applied along the axis of an aluminum rod that has a diameter of 10 mm. Determine the magnitude of load required to produce a 2.5×10^{-3} mm change in diameter and the deformation is entirely elastic. The value for Poisson's ratio is 0.33 and the modulus of elasticity is 69 GPa for aluminum.

(30 markah)

(b) Tegasan regangan dikenakan kepada satu kristal tunggal Aluminum pada arah [001]. Sekiranya gelinciran berlaku pada satah (111) dan dalam arah $[\bar{1}01]$, dan dimulakan oleh satu tegasan regangan sebanyak 5 MPa, kira tegangan ricih peleraian kritikal.

A tensile stress is applied to a single crystal of Aluminum in a [001] direction. If the slip occurs on a (111) plane and in a $[\bar{1}01]$ direction, and it is initiated at an applied tensile stress of 5 MPa, compute the critical resolved shear stress.

(40 markah)

(c) Terangkan tentang kecacatan titik serta kecacatan titik bendasing yang wujud dalam pepejal. Lukiskan lakaran yang sesuai.

Explain the point defects and also impurity point defects which are found in solids. Draw suitable sketches.

(30 markah)

3. (a) Terangkan dengan bantuan gambarajah tentang pembentukan struktur mikro dalam aloy isomorphous berdasarkan:

Explain with the help of diagrams the development of microstructure in isomorphous alloys based on:

(i) Penyejukan Keseimbangan
Equilibrium Cooling

(ii) Penyejukan Tak-Seimbang
Nonequilibrium Cooling

(20 markah)

(b) Jawab soalan ini berdasarkan Rajah 2. Bagi aloy 99.65 wt% Fe – 0.35 wt % C yang berada pada suhu sedikit di bawah eutectoid, tentukan:

Answer this question based on Figure 2. For a 99.65 wt% Fe – 0.35 wt % C alloy at a temperature just below the eutectoid, determine the following:

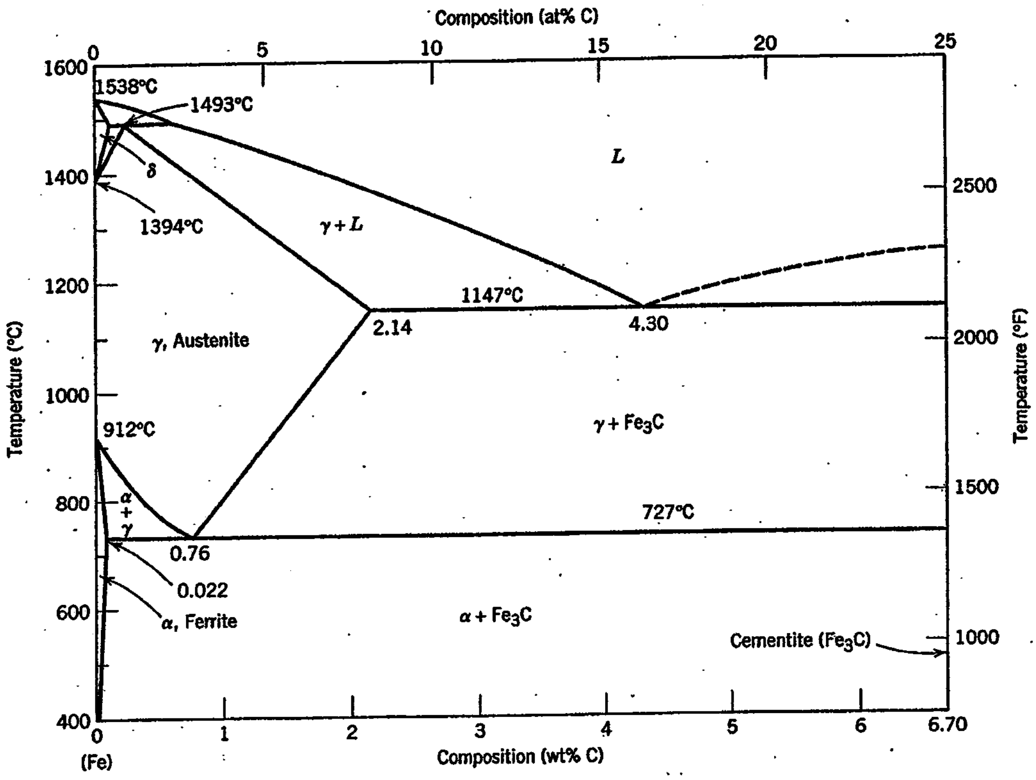
(i) Pecahan bagi fasa ferrite dan cementite
The fractions of total ferrite and cementite phases

