H K Paul
07.12.14

L-2/T-1/MME **Date : 07/12/2014**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2013-2014

Sub : **MME 231** (Materials Thermodynamics)

Full Marks: 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Distinguish between the following: **(9)**

   (i) State variables and process variables

   (ii) Intensive properties and extensive properties

   (iii) Path and process

   (b) The functional relation between three variables x, y, and z can be represented as $z = 4x^2y + 3xy^3$. Determine the total differential equation of the function $z = z(x, y)$ and then obtain the coefficient relations. Are these variables state functions? **(6+5=11)**

   (c) Find the amount of work done on the surroundings when 1 litre of an ideal gas, initially at a pressure of 10 atm and 27 °C temperature, is allowed to expand at constant temperature to 10 litres by (i) reducing the external pressure to 1 at in a single step, (ii) reducing the pressure first to 5 atm and then to 1 atm, and (iii) allowing the gas to expand freely. **(15)**

2. (a) "The first law of thermodynamics deals with the conservation of energy while the second Law deals with the degradation of energy" — Explain. **(10)**

   (b) Indicate the contributions of Richards, Nernst and Plank in the development of the third law of thermodynamics. **(10)**

   (c) State and prove the third law of thermodynamics. Mention one important use of this law. **(2+10+3=15)**

3. (a) Deduce a relationship for the change in internal energy of the system to its pressure and volume. **(15)**

   (b) 5 moles of an ideal diatomic gas, initially at 15 atm pressure and 27 °C temperature, is expanded thrice of its volume by a reversible isothermal process. Calculate the change in internal energy of the system. **(10)**

Contd P/2

MME 231/MME

Contd... Q. No. 3

(c) Starting with the following alternative expression of C_p and C_v: **(10)**

$$C_p = T\left(\frac{\partial S}{\partial T}\right)_P \; ; \; C_v = T\left(\frac{\partial S}{\partial T}\right)_V$$

Show that ($C_p - C_v$) can be expressed as a function of PVT properties only. Using the result, show that $C_p - C_v = R$ for an ideal gas.

4. (a) Explain the concept of equilibrium in classical thermodynamics. How does this differ from that used in statistical thermodynamics? **(4+6=10)**

(b) "For a system constrained to constant entropy, volume and quantity of its components, the internal energy decreases and it is a minimum at equilibrium." Deduce the conditions for equilibrium for unary, two-phase equilibrium using the above-mention assertion. **(15)**

(c) Using the G-X diagrams given in Figure 1, draw and label the phase diagram of the A-B system. **(10)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

Graph paper is supplied.

5. (a) Given the integral heats of mixing (ΔH^M, J/mol) of zinc with mole fraction (X_{Zn}) in a Zn-Cd alloy at 700 °C, calculate the partial molar heats of mixing of zinc and cadmium containing 0.6 atom fraction zinc at 700 °C. **(15)**

X_{Zn}	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
ΔH^M	753	1326	1728	1958	2054	2000	1774	1377	787

(b) The partial molar enthalpy of component 1 in a binary solution is given by the equation $\Delta \overline{H}_1 = aX_2^2$. Calculate the partial molar enthalpy for component 2 and molar enthalpy for the solution. **(12)**

(c) The activity coefficient of a component A in an infinitely dilute solution is 0.25. When the mole fraction of A is 0.60, its activity referred to the pure substance is 0.4. From this data calculate the Henrian activity of the component referred to the infinite dilute solution. **(8)**

6. (a) Explain the concept of wetting. **(15)**

   (b) Discuss surface free energy and surface tension. **(15)**

   (c) Differentiate between chemical adsorption and physical adsorption. **(5)**

7. (a) Will a blast furnace gas analyzing 28% CO, 13% CO_2 and 59% N_2 reduce FeO at 727 °C? Given data: **(15)**

   $$\langle Fe \rangle + 1/2\,(O)_2 = \langle FeO \rangle;\ \Delta G^\circ = -62050 + 14.95\,T \text{ cal}$$

   $$\langle CO \rangle + 1/2\,(O)_2 = \langle CO2 \rangle;\ \Delta G^\circ = -627500 + 20.75\,T \text{ cal}$$

   (b) Explain how the concept of equilibrium constant can be used for deoxidation in steel making process. **(10)**

   (c) The latent heat of evaporation of manganese at its normal boiling point (2095 °C) is 226 KJ/mol. Calculate its vapor pressure at the temperature of molten steel (1600 °C). **(10)**

8. (a) The vapor pressure of solid zinc varies with temperature as **(20)**

   $$\ln P(\text{atm}) = -15775/T - 0.755 \ln T + 19.25$$

   And the vapor pressure of liquid zinc varies with temperature as

   $$\ln P(\text{atm}) = -15246/T - 1.255 \ln T + 21.79$$

   Calculate (i) the normal boiling point of liquid zinc, (ii) the triple point temperature, (iii) the heat of evaporation of zinc at normal boiling point, (iv) the heat of fusion of zinc at the triple point, (v) the difference of the heat capacities of solid and liquid zinc.

   (b) Consider a system with two particles A and B that may exhibit any of the four energy levels ε_1, ε_2, ε_3, ε_4. **(15)**

   (i) How many microstates may this system exhibit?

   (ii) Estimate its macrostate.

   (iii) Use the list of macrostates to generate a list of macrostates for this system.

   (iv) Identify the microstates corresponding to each macrostate.

