U.V 2/5/14 M. E. (Mechanical) Sem - II Machine Design
Advanced Finite Element Methods

MASTER

Bharatiya Vidya Bhavan's

SARDAR PATEL COLLEGE OF ENGINEERING

(An Autonomous Institution Affiliated to University of Mumbai)

End Examination_apr-may_2014

Total Marks: 100 Duration: 4 Hours

CLASS/SEM: M. E.(Mech)-m/c Deg./ **II** SUBJECT: **Adv. FEM (ME662)**

- Attempt any **FIVE** questions out of seven questions.
- Figures to the right indicate full marks.
- Make any suitable assumption if needed with proper reasoning.
- Answer to the sub questions should be grouped together.

Q.no. 1

a) For a fixed-fixed beam solve the problem using weak formulation. **10**

$$\frac{d^4v}{dx^4}EI - q_0 = 0$$

Assume appropriate b.c.

b) Explain the weak form and compare with weighted residual technique. **05**

c) A bar is suspended vertically. Find out the expression for deformation under its self-weight, using W.R. technique. **05**

Q.no.2

a) Solve the following equation using a two-parameter trial solution by Galerkin method. Compare the results with exact solution. **10**

$$\frac{dy}{dx} - y = 0, \quad 0 \le x \le 1$$

$y(0) = 1$

b) Derive the stiffness matrix for an arbitrary oriented truss element w.r.t. global coordinate system. **05**

c) Explain different types of Boundary Conditions. **05**

Q.no.3

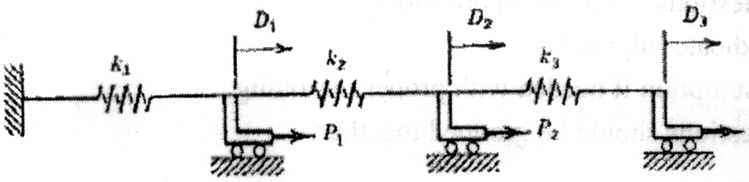
a) Derive the shape function, stiffness matrix and load vector for a quadratic bar element. **12**

b) Use Gauss quadrature to evaluate the integral. (Use: 1x1, 2x2 3x3 points.) **08**

$$I = \iint \frac{3+x^2}{2+y^2}\,dx\,dy$$

M. E. (Mechanical) Sem-II Machine Design
Advanced Finite Element Method 02/05/2014

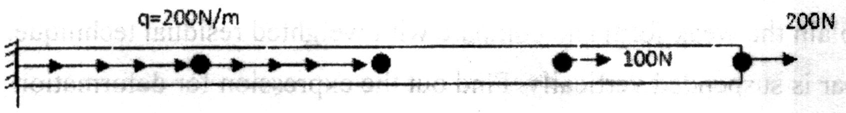
Q. no. 4 a) Derive i) stiffness matrix using direct stiffness method (fig. below) ii) Find displacements D_1, D_2, D_3 if $K_1 = 3$, $K_2 = 2$, $K_3 = 1$ kN/m resp. and $P_1 = 3$, $P_2 = 2$, $P_3 = 1$ kN resp. iii) What will be the stiffness matrix if we connect the forth spring between left support and node 3 at extreme right? **10**



b) Explain the concept of FEM briefly and outline the procedure **10**

Q. no.5

a) A rod under distributed and concentrated forces. Solve for nodal displacement, stress –strain and support reaction. Given: A=30 mm², E= 200 GPa., total length= 1m, four elements of each 0.25m length. (Fig. below) **14**



b) Explain the Jacobian matrix. What is the effect of node numbering on it? **06**

Q. no.6

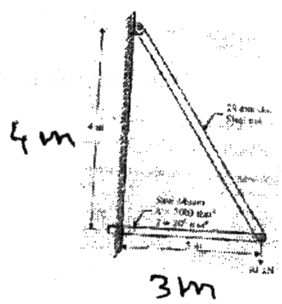
a) Discuss the effect of node numbering on assembled stiffness matrix. **05**

b) What is the shape function? How elements are classified based on the shape function for an element? Discuss. **06**

c) What is constant strain triangle element? Explain. **05**

d) Discuss the characteristics of the stiffness matrix **04**

Q. no7 a) Derive stiffness matrix separately for each frame element. (*horizontal frame*: I-beam, c/s A=2000 mm², I=10^5mm⁴, *inclined frame*: c/s area=314.16mm², I=7854 mm⁴) **20**



Lib 17/OT/14

M.E(M) with m/c Design Sem II

Bharatiya Vidya Bhavan's

SARDAR PATEL COLLEGE OF ENGINEERING

(An Autonomous Institution Affiliated to University of Mumbai)

MASTER

Re-End Examination_may_jun2014

Total Marks: 100 Duration: 4 Hours

CLASS/SEM: M. E.(Mech)-m/c Deg./ **II** SUBJECT: **Adv. FEM (ME662)**

- Attempt any **FIVE** questions out of seven questions.
- Figures to the right indicate full marks.
- Make any suitable assumption if needed with proper reasoning.
- Answer to the sub questions should be grouped together.

Advanced finite Element methods.