(ii) Pecahan bagi fasa proeutectoid ferrite and pearlite
The fraction of the proeutectoid ferrite and pearlite

(iii) Pecahan bagi eutectoid ferrite
The fraction of eutectoid ferrite

(60 markah)

...5/-



Rajah 2
Figure 2

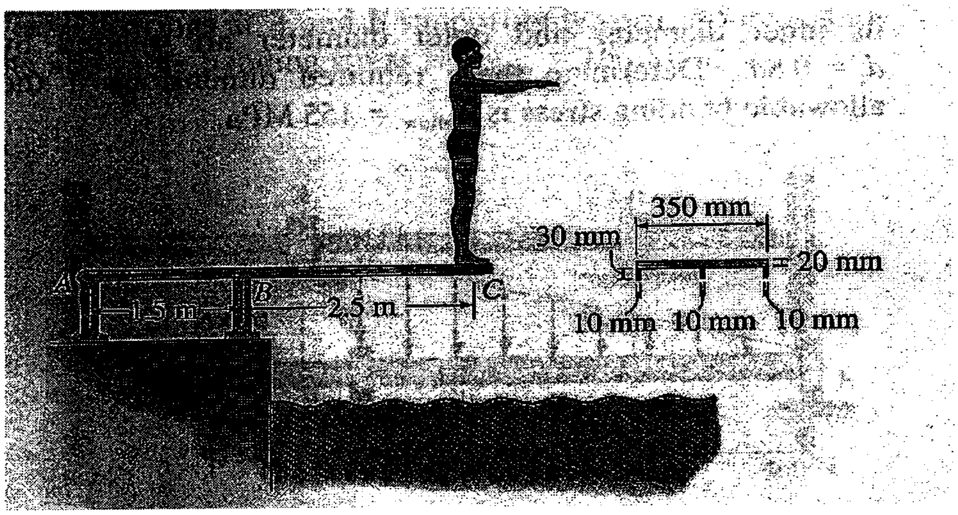
(c) Terangkan tiga (3) ciri yang mempengaruhi darjah kelarutan bahan larut dalam atom-atom pelarut.

Explain three (3) features which affects the degree of solute dissolves in solvent atoms.

(20 markah)

4. (a) Seorang lelaki mempunyai jisim 78 kg berdiri pegun dihujung papan anjal. Sekiranya papan tersebut mempunyai keratin rentas seperti ditunjukkan, tentukan terikan normal maksima yang wujud dalam papan tersebut. Modulus kekenyalan bagi papan anjal ialah 125 GPa. Anggap A sebagai pin dan B sebagai guling.

The man has a mass of 78 kg and stands motionless at the end of the diving board. If the board has the cross section shown, determine the *maximum normal strain developed in the board. The modulus of elasticity for the material is 125 GPa. Assume A is a pin and B is a roller.*



(60 markah)

(b) Tiga 50-mm × 100-mm papan keping diikat oleh 5 mm garis pusat bolt yang mana jarak antara satu sama lain ialah 40 mm seperti ditunjukkan dalam Rajah 6(c). Tegasan ricih yang dibenarkan ialah 100 MPa. Tentukan beban tertumpu maksima yang boleh dikenakan pada titik tengah bagi 3-m rentang mudah. Abaikan berat rasuk tersebut.

Three 50-mm × 100-mm planks are fastened by 5 mm diameter bolts spaced at a pitch of 40 mm as shown in Figure 6(c). The allowable shear stress for the bolts is 100 MPa. Determine the maximum concentrated load that can be applied at the mid point of 3-m simple span. Neglect the weight of the beam.