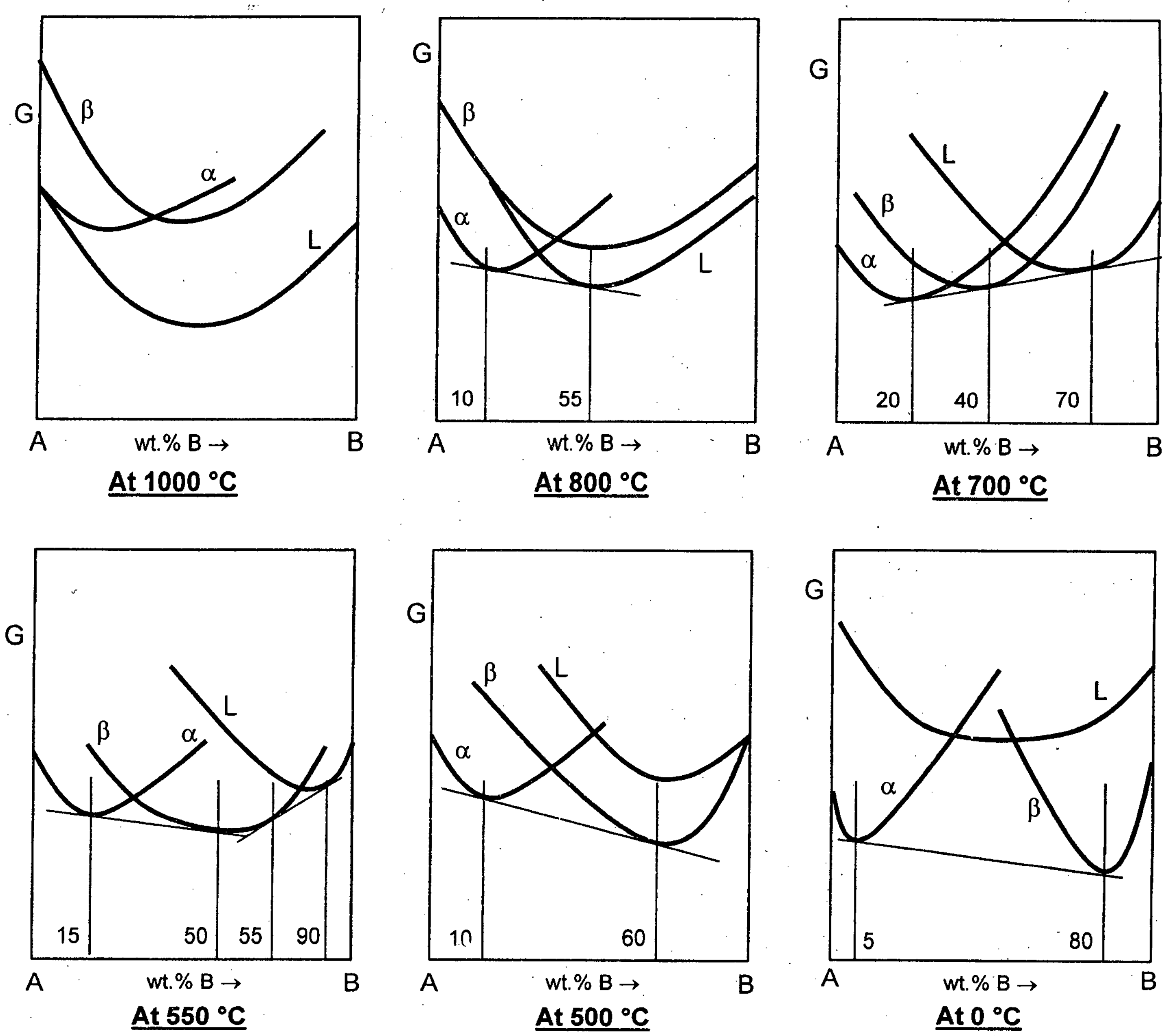

Figure 1: G-X diagrams of A – B phase diagrams at indicated temperatures.

For question no. 4(c)

Checked
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L-2/T-1/MME **Date : 13/12/2014**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2013-2014

Sub : **MME 211** (Crystallography and Structure of Materials)

Full Marks: 140 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

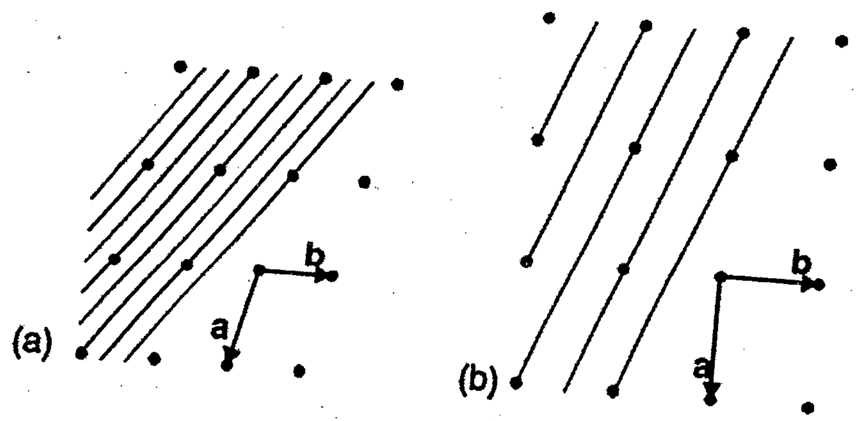
SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

Use tracing paper, Wulff net and Thumb tracks as and when required.

1. (i) Index the lattice planes drawn in Figure 1. The C-axis in all lattices is normal to the plane of the page and hence the index l is 0 in both cases. **(7⅓)**

Figure 1 for Q.1(i)



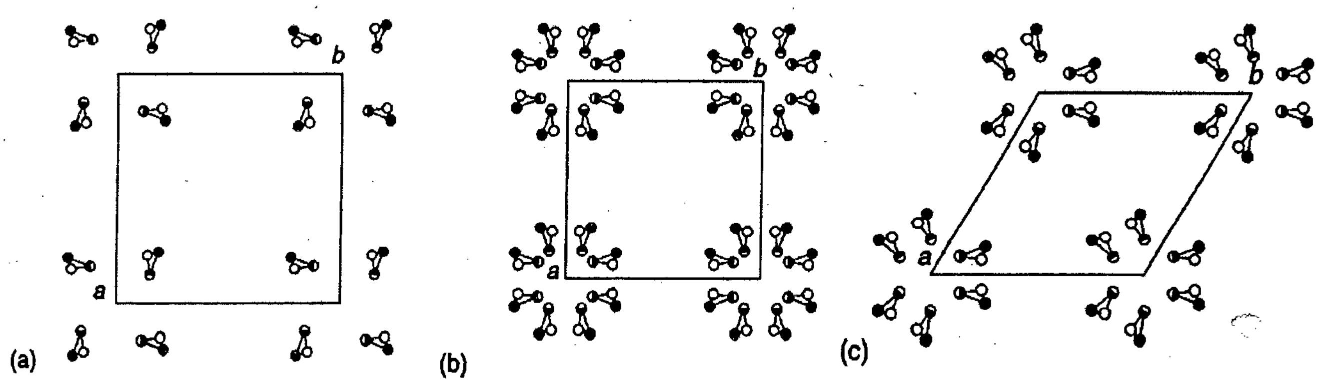
(ii) Sketch the direct and reciprocal lattices for

(a) a primitive monoclinic Bravais lattice with a = 15 nm, b = 6 nm, c = 9 nm, $\beta = 105^\circ$ **(8)**

(b) a primitive tetragonal Bravais lattice with a = 7 nm, C = 4 nm. **(8)**

2. Determine the plane groups of the patterns shown in Figure 2. **(7⅓)**

Figure 2 for Q.2.