Q.no. 1 a) Discuss the steps involved in Rayleigh Ritz method and solve the following differential equation of a bar element with uniform loading using RR method (All the terms with usual meaning). **20**

$$AE\,(d^2u/dx^2) + q = 0\,; \qquad u(0) = 0,\ (du/dx)_{x=L} = 0$$

Q.no.2 a) Discuss Weighted Residual method, solve the following differential equation of a bar element with uniform loading. (All the terms with usual meaning). Compare the result with Rayleigh Ritz method. **20**

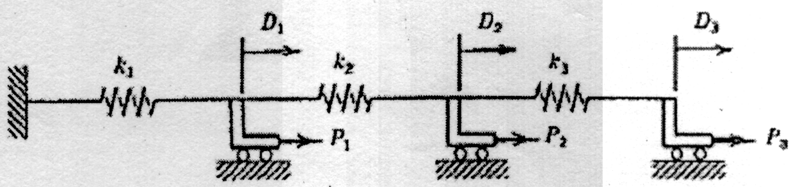
$$AE\,(d^2u/dx^2) + q = 0\,; \qquad u(0) = 0,\ (du/dx)_{x=L} = 0$$

Q.no.3 a) Derive the stiffness matrix for an arbitrary oriented truss element w.r.t. global coordinate system. **10**

b) Explain different types of Boundary Conditions. **10**

Q. no. 4 a) Derive the shape function, stiffness matrix and load vector for a quadratic bar element. **20**

Q. no.5 a) Derive i) stiffness matrix using direct stiffness method (fig. below) ii) Find displacements D_1, D_2, D_3 if K_1 =3, K_2 =2, K_3=1 kN/m resp. and P_1 =3, P_2 =2, P_3=1 kN resp. iii) What will be the stiffness matrix if we connect the forth spring between left support and node 3 at extreme right? **20**



Page (1)

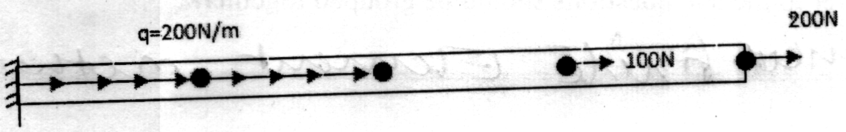
Advanced Finite Element Methods

M.E(M) with MC Design Sem II 17/6/14

Q. no.6 a) Explain the concept of FEM briefly and outline the procedure 10

b) What is constant strain triangle element? Explain. 10

Q. no7 a) A rod under distributed and concentrated forces. Solve for nodal displacement, stress –strain and support reaction. Given: A=30 mm^2, E= 200 GPa., total length= 1m, four elements of each 0.25m length. (Fig. below) 20



Page (2)

lib.
07/05/14

Bhartiya Vidya Bhavan's

Sardar Patel College of Engineering

(An Autonomous Institution affiliated to University of Mumbai)

End Sem. Exam. **Second Half 2013-14**

Class/Sem.: **M.E. (Machine Design)/II** Subject: **Design of Power Transmission Systems**

Duration: **4 Hrs.** Total Marks: **100**

N.B.: M. E. (Mechanical) with Machine Design - II MASTER

1. Answer any **five** questions.
2. Use of PSG Design Data Book is permitted.
3. Assume suitable data, if necessary, giving reasons.
4. Draw neat sketches to illustrate your answers.
5. Figures to the right indicate full marks.

1. (a) Compare mechanical, hydraulic and pneumatic power transmission systems indicating advantages, disadvantages and applications. 10

   (b) Answer any two of the following: 10

   (i) Explain briefly hydraulic pressure control valves.

   (ii) Compare hydraulic and pneumatic systems with respect to motion control, speed control, acceleration and retardation, shock load etc.

   (iii) Describe briefly use of DC electric motors as prime movers.

2. (a) Bucket elevator head shaft has to be operated at 25 rpm from a 4-pole electric motor of 11 kW power. The last stage of the drive is pair of gears with speed reduction ratio of 4.2. Select suitable types of gears, design the same completely and draw sketches with dimensions. 10

   (b) If for the above last stage, chain drive is used, design the same and draw layout with details. Compare the two alternatives and suggest giving reasons which is preferred. 10

3. (a) Determine the size and number of V-belts to transmit 11 kW power from an electric motor rotating at 1450 rpm to a multi-cylinder reciprocating compressor operating at 400 rpm approximately. The expected life of the belts is 12 to13 months, 8-10 hrs/day. . Design also the driven pulley and sketch the same with dimensions. 10

   (b) Design a cone clutch along with linkage mechanism and spring to transmit 3.7 kW power from an ac 730 rpm electric motor to machine tool. Assume slip period 1.2 sec. during each clutching operation and number of clutching operations 40 per hour. 10

4. Following data relates to the hoisting mechanism of an EOT crane:

Load lifting capacity	100 kN
Lifting speed	6 m/min
Rope drum diameter	450 mm
Duty	Class II

   (a) Select a suitable electric motor indicating type, power, speed and other specifications. Suggest a suitable power transmission system giving brief description and preliminary details or specifications of each drive element including couplings, brake, gears, etc. Draw a neat layout of the power transmission system showing above details. 10

   (b) Design completely the first stage of gearing of the of the power transmission system suggested in part (a) and draw dimensional sketches. 10

M. E. (Mechanical) with Machine Design Sem-II
Design of Power Transmission System 07/05/2014

5. A hydraulic cylinder has to operate with following cycle: 20

(a) extend 135 mm at 30 bar in 6 sec.
(b) extend 15 mm at 200 bar in 6 sec.
(c) remain extended 15 at 200 bar for20 sec.
(b) retract 150 mm at 30 bar in 4 sec.
(c) remain retracted at 30 bar for 14 sec.