Diberikan sebutan bagi daya ricih yang mesti ditanggung oleh bolt:-
Given the expression for the shear force that must be carried by the bolt:-

$$F_s = p\frac{VQ}{I}$$

Iaitu

Where

p ialah the jarak antara bolt

p is the pitch of the bolts

V ialah daya ricih pada bahagian itu

V is the shear force at the section

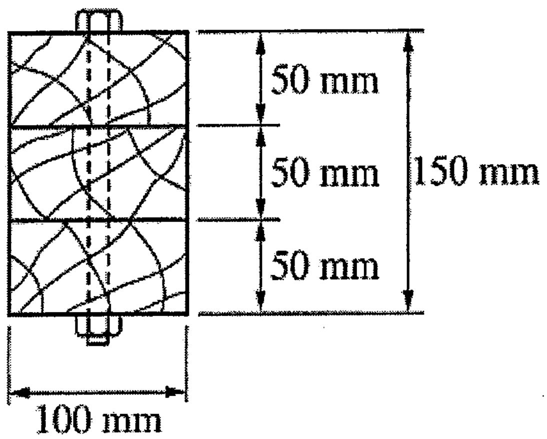
Q ialah momen pertama bagi kawasan terhadap paksi neutral

Q is the first moment of area about the neutral axis

I ialah momen inersia

I is the moment of inertia

(40 markah)



Rajah 6(c)

Figure 6(c)

5. (a) (i) Lukiskan gambarajah daya ricih dan momen lenturan bagi rasuk yang ditunjukkan dalam Rajah 5(a).

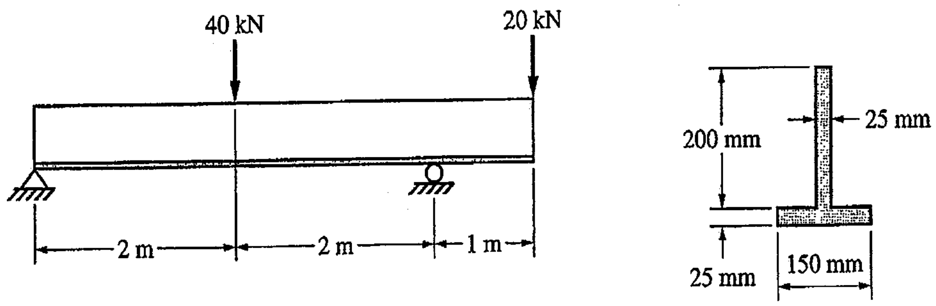
Draw the shear force and bending moment diagrams of the beam shown in Figure 5(a).

(40 markah)

(ii) Tentukan tegasan tegangan maksima dan tegasan mampat maksima di dalam rasuk. Abaikan berat rasuk tersebut.

Determine the maximum tensile and compressive stresses in the beam. Neglect the weight of the beam.

(30 markah)



Rajah 5(a)
Figure 5(a)

(b) Terangkan hubungan antara beban, ricih dan momen. Lukis lakaran yang sesuai.

Explain the relationship between load, shear and moment. Draw suitable sketches.

(30 markah)

6. (a) Kayu Southern Pine dengan 150 × 360 keratan rentas segiempat digunakan sebagai julur sepanjang 3 m. Kira lenturan maksima dan cerun maksima disebabkan beban seragam sebanyak 15 kN/m menggunakan:-

A 150 × 360 rectangular Southern pine section is used in a 3-m cantilever span. Compute the maximum deflection and the maximum slope due to a uniform load of 15 kN/m using:-

(i) Formula Method
Kaedah Formula

(20 markah)

(ii) Moment Area Method
Kaedah Momen Luas

(50 markah)

Diberikan E = 12 GPa
Given E = 12 GPa

(b) Jelaskan dengan bantuan gambarajah perbezaan antara bahan yang menunjukkan had kelesuan dan bahan yang tak menunjukkan had kelesuan. Berikan contoh kedua-dua bahan tersebut.

Explain with the help of diagrams the differences between a material that display a fatigue limit and a material that does not display a fatigue limit.

(30 markah)