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MME 211/MME

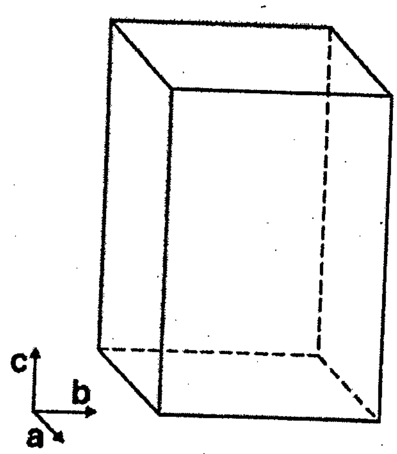
Contd... Q. No. 2

(a) Laying tracing paper over the above plane patterns, indicate the positions of all the symmetry elements within the unit cell. **(8)**

(b) Identify the differences in the distribution of all rotational symmetry elements and mirror lines in the above plane groups. **(8)**

3. Figure 3 is a shape of a brick in which $a \neq b \neq c$ and $\alpha = \beta = \gamma = 90^\circ$.

Figure 3 for Q.3.



(i) What are the point groups does the shape have? **$(4\frac{1}{3})$**

(ii) How many mirror planes does it have? **(4)**

(iii) How many 2-fold, 3-fold, 4-fold and 6-fold rotational axes does it have? **(6)**

(iv) Draw an approximate stereonet projection for each point group. **(9)**

4. Using the standard (001) stereographic projection for a cubic crystal,

(i) Draw in and label the traces for the planes: **(6)**

$(101); (\bar{1}01); (011); (0\bar{1}1)$.

(ii) Plot the normals to the four $\{111\}$ planes. **(4)**

(iii) Plot and label the traces representing the following planes: **(6)**

$(111); (\bar{1}11); (\bar{1}\bar{1}1); (1\bar{1}1)$.

(iv) Use the Wulff net to measure the angles between the poles: **$(7\frac{1}{3})$**

$[100]$ and $[010]$

$[100]$ and $[101]$

$[101]$ and $[011]$

$[111]$ and $[\bar{1}11]$

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Within a cubic unit cell, sketch the following directions: **(12)**

(i) $[100]$, (ii) $[101]$, (iii) $[\bar{1}1\bar{1}]$, (iv) $[120]$, (v) $[1\bar{1}0]$ and (vi) $[\bar{2}1\bar{2}]$.

Contd P/3

MME 211/MME

(b) What are Miller indices? Determine the Miller indices of a plane that intersects the y axis at –1, the z axis at $\frac{1}{2}$, and is parallel to x axis. **(2+3⅓)**

(c) Sketch within a cubic unit cell the following planes. **(6)**

(i) (012), $(10\bar{1})$, and $(\bar{1}11)$.

6. (a) Calculate the volumes of BCC and FCC unit cells in terms of their atomic radii R. **(9)**

(b) Show that the atomic packing factor for BCC and HCP crystal structures are 0.68 and 0.74 respectively. **(9)**

(c) Molybdenum has a BCC crystal structure, an atomic radius of 0.1363 nm, and an atomic weight of 95.94 g/mol. Compute its theoretical density. **(5⅓)**

7. (a) Derive linear density expressions for FCC [100] and [111] directions in terms of the atomic radius R. **(8)**

(b) Derive planar density expressions for BCC (100) and (110) planes in terms of the atomic radius R. **(8)**

(c) What is Weiss zone law? Find out the zone axis of the planes (110) and (111). **(7⅓)**

8. (a) Compute (i) the interplanar spacing, and (ii) the diffraction angle for the (220) set of planes of copper. Copper has a FCC crystal structure with lattice parameter 0.3615 nm. Also, assume that monochromatic radiation having a wavelength of 0.1790 nm is used, and the order of reflection is 1. **(8)**

(b) Figure 4 shows the first five peaks of the x-ray diffraction pattern for tungsten, which has a BCC crystal structure; monochromatic x-radiation having a wavelength of 0.1542 nm was used. **(15⅓)**

(i) Index (i. e., give h, k, and l indices) for each of these peaks.
(ii) Determine the interplanar spacing for each of the peaks.
(iii) Determine the atomic radius for the tungsten atom.