Cylinder bore is 200 mm and stroke 150 mm. Choose suitable rod diameter.
Draw displacement, flow rate and pressure diagrams.

(i) Design and analyze hydraulic system using two fixed displacement pumps.
(ii) Design and analyze hydraulic system using one fixed displacement and accumulator.

6. (a) (i) Explain briefly the main parameters affecting the selection of a hydraulic pump. 10
(ii) Compare different methods of flow control in hydraulic circuits.

(b) A mass of 2500 kg is to be accelerated vertically up and down up to a velocity of 1 m/s from rest over a distance of 50 mm. Friction between piston and cylinder is equal to 8% of inertia force, seal friction is equal to a pressure drop of 5 bar, back pressure and pipe pressure drop equals to 6 bar. Calculate the size of the cylinder required if the pump pressure is 105 bar. Calculate also pump delivery and power required. Draw hydraulic circuit diagram. 10

7. (a) Considering tractor as an application, discuss the scope of using mechanical, hydraulic and pneumatic power for different operations. 06

(b) A tractor operating on rough terrain is to be driven by a hydraulic motor in each of the two rear wheels. Design and analyze a closed circuit hydraulic transmission with the facility for the power take off. The details of the tractor and the design requirements are as follows: 14

The weight of the fully loaded vehicle is 2500 kg, the weight distribution 70 % on the rear wheels, the maximum gradient 1in 4, the maximum coefficient of rolling resistance 0.3, the minimum coefficient of adhesion between tire and ground is 0.85. The diameter of the drive wheels is 1.2 m, maximum speed of the drive engine 2000 rpm, maximum design speed 16 kmph on level ground and a speed of 8 kmph is acceptable when vehicle is ascending maximum gradient of 1 in 4. Assume volumetric efficiency 0.98 and overall efficiency 0.9 for both hydraulic pumps and motors. Draw hydraulic circuit diagram and explain the working.

Lib 19/6/14

Bhartiya Vidya Bhavan's

Sardar Patel College of Engineering

(An Autonomous Institution affiliated to University of Mumbai)

RE Exam. Mech Date: 19.06. 2014

Class/Sem.: **M.E. (Machine Design)/II** Subject: **Design of Power Transmission Systems**

Duration: **4 Hrs.** ~~Total Marks: 100~~

MASTER

N.B.:

1. Answer any **five** questions.
2. Use of PSG Design Data Book is permitted.
3. Assume suitable data, if necessary, giving reasons.
4. Draw neat sketches to illustrate your answers.
5. Figures to the right indicate full marks.

1. (a) Considering machine tools as an application, discuss the scope of using mechanical, hydraulic and pneumatic power transmission systems. Explain why a particular power transmission system is more preferred to the others giving examples. **10**

   (b) Answer any two of the following: **10**

   (i) Explain the use of flexible power transmission elements with merits and demerits.

   (ii) Compare hydraulic and pneumatic systems with respect to motion control, speed control, acceleration and retardation, shock load etc.

   (iii) Draw hydraulic circuit diagrams showing pressure relief valve, pressure reducing valve, sequence valve, pressure unloading valve and back pressure valve, indicating their functions.

2. A 15 kW, 1440 rpm electric motor transmits power to a bucket elevator shaft operating at 40 rpm through a worm and worm gear unit. Selecting suitable materials and stresses design worm and worm gear completely considering strength, wear and heat dissipation capacity. Draw dimensional sketches of assembly, including housing, worm, worm gear, bearings etc. **20**

3. (a) Determine the size and number of V-belts to transmit power from a 3.7 kW, 1440 rpm electric motor to a multi-cylinder reciprocating air compressor operating at 400 rpm. Design also the driven pulley and sketch the same with dimensions. **10**

   (b) Design a multiple- disc, dry friction clutch along with linkage mechanism and springs to transmit 3.7 kW power from an ac 730 rpm electric motor to machine tool. Assume slip period 1 sec. during each clutching operation and number of operations 30 per hour. **10**

4. Following data relates to the hoisting mechanism of an EOT crane:

Load lifting capacity	100 kN
Lifting speed	6.2 m/min
Rope drum diameter, speed	450 mm, 8.7 rpm
Duty	Class II

   (a) Select a suitable electric motor indicating type, power, speed and other specifications. Suggest a suitable power transmission system giving brief description and preliminary details or specifications of each drive element including couplings, brake, gears, etc. Draw a neat layout of the power transmission system showing above details. **10**

   (b) Design and draw a suitable brake for the above mechanism **10**

[TURN OVER

Page 6

M.E (M) with m/c Design Sem II Design of Power Trans. Systems. 19/6/14

5. (a) Design and sketch a pair of 90° bevel gears to transmit 15 kW power from a pinion speed of 200 rpm and speed reduction ratio of 3.8. The drive is subjected to a medium shock and duty 8-10 hrs/day. **10**

(b) Explain briefly the different types of electric motors used as prime movers, their important features, characteristics, applications, selection etc. **10**

6. (a) Explain the use of an accumulator in a hydraulic power transmission system. Explain with a suitable application, how you decide the type and capacity of the accumulator. **10**