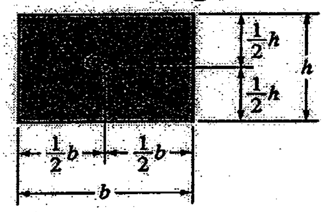
- oooOooo -

Characteristics of Selected Elements

Element	*Symbol*	*Atomic Number*	*Atomic Weight (amu)*	*Density of Solid, 20°C (g/cm³)*	*Crystal Structure, 20°C*	*Atomic Radius (nm)*	*Ionic Radius (nm)*	*Most Common Valence*	*Melting Point (°C)*
Aluminum	Al	13	26.98	2.71	FCC	0.143	0.053	3+	660.4
Argon	Ar	18	39.95	—	—	—	—	Inert	−189.2
Barium	Ba	56	137.33	3.5	BCC	0.217	0.136	2+	725
Beryllium	Be	4	9.012	1.85	HCP	0.114	0.035	2+	1278
Boron	B	5	10.81	2.34	Rhomb.	—	0.023	3+	2300
Bromine	Br	35	79.90	—	—	—	0.196	1−	−7.2
Cadmium	Cd	48	112.41	8.65	HCP	0.149	0.095	2+	321
Calcium	Ca	20	40.08	1.55	FCC	0.197	0.100	2+	839
Carbon	C	6	12.011	2.25	Hex.	0.071	~0.016	4+	(sublimes at 3367)
Cesium	Cs	55	132.91	1.87	BCC	0.265	0.170	1+	28.4
Chlorine	Cl	17	35.45	—	—	—	0.181	1−	−101
Chromium	Cr	24	52.00	7.19	BCC	0.125	0.063	3+	1875
Cobalt	Co	27	58.93	8.9	HCP	0.125	0.072	2+	1495
Copper	Cu	29	63.55	8.94	FCC	0.128	0.096	1+	1085
Fluorine	F	9	19.00	—	—	—	0.133	1−	−220
Gallium	Ga	31	69.72	5.90	Ortho.	0.122	0.062	3+	29.8
Germanium	Ge	32	72.59	5.32	Dia. cubic	0.122	0.053	4+	937
Gold	Au	79	196.97	19.32	FCC	0.144	0.137	1+	1064
Helium	He	2	4.003	—	—	—	—	Inert	−272 (at 26 atm)
Hydrogen	H	1	1.008	—	—	—	0.154	1+	−259
Iodine	I	53	126.91	4.93	Ortho.	0.136	0.220	1−	114
Iron	Fe	26	55.85	7.87	BCC	0.124	0.077	2+	1538
Lead	Pb	82	207.2	11.35	FCC	0.175	0.120	2+	327
Lithium	Li	3	6.94	0.534	BCC	0.152	0.068	1+	181
Magnesium	Mg	12	24.31	1.74	HCP	0.160	0.072	2+	649
Manganese	Mn	25	54.94	7.44	Cubic	0.112	0.067	2+	1244
Mercury	Hg	80	200.59	—	—	—	0.110	2+	−38.8
Molybdenum	Mo	42	95.94	10.22	BCC	0.136	0.070	4+	2617
Neon	Ne	10	20.18	—	—	—	—	Inert	−248.7
Nickel	Ni	28	58.69	8.90	FCC	0.125	0.069	2+	1455
Niobium	Nb	41	92.91	8.57	BCC	0.143	0.069	5+	2468
Nitrogen	N	7	14.007	—	—	—	0.01–0.02	5+	−209.9
Oxygen	O	8	16.00	—	—	—	0.140	2−	−218.4
Phosphorus	P	15	30.97	1.82	Ortho.	0.109	0.035	5+	44.1
Platinum	Pt	78	195.08	21.45	FCC	0.139	0.080	2+	1772
Potassium	K	19	39.10	0.862	BCC	0.231	0.138	1+	63
Silicon	Si	14	28.09	2.33	Dia. cubic	0.118	0.040	4+	1410
Silver	Ag	47	107.87	10.49	FCC	0.144	0.126	1+	962
Sodium	Na	11	22.99	0.971	BCC	0.186	0.102	1+	98
Sulfur	S	16	32.06	2.07	Ortho.	0.106	0.184	2−	113
Tin	Sn	50	118.69	7.17	Tetra.	0.151	0.071	4+	232
Titanium	Ti	22	47.88	4.51	HCP	0.145	0.068	4+	1668
Tungsten	W	74	183.85	19.3	BCC	0.137	0.070	4+	3410
Vanadium	V	23	50.94	6.1	BCC	0.132	0.059	5+	1890
Zinc	Zn	30	65.39	7.13	HCP	0.133	0.074	2+	420
Zirconium	Zr	40	91.22	6.51	HCP	0.159	0.079	4+	1852