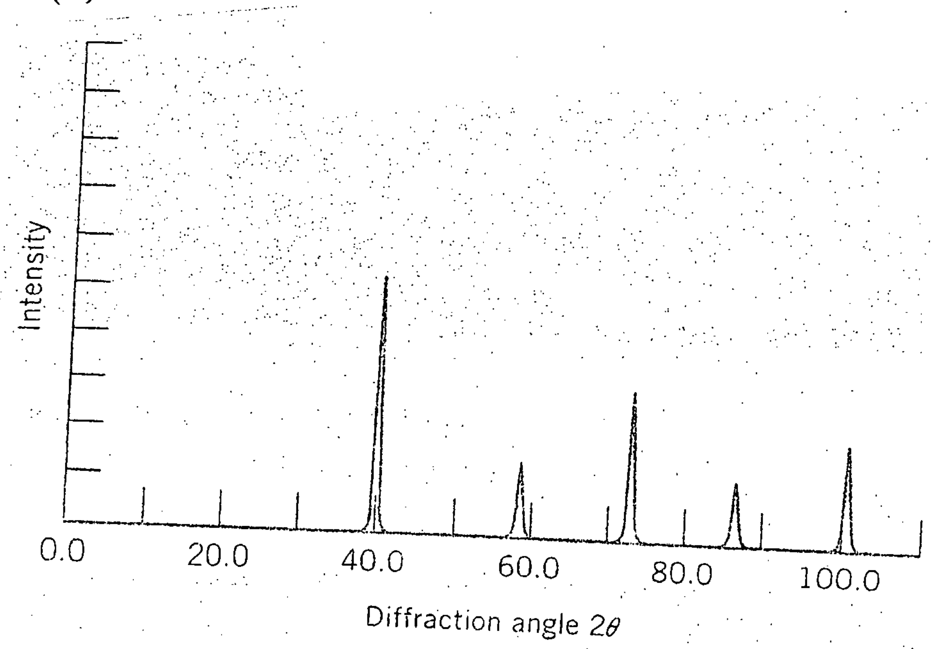
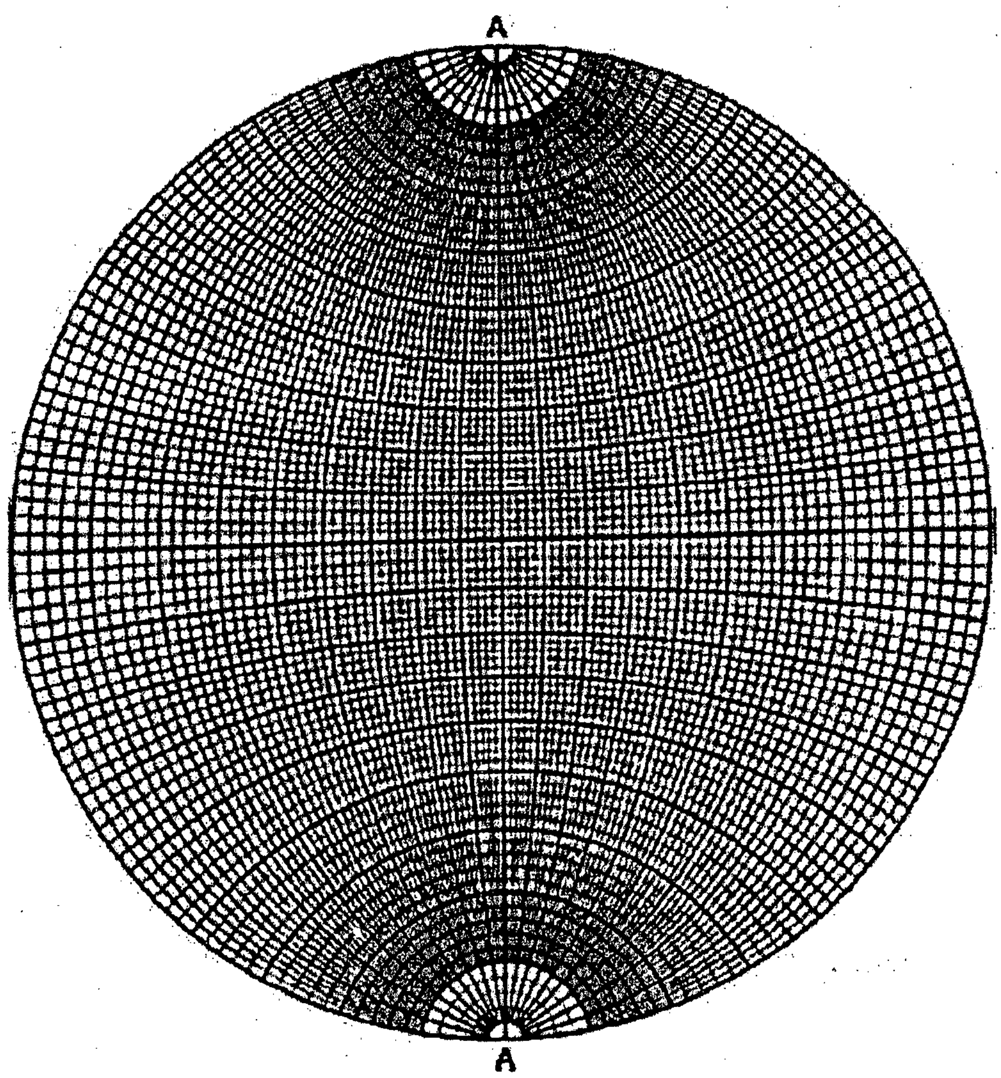


Figure 4 for Q. No. 4 (b)



The Wulff net

2

L-2/T-1/MME Date : 05/01/2015

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2013-2014

Sub : **MATH 271** (Numerical Analysis and Statistics)

Full Marks: 280 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

Symbols used have their usual meaning.

1. (a) Derive Lagrange interpolation formula and hence find the inverse interpolation formula. **(23)**

(b) Find the equation of the curve passing through the points (0,18), (1,10), (3,-18) and (6,90). **($23\frac{2}{3}$)**

2. (a) From the following table find the value of x for y = 75 **(23)**

x :	2	5	8	14
y :	94.8	87.9	81.3	68.7

(b) A curve is expressed by the following values of x and y. Find first and second derivative at x = 1.5. **($23\frac{2}{3}$)**

x :	0.0	0.5	1.0	1.5	2.0
y :	0.4	0.35	0.24	0.13	0.05

3. (a) Discuss Gauss quadrature method to evaluate the integral $\int_a^b f(x)dx$. **(23)**

(b) Evaluate $\int_0^{\frac{\pi}{2}} \sqrt{1-0.25\sin^2 x}\, dx$ by Weddle's rule taking 12 subintervals. **($23\frac{2}{3}$)**

4. Discuss Newton-Raphson method to solve the simultaneous equations $\phi(x,y)=0$ and $\psi(x,y)=0$. Use this method to find the roots of the equations **($46\frac{2}{3}$)**

$$4.2x^2+8.8y^2=1.42$$

$$(x-1.2)^2+(y-0.6)^2=1$$

Contd P/2

MATH 271/MME

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.
Symbols used have their usual meaning.

5. (a) The following table shows the hardness (X) and tensile strength (Y) of 5 samples of metal: **(26⅔)**

X	146	152	158	164	170
Y	75	78	77	89	82

Find the regression line Y on X. Is this linear model adequate for the given data set. Justify your result.

(b) Using moments calculate the coefficients of skewness and kurtosis from the distribution given below and comment on the results obtained. **(20)**

Profit (in Taka)	10-20	20-30	30-40	40-50	50-60
No. of Companies	18	20	30	22	10

6. (a) Four salesmen were posted in different areas by a company. The number of units sold by them are given below: **(28⅔)**

A	20	23	28	29
B	25	32	30	21
C	23	28	35	18
D	15	21	19	25

Is there any significant difference in the performance of these salesmen at 5% level of significance? (Necessary chart 1 is attached).

(b) If X is a binomial random variable with probability distribution $b(x; n, p)$, when $n \to \infty$, $p \to 0$ and $\lambda = np$ remains constant then prove that $b(x; n, p) \to p(x; \lambda)$. **(18)**

7. (a) Apply Lagrange's auxiliary equation technique to solve **(14)**

$$x(y^2 + z)p - y(x^2 + z)q = z(x^2 - y^2)$$

(b) Solve the following PDEs by Charpit's method

(i) $pxy + pq + qy = yz$ **(18⅔)**

(ii) $p^2 - y^2 q = y^2 - x^2$ **(14)**

8. Solve the following higher order PDEs

(a) $(D_x^3 - 4D_x^2 D_y + 4D_x D_y^2)z = 4\sin(2x + y)$ **(14)**

(b) $(D_x^2 - D_x D_y - 2D_y^2 + 2D_x + 2D_y)z = e^{2x+3y} + xy$ **(18⅔)**

(c) $(x^2 D_x^2 - xy D_x D_y - 2y^2 D_y^2 + xD_x - 2yD_y)z = x^2 y^3$ **(14)**

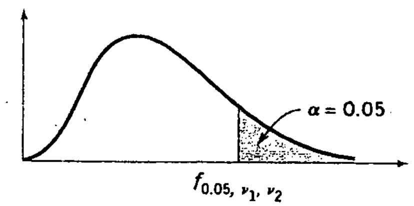


Table VI Percentage Points f_{α,ν_1,ν_2} of the F Distribution (*continued*)