(b) A hydraulic cylinder of 120 mm bore, rod diameter 80mm and stroke 300 mm drives a load of 25 kN vertically up and down at a maximum speed of 1.5 m/sec. The lift speed is set by adjusting the pump flow and return speed by a flow control valve. The load is slowed down to rest in a cushion length of 50mm at each end. The relief valve is set at 100 bar, determine the average pressure in the cushions on the lift and return strokes. Also find the average acceleration and acceleration time during the start of stroke and the maximum pump flow rate. **10**

7. (a) A single acting up stroking hydraulic press, 3 MN capacity, 260 mm stroke, of which 235 mm is to close the dies at a cylinder pressure of 30 bar, in 5 sec. The final 25 mm stroke to be pressing at a cylinder pressure of 320 bar, in 5 sec followed by holding (curing) at 320 bar pressure for 25 sec, return by gravity in 10 sec and unloading and loading the press in 15 sec. **20**

Making suitable assumptions design the press by determining cylinder size, selecting number and size of pumps and other hydraulic components. Draw hydraulic circuit diagram, explain the working of the press and analyse the performance.

Page 2

Lib 29/4/14

Bharatiya Vidya Bhavan's

SARDAR PATEL COLLEGE OF ENGINEERING

(An Autonomous Institution Affiliated to University of Mumbai)

M.E (Mech) with M/C Design - II Sem II End Examination apr-may 2014

Total Marks: 100 Duration: 4 Hours

CLASS/SEM: M. E.(Mech)-m/c Deg./ II SUBJECT: **FRACTURE MECHANICS (ME661)**

- Attempt any **FIVE** questions out of seven questions.
- Figures to the right indicate full marks.
- Make any suitable assumption if needed with proper reasoning.
- Answer to the sub questions should be grouped together.

MASTER

Q1 a) Show that for $\phi = -X_2 Re\overline{Z_{II}}$ chosen for the mode II problems, satisfies the bi-harmonic equation. Determine the stress components in terms of Z_{II}. 10

b) For a center crack in an infinite plate loaded in Mode II, determine the stress components near vicinity of crack in terms of K_{II}. 10

Q2 a) Determine plastic zone size for plane stress and plane strain condition using mises criterion. 10

b) Explain Irwin Plastic Zone correction for effective crack length. 10

Q3 a) Derive the expression of energy release rate for DCB specimen using fixed grip and constant load and show that it is same. 12

b) Determine the shape of the DCB specimen if G_I is to remain constant with growth of crack. The specimen is loaded in constant load mode. Determine the depth *h* of the specimen beyond the crack tip if thickness of the specimen remains constant (B=30mm). The initial crack length is 40mm, modulus 207 GPa and depth of each cantilever 12mm up to initial crack length. (Calculate for crack up to 80mm.) 08

Q4 a) An edge crack of 3.1mm is detected on a plate of 100mm wide, subjected to a constant amplitude cyclic load having maximum and minimum stress of 310 MPa and 172MPa respectively. Determine total propagation life up to failure, considering the effect of form factor (take the crack step of 10mm for the effect of form factor). Material properties are: K_{IC} = 165 MPa $m^{0.5}$, C= 6.8 x 10^{-12}, m= 3. 14

b) Discuss the phenomenon of crack closure. 06

M.E. mech with machine Design -II Sem-II Fracture mechanics 23/04/2014.

Q5 a) Consider a three point bend specimen with a center load as shown figure below. Determine: i) K_I, ii) G_I based on LEFM, iii) J_P using engineering approach, iv) Plastic zone size. (take β=1.12). **20**

Q6 Write short notes on **20**

a) J-integral

b) Ductile and brittle fracture

c) SIF

d) Damage tolerant design

Q7

a) Discuss the factors influencing environment-assisted fracture. **10**

b) Discuss modes of fracture with neat sketch **05**

c) Discuss Griffith energy criterion **05**

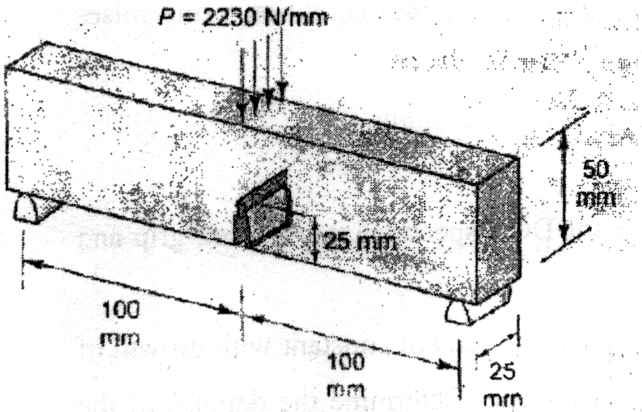
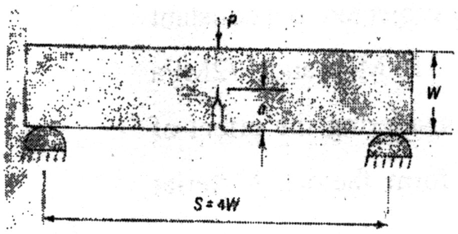


Fig: for Q.no. 5 a)

$\sigma_{ys} = \sigma_0 = 700$ MPa, $\varepsilon_0 = \sigma_0 / E$

$E = 207$ GPa, $\alpha = 8.2$, $n = 6$



$$K_I = \frac{PS}{BW^{3/2}} f(\alpha)$$

$$\alpha = \frac{a}{W}$$

B = Plate thickness

$$f(\alpha) = \frac{3\alpha^{1/2}\left[1.99 - \alpha(1-\alpha)\,(2.15 - 3.93\alpha - 2\ldots\right.}{2(1+2\alpha)\,(1-\alpha)^{3/2}}$$

$2.7\alpha^2$

M.E. mechanical with machine design - II Sem - II
Fracture mechanics 29/04/2014.