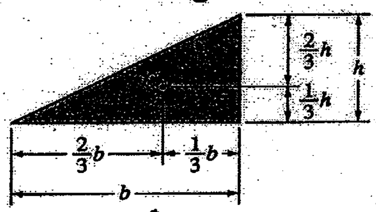
Centroids of Areas of Common Shapes

Rectangle



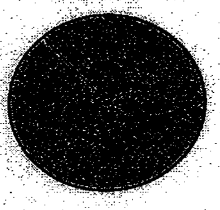
$A = bh$

Triangle



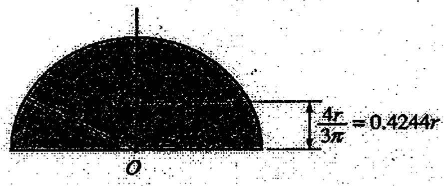
$A = \frac{1}{2}bh$

Circle



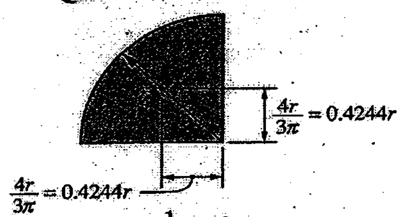
$A = \pi r^2$

Semicircle



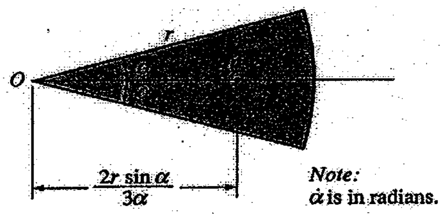
$A = \frac{1}{2}\pi r^2$

Quarter-Circle



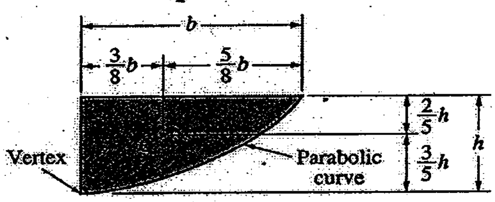
$A = \frac{1}{4}\pi r^2$

Sectors



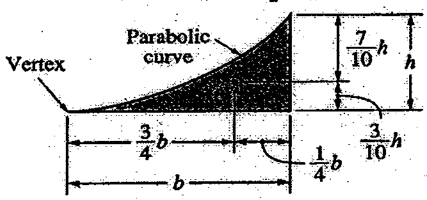
$A = \alpha r^2$

Semiparabolic Area



$A = \frac{2}{3}bh$

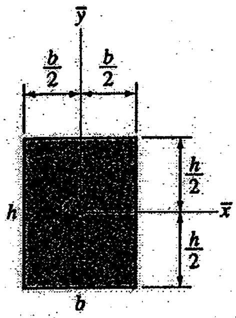
Parabolic Spandrel



$A = \frac{1}{3}bh$

Properties of Areas of Common Shapes

Rectangle



$A = bh$

$\bar{I}_x = \frac{1}{12}bh^3$

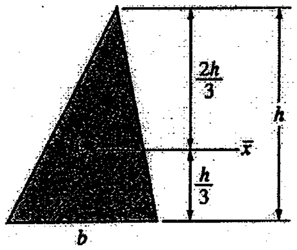
$\bar{I}_y = \frac{1}{12}hb^3$

$\bar{J} = \frac{1}{12}bh(h^2 + b^2)$

$\bar{r}_x = \frac{h}{\sqrt{12}}$

$\bar{r}_y = \frac{b}{\sqrt{12}}$

Triangle

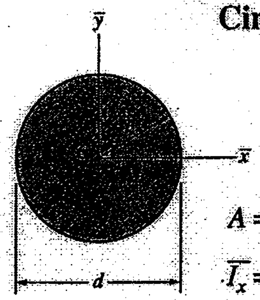


$A = \frac{1}{2}bh$

$\bar{I}_x = \frac{1}{36}bh^3$

$\bar{r}_x = \frac{h}{\sqrt{18}}$

Circle



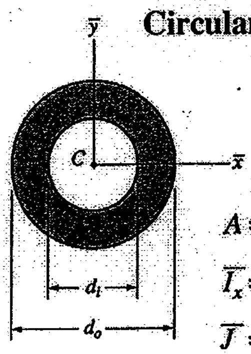
$A = \frac{1}{4}\pi d^2 = \pi r^2$

$\bar{I}_x = \bar{I}_y = \frac{1}{64}\pi d^4 = \frac{1}{4}\pi r^4$