$f_{0.05,\nu_1,\nu_2}$

ν_2 \ ν_1	Degrees of freedom for the numerator (ν_1)																	
	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	∞
1	161.4	199.5	215.7	224.6	230.2	234.0	236.8	238.9	240.5	241.9	243.9	245.9	248.0	249.1	250.1	251.1	252.2	253.3	254.3
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38	19.40	19.41	19.43	19.45	19.45	19.46	19.47	19.48	19.49	19.50
3	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.74	8.70	8.66	8.64	8.62	8.59	8.57	8.55	8.53
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.91	5.86	5.80	5.77	5.75	5.72	5.69	5.66	5.63
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.68	4.62	4.56	4.53	4.50	4.46	4.43	4.40	4.36
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	4.00	3.94	3.87	3.84	3.81	3.77	3.74	3.70	3.67
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.57	3.51	3.44	3.41	3.38	3.34	3.30	3.27	3.23
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.28	3.22	3.15	3.12	3.08	3.04	3.01	2.97	2.93
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.07	3.01	2.94	2.90	2.86	2.83	2.79	2.75	2.71
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.91	2.85	2.77	2.74	2.70	2.66	2.62	2.58	2.54
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85	2.79	2.72	2.65	2.61	2.57	2.53	2.49	2.45	2.40
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75	2.69	2.62	2.54	2.51	2.47	2.43	2.38	2.34	2.30
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67	2.60	2.53	2.46	2.42	2.38	2.34	2.30	2.25	2.21
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60	2.53	2.46	2.39	2.35	2.31	2.27	2.22	2.18	2.13
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.48	2.40	2.33	2.29	2.25	2.20	2.16	2.11	2.07
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49	2.42	2.35	2.28	2.24	2.19	2.15	2.11	2.06	2.01
17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49	2.45	2.38	2.31	2.23	2.19	2.15	2.10	2.06	2.01	1.96
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41	2.34	2.27	2.19	2.15	2.11	2.06	2.02	1.97	1.92
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38	2.31	2.23	2.16	2.11	2.07	2.03	1.98	1.93	1.88
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.28	2.20	2.12	2.08	2.04	1.99	1.95	1.90	1.84
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37	2.32	2.25	2.18	2.10	2.05	2.01	1.96	1.92	1.87	1.81
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30	2.23	2.15	2.07	2.03	1.98	1.94	1.89	1.84	1.78
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32	2.27	2.20	2.13	2.05	2.01	1.96	1.91	1.86	1.81	1.76
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.25	2.18	2.11	2.03	1.98	1.94	1.89	1.84	1.79	1.73
25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28	2.24	2.16	2.09	2.01	1.96	1.92	1.87	1.82	1.77	1.71
26	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27	2.22	2.15	2.07	1.99	1.95	1.90	1.85	1.80	1.75	1.69
27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.25	2.20	2.13	2.06	1.97	1.93	1.88	1.84	1.79	1.73	1.67
28	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24	2.19	2.12	2.04	1.96	1.91	1.87	1.82	1.77	1.71	1.65
29	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22	2.18	2.10	2.03	1.94	1.90	1.85	1.81	1.75	1.70	1.64
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.09	2.01	1.93	1.89	1.84	1.79	1.74	1.68	1.62
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.08	2.00	1.92	1.84	1.79	1.74	1.69	1.64	1.58	1.51
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04	1.99	1.92	1.84	1.75	1.70	1.65	1.59	1.53	1.47	1.39
120	3.92	3.07	2.68	2.45	2.29	2.17	2.09	2.02	1.96	1.91	1.83	1.75	1.66	1.61	1.55	1.55	1.43	1.35	1.25
∞	3.84	3.00	2.60	2.37	2.21	2.10	2.01	1.94	1.88	1.83	1.75	1.67	1.57	1.52	1.46	1.39	1.32	1.22	1.00

Degrees of freedom for the denominator (ν_2)

MATH 271

Chart-I for Q. No. 6(a)

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2013-2014

Sub : **MME 241** (Fuels and Combustion)

Full Marks: 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Describe, with the help of a labelled diagram, the relationship between energy losses and exit gas temperature. **(20)**

   (b) What is induced draught? **(15)**

2. (a) Explain the operation of an overfeed stoker with the help of a labelled diagram. **(20)**

   (b) Differentiate between horizontal and tangential fired furnaces. **(15)**

3. (a) What is CNG? Discuss the advantages and disadvantages of CNG. **(20)**

   (b) Discuss the factors affecting the composition of producer gas. **(15)**

4. (a) Describe the operation of a wall-wiping Flame Rotary Vaporizing Burner with the help of a diagram. **(20)**

   (b) What do you understand by atomizing oil burners? How do they operate? **(15)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Give the differences between thermal and catalytic cracking. With the help of a neat flowsheet describe the working principle of thermofer catalytic cracking (TCC) moving bed process. **(20)**

   (b) Explain distillation of crude oil. Give a schematic diagram of the two stage distillation unit and mention how it works. **(15)**

6. (a) What is petroleum? Discuss the theories of origin of petroleum. **(15)**

   (b) How can coal be transformed to liquid fuel by Fischer-Tropsch process. **(12)**

   (c) Write a note on 'propane deasphalting process'. **(8)**

Contd P/2

MME 241/MME

7. (a) Define 'ranking of coal' and show the variation in ranking with composition and physical properties of coal. **(15)**

   (b) What are the ultimate and proximate analyses of coal and what are their significances to the coal users? **(12)**

   (c) Distinguish between lower heating value and higher heating value of coal. **(8)**

8. (a) Describe the stages in the formation of coal from vegetable matter. **(15)**

   (b) Describe one dry process and one wet process of coal washing mentioning their advantages and disadvantages. **(20)**

L-2/T-1/MME **Date : 15/01/2015**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2013-2014

Sub : **ME 243** (Mechanics of Solids)

Full Marks: 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

One figure and one chart are attached.