... to be same as yield stress (σ_{ys}) ... strain ($p-\varepsilon$) for some commonly encountere... given, and the geomet...

6B.1 Three-Point Bend Specimen

The specimen is loaded with force P per unit thickness, as shown in Fig. 6.12.

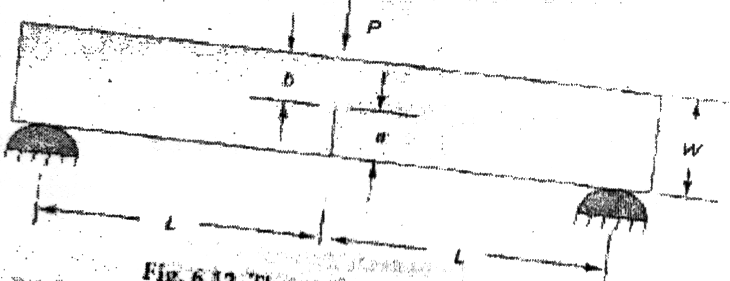


Fig. 6.12 Three-point bend specimen

$P_0 = 0.728\ \sigma_{ys}\ b^2/L$ for plane strain
$P_0 = 0.536\ \sigma_{ys}\ b^2/L$ for plane stress
$g_1 = 1$, and h_1 = listed in Table 6.1 for $L/W = 2$.

Table 6.1 h_1 for three-point bend specimen

a/W	Type	n = 1	2	3	5	7	10	13	16	20
1/8	p-ε	0.937	0.869	0.805	0.687	0.580	0.437	0.329	0.245	0.165
	p-σ	0.676	0.600	0.548	0.459	0.383	0.297	0.238	0.192	0.148
1/4	p-ε	1.20	1.034	0.930	0.762	0.633	0.523	0.396	0.304	0.215
	p-σ	0.869	0.731	0.629	0.479	0.370	0.246	0.174	0.117	0.0593
3/8	p-ε	1.33	1.15	1.02	0.846	0.695	0.556	0.442	0.360	0.265
	p-σ	0.963	0.797	0.680	0.527	0.418	0.307	0.232	0.174	0.105
1/2	p-ε	1.41	1.09	0.922	0.675	0.495	0.331	0.211	0.135	0.0741
	p-σ	1.02	0.767	0.621	0.453	0.324	0.202	0.128	0.0813	0.0298
5/8	p-ε	1.46	1.07	0.896	0.631	0.436	0.255	0.142	0.084	0.411
	p-σ	1.05	0.786	0.649	0.494	0.357	0.235	0.173	0.105	0.471
3/4	p-ε	1.48	1.15	0.974	0.693	0.500	0.348	0.223	0.140	0.0745
	p-σ	1.07	0.786	0.643	0.474	0.343	0.230	0.167	0.110	0.0442

Lib 16/6/07

Bharatiya Vidya Bhavan's

SARDAR PATEL COLLEGE OF ENGINEERING

(An Autonomous Institution Affiliated to University of Mumbai)

Re_End Examinatio -may_jun 2014

Total Marks: 100 Duration: 4 Hours

CLASS/SEM: M. E.(Mech)-m/c Deg./ **II** SUBJECT: **FRACTURE MECHANICS (ME661)**

- Attempt any **FIVE** questions out of seven questions.
- Figures to the right indicate full marks.
- Make any suitable assumption if needed with proper reasoning.
- Answer to the sub questions should be grouped together.

MASTER

M.E(M) with M/c Design Sem II

Q1		What are the different methods available for determination of SIF? Derive step-by step expression for mode-I crack tip stresses using Westergaard stress function approach.	20
Q2		Derive the expression for crack tip plastic zone size in terms of principal stresses using Tresca and Mises criterion. Also show that for metals plane stress plastic zone size is much larger than plane strain case.	20
Q3	a)	Derive the expression of energy release rate for DCB specimen using fixed grip and constant load and show that it is same.	12
	b)	Determine the shape of the DCB specimen if G_I is to remain constant with growth of crack. The specimen is loaded in constant load mode. Determine the depth *h* of the specimen beyond the crack tip if thickness of the specimen remains constant (B=30mm). The initial crack length is 40mm, modulus 207 GPa and depth of each cantilever 12mm up to initial crack length. (Calculate for crack up to 80mm.)	08
Q4	a)	An edge crack of 3.1mm is detected on a plate of 100mm wide, subjected to a constant amplitude cyclic load having maximum and minimum stress of 310 MPa and 172MPa respectively. Determine total propagation life up to failure, considering the effect of form factor (take the crack step of 10mm for the effect of form factor). Material properties are: K_{IC} = 165 MPa $m^{0.5}$, C= 6.8 x 10^{-12}, m= 3.	12
	b)	Discuss the phenomenon of crack closure.	08
Q5	a)	Consider a three point bend specimen with a center load as shown figure below. Determine: i) K_I, ii) G_I based on LEFM, iii) J_P using engineering approach, iv) Plastic zone size. (take β=1.12).	20
		Page (1)	