$\bar{J} = \frac{1}{32}\pi d^4 = \frac{1}{2}\pi r^4$

$\bar{r}_x = \bar{r}_y = \frac{1}{4}d$

Circular Ring



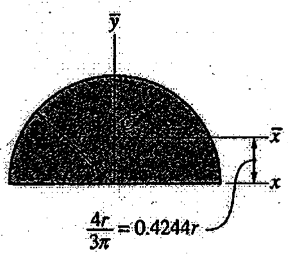
$A = \frac{1}{4}\pi(d_o^2 - d_i^2)$

$\bar{I}_x = \bar{I}_y = \frac{1}{64}\pi(d_o^4 - d_i^4)$

$\bar{J} = \frac{1}{32}\pi(d_o^4 - d_i^4)$

$\bar{r}_x = \bar{r}_y = \frac{1}{4}\sqrt{d_o^2 + d_i^2}$

Semicircle



$A = \frac{1}{2}\pi r^2$

$\bar{I}_x = 0.1098r^4$

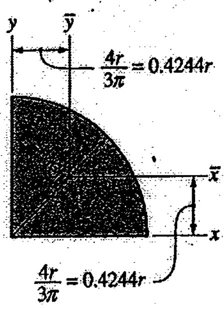
$\bar{I}_y = \bar{I}_x = \frac{1}{8}\pi r^4$

$\bar{J} = 0.5025r^4$

$\bar{r}_x = 0.2644r$

$\bar{r}_y = r_x = \frac{1}{2}r$

Quarter-Circle



$A = \frac{1}{4}\pi r^2$

$\bar{I}_x = \bar{I}_y = 0.0549r^4$

$I_x = I_y = \frac{1}{16}\pi r^4$

$\bar{J} = 0.1098r^4$

$\bar{r}_x = \bar{r}_y = 0.2644r$

$r_x = r_y = \frac{1}{2}r$

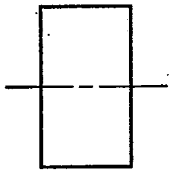
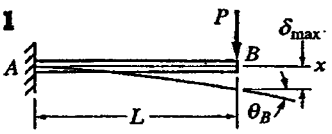
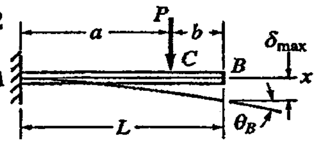
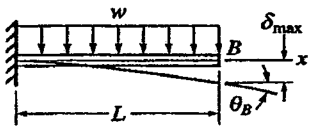
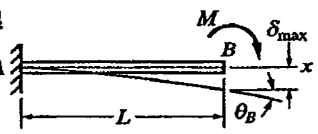
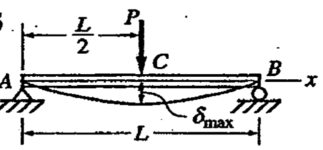
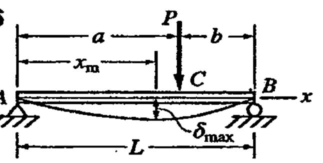
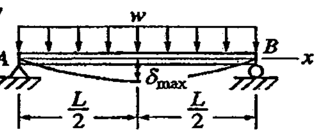
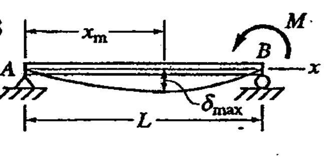