1. (a) The tank shown in Fig. for question No. 1(a) is fabricated from $\frac{1}{8}$ in steel plate. Calculate the maximum longitudinal and circumferential stress caused by an internal pressure of 125 psi. **(17)**

(b) Derive expressions of radial and tangential stresses for a thick-walled cylinder, when the cylinder is subjected to an external pressure only. **(18)**

2. (a) A compound shaft consisting of a steel segment and an aluminum segment is acted upon by two torques as shown in Fig. for question No. 2(a). Determine the maximum permissible value of 'T' subject to the following conditions: $\tau_{st} \leq 83$ MPa, $\tau_{al} \leq 55$ MPa and the angle of rotation of the free end is limited to 6°. For steel G = 83 GPa and for aluminum G = 28 GPa. **(18)**

(b) Two steel springs arranged in series as shown in Fig. for question No. 2(b) support a load P. The upper spring has 12 turns of 25 mm-diameter wire on a mean radius of 100 mm. The lower spring consists of 10 turns of 20 mm-diameter wire on a mean radius of 75 mm. If the maximum shearing stress in either spring must no exceed 200 MPa, compute the maximum value of P and the total elongation of the assembly. Use G = 83 GPa. **(17)**

3. (a) Deduce an expression of critical load for axially loaded both ends fixed column with necessary assumptions. **(15)**

(b) Select the lightest W shape column that will support an axial load of 90 kips on an effective length of 15 ft. Use AISC column specification [given in table for question No. 3(b)] with $\sigma_{yp} = 36$ ksi and E = 29×10^{6} psi. **(20)**

4. (a) A timber beam is reinforced with steel plates rigidly attached at the top and bottom as shown in Fig. for question No. 4(a). What is the amount of moment increased by the reinforcement if n = 15 and the allowable stresses in the wood and steel are 8 MPa and 120 MPa respectively? **(17)**

(b) The cross section of a circular link shown in Fig. for question No. 4(b) has a rectangular section 100 mm wide by 50 mm thick. Compute the stresses at A and B and at C and D. **(18)**

Contd P/2

ME 243/MME

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

Symbols indicate their usual meaning. Assume any missing data.

5. (a) As shown in Fig. 5(a), a rigid bar with negligible mass is pinned at O and attached to two vertical rods. Assuming that the rods were initially stress-free, what maximum load P can be applied without exceeding stresses of 150 MPa in the steel rod and 70 MPa in the bronze rod. **(15)**

(b) As shown in Fig. 5(b), there is a gap between the aluminum bar and the rigid slab that is supported by two copper bars. At 10°C, $\Delta = 0.18$ mm. Neglecting the mass of the slab, calculate the stress in each rod when the temperature in the assembly is increased to 95°C. For each copper bar, A = 500 mm^2, E = 120 GPa, and α = 16.8 μm/(m.°C). For the aluminum bar, A = 400 mm^2, E = 70 GPa, and α = 23.1 μm/(m.°C). **(20)**

6. (a) Write shear force and bending moment equations for the beam as shown in Fig. 6(a). Also, draw the shear force and bending moment diagrams for the beam specifying values at all changes of loading positions and at all points of zero shear. **(15)**

(b) A cast iron beam 10 m long and supported as shown in Fig. 6(b) carries a uniformly distributed load of intensity w_o (including its own weight). The allowable stresses are $\sigma_t \leq 20$ MPa and $\sigma_c \leq 80$ MPa. Determine the maximum safe value of w_o if $x = 1.0$ m. **(20)**

7. (a) Compute the value of $EI\delta$ at midspan for the beam loaded as shown in Fig. 7(a). Solve the problem by the method of double integration. **(15)**

(b) Find the value of $EI\delta$ under each concentrated load of the simply supported beam as shown in Fig. 7(b). Use area moment method to solve the problem. **(20)**

8. (a) Determine the largest load P that can be supported by the circular steel bracket as shown in Fig. 8(a) if the normal stress on section $A|$-B is limited to 80 MPa. **(15)**

(b) If an element is subjected to the state of stress as shown in Fig. 8(b), find the principal stresses and the maximum in-plane shearing stresses. Also, determine the stress components on planes whose normals are at 45° and 135° with the x-axis. Show all results on complete sketches of the appropriate element. **(20)**

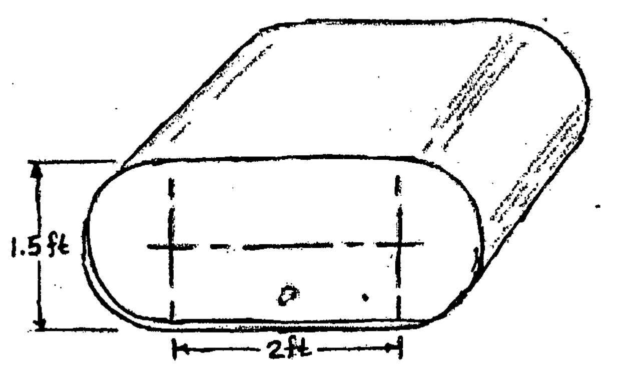


Fig. for question no. 1(a)

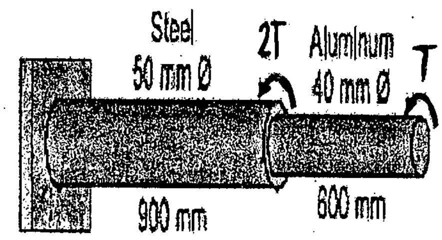


Fig. for question no. 2(a)

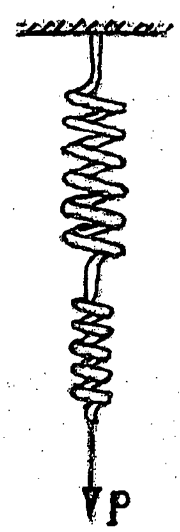


Fig. for question no. 2(b)

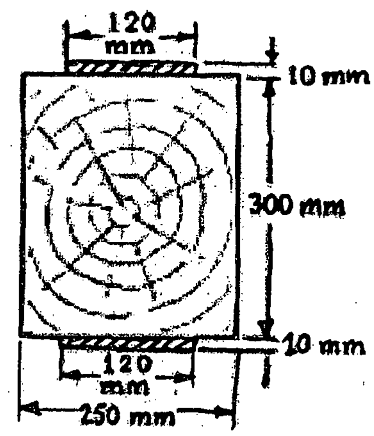


Fig. for question no. 4(a)

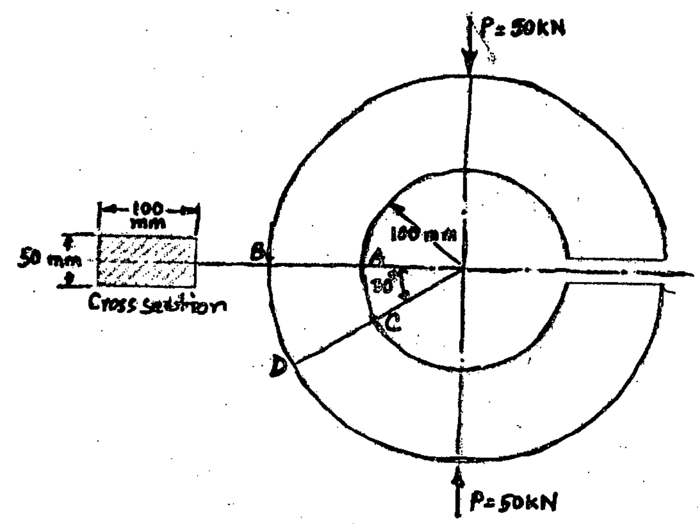


Fig. for question no. 4(b)

for question no. 3(b)