2ib
16/6/07

Bharatiya Vidya Bhavan's

SARDAR PATEL COLLEGE OF ENGINEERING

(An Autonomous Institution Affiliated to University of Mumbai)

Re_End Examinatio -may_jun 2014

Total Marks: 100 Duration: 4 Hours

CLASS/SEM: M. E.(Mech)-m/c Deg./ **II** SUBJECT: **FRACTURE MECHANICS (ME661)**

- Attempt any **FIVE** questions out of seven questions.
- Figures to the right indicate full marks.
- Make any suitable assumption if needed with proper reasoning.
- Answer to the sub questions should be grouped together.

MASTER

M.E(M) with m/c Design Sem II

Q1		What are the different methods available for determination of SIF? Derive step-by step expression for mode-I crack tip stresses using Westergaard stress function approach.	**20**
Q2		Derive the expression for crack tip plastic zone size in terms of principal stresses using Tresca and Mises criterion. Also show that for metals plane stress plastic zone size is much larger than plane strain case.	**20**
Q3	a)	Derive the expression of energy release rate for DCB specimen using fixed grip and constant load and show that it is same.	**12**
	b)	Determine the shape of the DCB specimen if G_I is to remain constant with growth of crack. The specimen is loaded in constant load mode. Determine the depth *h* of the specimen beyond the crack tip if thickness of the specimen remains constant (B=30mm). The initial crack length is 40mm, modulus 207 GPa and depth of each cantilever 12mm up to initial crack length. (Calculate for crack up to 80mm.)	**08**
Q4	a)	An edge crack of 3.1mm is detected on a plate of 100mm wide, subjected to a constant amplitude cyclic load having maximum and minimum stress of 310 MPa and 172MPa respectively. Determine total propagation life up to failure, considering the effect of form factor (take the crack step of 10mm for the effect of form factor). Material properties are: K_{IC} = 165 MPa $m^{0.5}$, C= 6.8 x 10^{-12}, m= 3.	**12**
	b)	Discuss the phenomenon of crack closure.	**08**
Q5	a)	Consider a three point bend specimen with a center load as shown figure below. Determine: i) K_I, ii) G_I based on LEFM, iii) J_P using engineering approach, iv) Plastic zone size. (take β=1.12).	**20**

Q6		Write short notes on	
	a)	J-integral	
	b)	Ductile and brittle fracture	
	c)	SIF	
	d)	Damage tolerant design	
Q7	a)	Discuss the factors influencing environment-assisted fracture.	10
	b)	Discuss modes of fracture with neat sketch	05
	c)	Discuss Griffith energy criterion	05

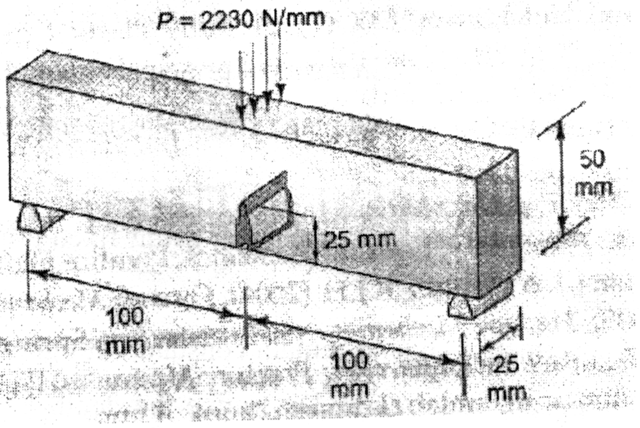
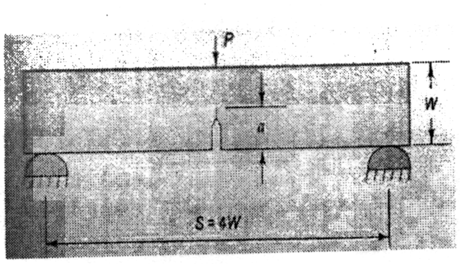


Fig: for Q.no. 5 a)

$\sigma_{ys} = \sigma_0 = 700$ MPa, $\varepsilon_0 = \sigma_0/E$
$E = 207$ GPa, $\alpha = 8.2$, $n = 6$



$$K_I = \frac{PS}{BW^{3/2}} f(\alpha)$$

$$\alpha = \frac{a}{W}$$

B = Plate thickness

$$f(\alpha) = \frac{3\alpha^{1/2}\left[1.99 - \alpha(1-\alpha)\left(2.15 - 3.93\alpha + 2.7\alpha^2\right)\right]}{2(1+2\alpha)(1-\alpha)^{3/2}}$$

$2.7\alpha^2$

M.E.(M) ... Design Sem II 16/6/14.

...strain ($p - \varepsilon$) for some commonly encountere...
...to be same as yield stress (σ_{ys}).

Fracture Mechanics.

6B.1 THREE-POINT BEND SPECIMEN

The specimen is loaded with force P per unit thickness, as shown in Fig. 6.12.