TABLE A–6(b) Properties of Structural Timber: SI Units

Nominal Size (mm)	Standard Dressed Size (mm)	Area of Section A ($\times 10^{-3}$ m^2)	Moment of Inertia I ($\times 10^{-6}$ m^4)	Section Modulus S ($\times 10^{-3}$ m^3)	Weight per ft w (kN/m)
50 × 100	38.1 × 88.9	3.39	2.23	0.0502	0.0213
× 150	× 140	5.32	8.66	0.124	0.0334
× 200	× 184	7.03	19.8	0.215	0.0441
× 260	× 235	8.97	41.2	0.351	0.0562
80 × 100	63.5 × 88.9	5.65	3.72	0.0836	0.0355
× 150	× 140	8.90	14.4	0.207	0.0557
× 200	× 184	11.7	33.0	0.359	0.0735
× 250	× 235	14.9	68.7	0.585	0.0937
× 300	× 286	18.1	124	0.864	0.114
100 × 100	88.9 × 88.9	7.94	5.20	0.117	0.0496
× 150	× 140	12.5	20.2	0.288	0.0781
× 200	× 184	16.4	46.2	0.503	0.103
× 250	× 235	20.9	96.1	0.818	0.130
× 300	× 286	25.4	173	1.21	0.159
× 360	× 337	29.9	282	1.67	0.188
150 × 150	140 × 140	19.5	31.8	0.454	0.123
× 200	× 191	26.6	80.3	0.851	0.168
× 250	× 241	33.7	164	1.36	0.212
× 300	× 292	40.8	290	1.98	0.257
× 360	× 343	47.9	469	2.74	0.301
× 410	× 394	55.0	710	3.61	0.346
× 460	× 445	62.1	1022	4.601	0.390
200 × 200	191 × 191	36.3	110	1.15	0.228
× 250	× 241	46.0	223	1.85	0.289
× 300	× 292	55.7	396	2.70	0.350
× 360	× 343	65.2	640	3.74	0.410
× 410	× 394	74.8	968	4.92	0.471
× 460	× 445	84.5	1390	6.28	0.533
× 510	× 495	94.2	1929	7.79	0.592
250 × 250	241 × 241	58.3	283	2.34	0.366
× 300	× 292	70.3	501	3.43	0.442
× 360	× 343	82.6	811	4.74	0.519
× 410	× 394	94.8	1230	6.23	0.597
× 460	× 445	107	1770	7.95	0.674
× 510	× 495	119	2440	9.87	0.751
× 560	× 546	132	3270	12.0	0.827

Note: Properties and weights are for dressed sizes. Weight per unit foot is based on an assumed average weight of 6.28 kN/m^3. Moment of inertia and section modulus are about the strong axis.

Lampiran E: Formula untuk Lenturan Rasuk

Beam Loading and Deflection	Maximum Deflection	Slope at End(s)	Deflection Equations
1 	$\delta_{max} = \frac{PL^3}{3EI}$	$\theta_B = \frac{PL^2}{2EI}$	$\delta = \frac{Px^2}{6EI}(3L - x)$
2 	$\delta_{max} = \frac{Pa^2}{6EI}(3L - a)$	$\theta_B = \frac{Pa^2}{2EI}$	$\delta_{AC} = \frac{Px^2}{6EI}(3a - x)$ $\delta_{CB} = \frac{Pa^2}{6EI}(3x - a)$
3 	$\delta_{max} = \frac{wL^4}{8EI}$	$\theta_B = \frac{wL^3}{6EI}$	$\delta = \frac{wx^2}{24EI}(x^2 - 4Lx + 6L^2)$
4 	$\delta_{max} = \frac{ML^2}{2EI}$	$\theta_B = \frac{ML}{EI}$	$\delta = \frac{Mx^2}{2EI}$
5 	$\delta_{max} = \frac{PL^3}{48EI}$	$\theta_A = \theta_B = \frac{PL^2}{16EI}$	$\delta_{AC} = \frac{Px}{48EI}(3L^2 - 4x^2)$
6 	For $a > b$: $\delta_{max} = \frac{Pb(L^2 - b^2)^{3/2}}{9\sqrt{3}EIL}$ at $x_m = \sqrt{\frac{L^2 - b^2}{3}}$	$\theta_A = \frac{Pb(L^2 - b^2)}{6EIL}$ $\theta_B = \frac{Pa(L^2 - a^2)}{6EIL}$	$\delta_{AC} = \frac{Pbx}{6EIL}(L^2 - x^2 - b^2)$ $\delta_{CB} = \frac{Pb}{6EIL}\left[\frac{L}{b}(x - a)^3 + (L^2 - b^2)x - x^3\right]$
7 	$\delta_{max} = \frac{5wL^4}{384EI}$	$\theta_A = \theta_B = \frac{wL^3}{24EI}$	$\delta = \frac{wx}{24EI}(L^3 + x^3 - 2Lx^2)$
8 	$\delta_{max} = \frac{ML^2}{9\sqrt{3}EI}$ at $x_m = \frac{L}{\sqrt{3}}$	$\theta_A = \frac{ML}{6EI}$ $\theta_B = \frac{ML}{3EI}$	$\delta = \frac{Mx}{6EIL}(L^2 - x^2)$