PROPERTIES OF WIDE-FLANGE SECTIONS (W SHAPES): U.S. CUSTOMARY UNITS (Continued)

Designation	Area ($in.^2$)	Depth (in.)	Web thickness (in.)	Flange Width (in.)	Flange Thickness (in.)	Axis X–X I ($in.^4$)	Axis X–X $S = \frac{I}{c}$ ($in.^3$)	Axis X–X $r = \sqrt{I/A}$ (in.)	Axis Y–Y I ($in.^4$)	Axis Y–Y $S = \frac{I}{c}$ ($in.^3$)	Axis Y–Y $r = \sqrt{I/A}$ (in.)
W8 ×28	8.25	8.06	0.285	6.535	0.465	98.0	24.3	3.45	21.7	6.63	1.62
×24	7.08	7.93	0.245	6.495	0.400	82.8	20.9	3.42	18.3	5.63	1.61
W8 ×21	6.16	8.28	0.250	5.270	0.400	75.3	18.2	3.49	9.77	3.71	1.26
×18	5.26	8.14	0.230	5.250	0.330	61.9	15.2	3.43	7.97	3.04	1.23
W8 ×15	4.44	8.11	0.245	4.015	0.315	48.0	11.8	3.29	3.41	1.70	0.876
×13	3.84	7.99	0.230	4.000	0.255	39.6	9.91	3.21	2.73	1.37	0.843
×10	2.96	7.89	0.170	3.940	0.205	30.8	7.81	3.22	2.09	1.06	0.841
W6 ×25	7.34	6.38	0.320	6.080	0.455	53.4	16.7	2.70	17.1	5.61	1.52
×20	5.87	6.20	0.260	6.020	0.365	41.4	13.4	2.66	13.3	4.41	1.50
×15	4.43	5.99	0.230	5.990	0.260	29.1	9.72	2.56	9.32	3.11	1.46
W6 ×16	4.74	6.28	0.260	4.030	0.405	32.1	10.2	2.60	4.43	2.20	0.966
×12	3.55	6.03	0.230	4.000	0.280	22.1	7.31	2.49	2.99	1.50	0.918
×9	2.68	5.90	0.170	3.940	0.215	16.4	5.56	2.47	2.19	1.11	0.905
W5 ×19	5.54	5.15	0.270	5.030	0.430	26.2	10.2	2.17	9.13	3.63	1.28
×16	4.68	5.01	0.240	5.000	0.360	21.3	8.51	2.13	7.51	3.00	1.27
W4 ×13	3.83	4.16	0.280	4.060	0.345	11.3	5.46	1.72	3.86	1.90	1.00

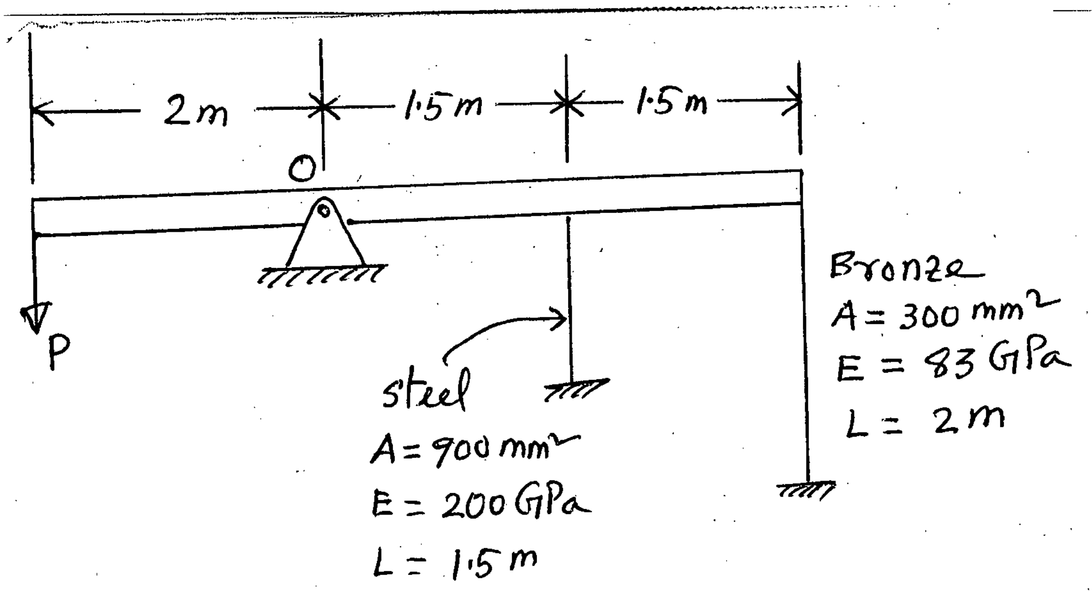


Fig. 5(a)

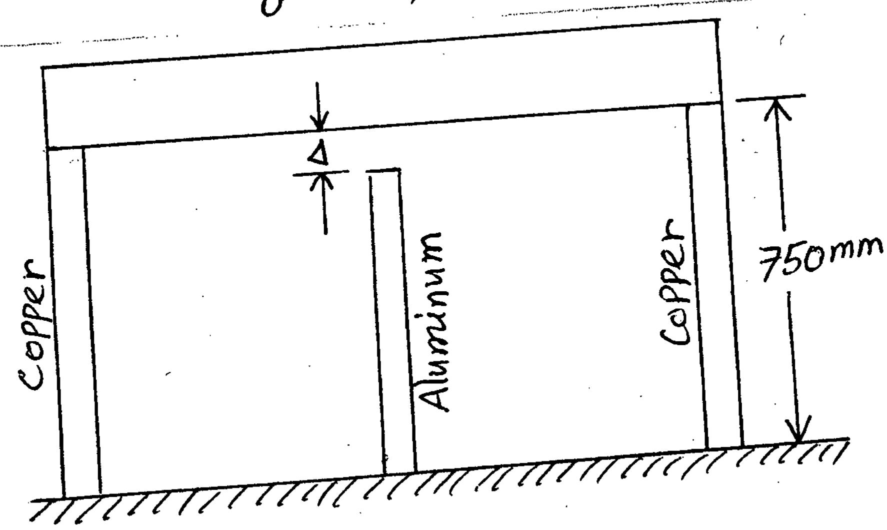


Fig. 5(b)