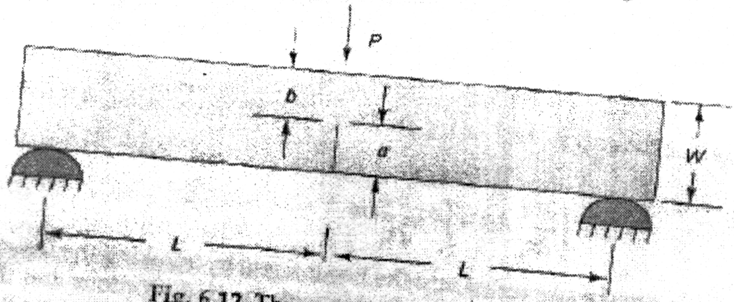


Fig. 6.12 Three-point bend specimen

$P_0 = 0.728\ \sigma_{ys}\ b^2/L$ for plane strain

$P_0 = 0.536\ \sigma_{ys}\ b^2/L$ for plane stress

$g_1 = 1$, and h_1 = listed in Table 6.1 for $L/W = 2$.

TABLE 6.1 h_1 for three-point bend specimen

a/W	Type	n = 1	2	3	5	7	10	13	16	20
1/8	$p-\varepsilon$	0.937	0.869	0.805	0.687	0.580	0.437	0.329	0.245	0.165
	$p-\sigma$	0.676	0.600	0.548	0.459	0.383	0.297	0.238	0.192	0.148
1/4	$p-\varepsilon$	1.20	1.034	0.930	0.762	0.633	0.523	0.396	0.304	0.215
	$p-\sigma$	0.869	0.731	0.629	0.479	0.370	0.246	0.174	0.117	0.0593
3/8	$p-\varepsilon$	1.33	1.15	1.02	0.846	0.695	0.556	0.442	0.360	0.265
	$p-\sigma$	0.963	0.797	0.680	0.527	0.418	0.307	0.232	0.174	0.105
1/2	$p-\varepsilon$	1.41	1.09	0.922	0.675	0.495	0.331	0.211	0.135	0.0741
	$p-\sigma$	1.02	0.767	0.621	0.453	0.324	0.202	0.128	0.0813	0.0298
5/8	$p-\varepsilon$	1.46	1.07	0.896	0.631	0.436	0.255	0.142	0.084	0.411
	$p-\sigma$	1.05	0.786	0.649	0.494	0.357	0.235	0.173	0.105	0.471
3/4	$p-\varepsilon$	1.48	1.15	0.974	0.693	0.500	0.348	0.223	0.140	0.0745
	$p-\sigma$	1.07	0.786	0.643	0.474	0.343	0.230	0.167	0.110	0.0442

Page 8

4b
5/5/14

BHARATIYA VIDYA BHAVAN'S

SARDAR PATEL COLLEGE OF ENGINEERING

(An Autonomous Institution Affiliated to University of Mumbai)
MUNSHI NAGAR, ANDHERI (WEST), MUMBAI- 400 058

M.E.(Mechanical) Machine Design Sem-II

MASTER

END-SEMESTER

CLASS/SEM: **M.E.(Machine Design) Sem II** — Total Marks: **100**

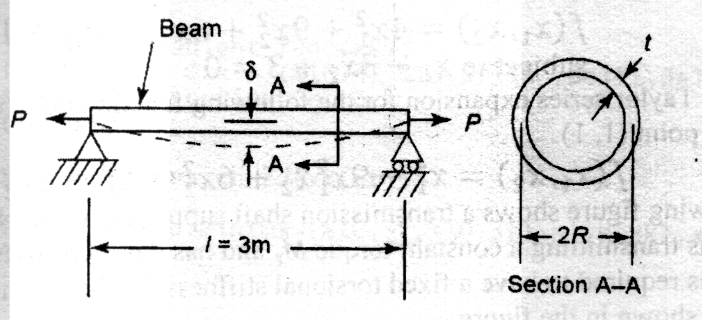
SUBJECT: **Optimization Methods** — Duration: **4 Hours**

Date: **May 2014**

- Attempt any FIVE out of seven questions.
- Answers to all sub questions should be grouped together.
- Figures to the right indicate full marks.
- Assume suitable data if necessary.

1. a) Classify optimization problems encountered in engineering. Give suitable examples. **(5)**
   b) Three characteristics common to optimization studies of machine elements are: functional requirements, undesirable effects and completeness of material/geometry specification. Describe these characteristics. **(5)**
   c) Explain the significance of primary, subsidiary and limit equations employed in optimization of machine elements. Illustrate with suitable example. **(5)**
   d) Explain the role of computer software such as MATLAB or OCTAVE in solving engineering optimization problems. Highlight software features which are useful in optimization studies. **(5)**

2. a) Optimize a hollow circular beam shown in the figure for minimum weight using graphical method. It is required that when P = 50 kN, the axial stress σ should be less than σ_a and when P = 0, deflection δ due to self-weight should satisfy $\delta \leq 0.001l$. The limits for dimensions are t = 1 to 10 mm, R = 20 to 200 mm, and $R/t \geq 20$. Write the optimization problem in standard form. Use following data: $\delta = 5wl^4/384EI$; w = self-weight in force/length; σ_a = 250 MPa; modulus of elasticity, E = 210 GPa; mass density, ρ = 7800 kg/m^3; $\sigma = P/A$; gravitational constant, g = 9.81 m/s^2; moment of inertia, $I = \pi R^3 t$. **(12)**



m. E. (Mechanical) machine Design Sem-II optimization methods 05/05/2014

b) Use Fibonacci search method to maximize the function (8)

$$f(x) = 10 + x^3 - 2x - 5e^x$$

in the interval (-5, 5). Use four function evaluations (n=4).