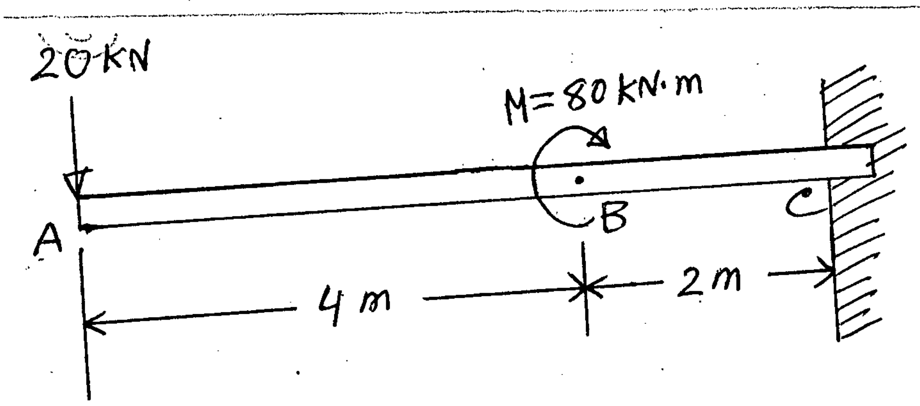


Fig. 6(a)

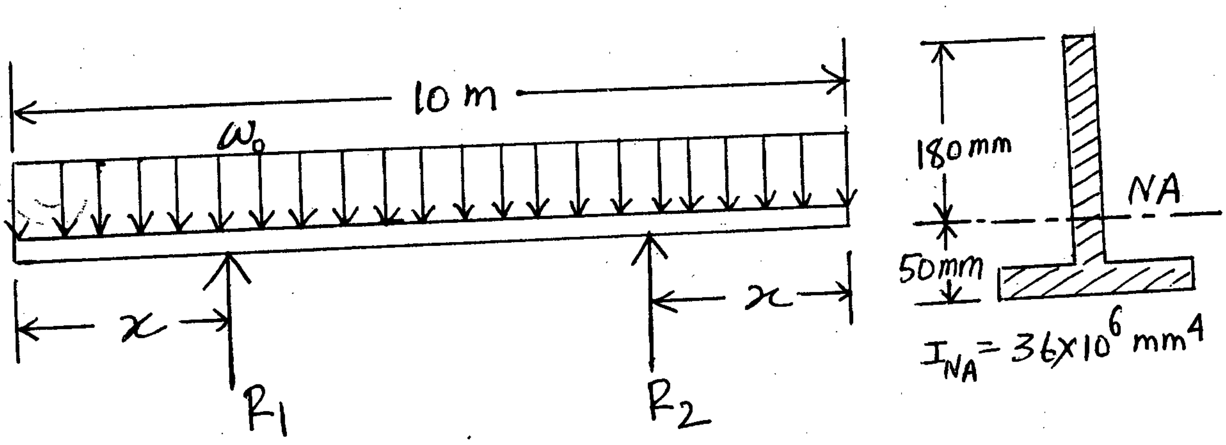


Fig. 6(b)

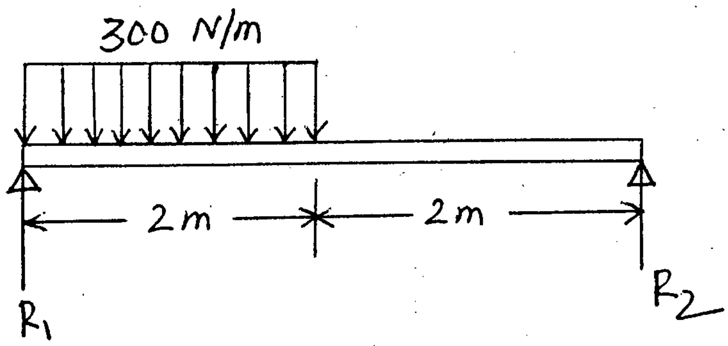


Fig. for 7(a)

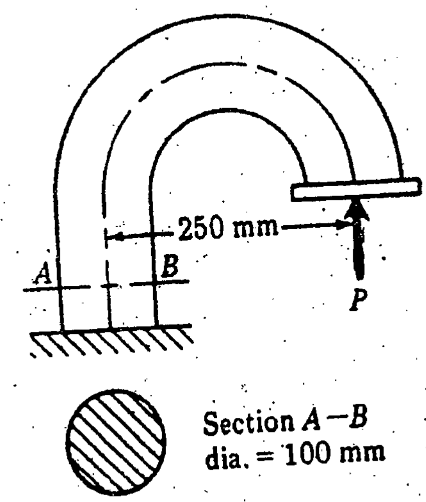


Fig. 8 (a)

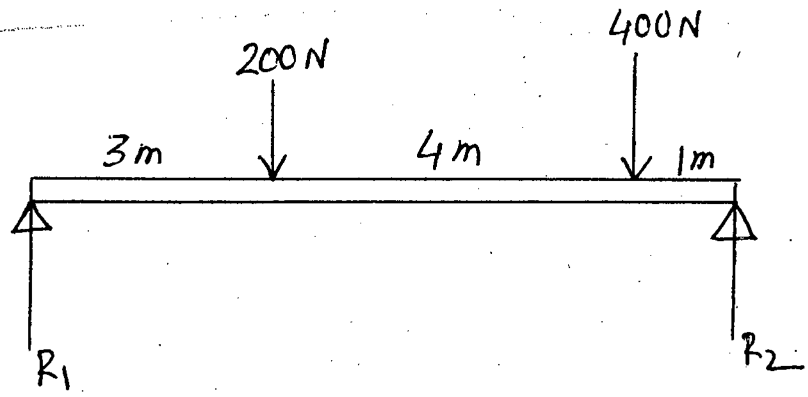


Fig. 7(b)

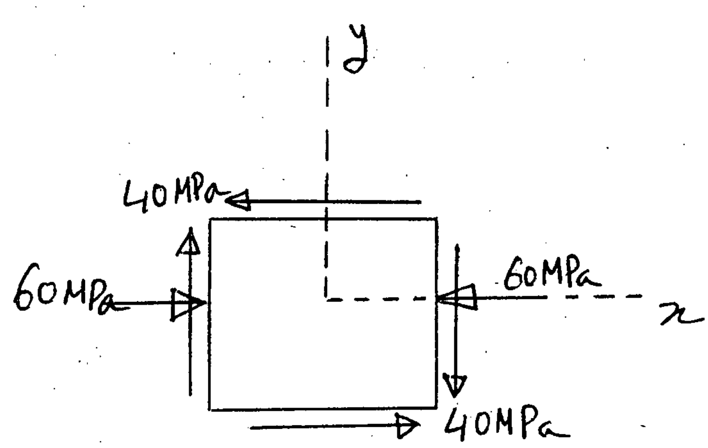


Fig. 8(b)