3. a) Write short note on Box's evolutionary optimization method. (8)

b) A company produces three types of bearings, B1, B2 and B3, on two machines A1 and A2. The processing times of the bearings on the two machines are indicated in the following table. (12)

	Processing time (minutes) for bearing:		
Machine	B1	B2	B3
A1	10	6	12
A2	8	4	4

The times available on machines A1 and A2 per day are 1200 and 1000 minutes, respectively. The profits per unit of B1, B2, B3 are Rs.4, Rs.2 and Rs.3, respectively. The maximum numbers of units the company can sell per day are 500, 400 and 600 for B1, B2 and B3, respectively. Formulate and solve the problem for maximizing the profit using Simplex method.

4. a) Find points satisfying KKT necessary conditions for following problem. (12)

$$\text{Minimize } f(x_1, x_2) = 4x_1^2 + 3x_2^2 - 5x_1x_2 - 8$$
$$\text{subject to } x_1 + x_2 \leq 4$$

Check if the points are optimum points using graphical method.

b) Write a short note on Genetic Algorithm (GA) technique for optimization. (8)

5. a) Minimize following function within range of (-5, 0). (14)

$$f(x) = -e^{0.2x} + (x+3)^2 + 0.01x^4$$

Use exhaustive search method to initially bracket the minima; choose suitable number of intermediate points. Thereafter, use two iterations of Bisection method to locate minima.

b) As per Johnson's optimum design method for mechanical elements for a problem with *normal specifications*, it will be possible to develop the primary design equation to the point where the effects of all subsidiary design equations are included and the optimum design can be directly extracted. Illustrate the case of optimization with *normal specification* using an example of design of a simple tensile bar. (6)

6. a) State Lagrange multiplier theorem. Use the theorem to minimize following function. (7)

$$f(x_1, x_2) = 4x_1^2 + 9x_2^2 + 6x_2 - 4x_1 + 13$$
$$\text{subject to } x_1 - 3x_2 + 3 = 0$$

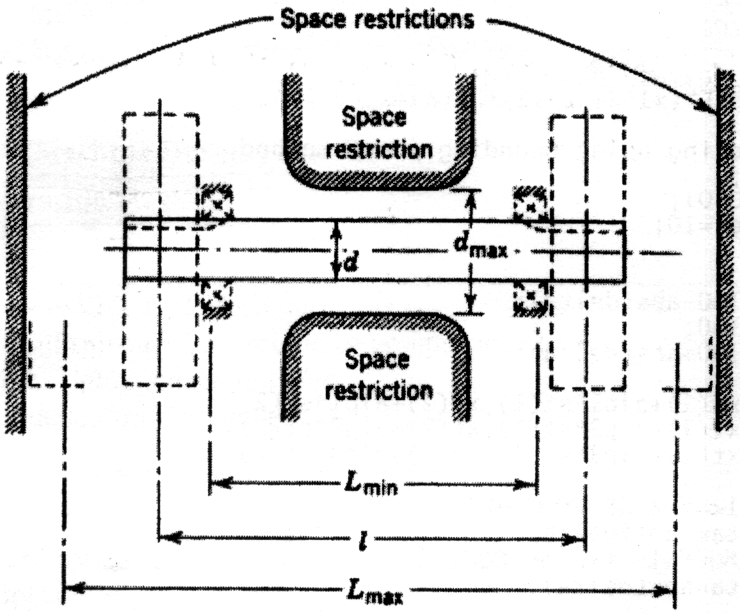
b) Write Taylor series expansion for the following function up to quadratic terms at the point (1, 1). (6)

$$f(x_1, x_2) = x_1^4 - 9x_1^2x_2 + 6x_2^2 + x_1^2 - 8x_2 + 9$$

c) Following figure shows a transmission shaft supported on two bearings. The shaft is transmitting a constant torque M_t and has keyways at its either end. The shaft is required to have a fixed torsional stiffness k. The geometric constraints are as shown in the figure. (7)

M.E. (Mechanical) Machine Design Sem-II Optimization Methods
05/05/2014

Describe how Johnson's optimum design method can be applied to design the shaft for minimum weight. Ignore bending moment due to self-weight.



7. a) Determine the nature of following quadratic form. (5)

$$f(\bar{X}) = x_1^2 + 2x_1x_3 - 2x_2^2 + 4x_3^2 - 2x_2x_3$$

b) Manufacturing errors, such as, error in measurement of curvature or presence of surface flaws can significantly make performance of a product sub-optimal. Explain the importance of including study of manufacturing errors in design optimization with examples taken from machine elements designed for contact stresses, fatigue life, dynamic forces, etc. (4)

c) Describe random search algorithm employed for solving constrained multivariable optimization problems. (4)

d) A part of MATLAB / OCTAVE code to estimate minima of multivariable function $f(x_1, x_2) = (x_1^2 + x_2 - 11)^2 + (x_1 + x_2^2 - 7)^2$ using Cauchy's steepest descent method is given below. Complete the code by filling in missing parts of the code at locations tagged as CODE-1, CODE-2, etc. (7)

```
function cauchy_steepest_descent (x0,e1,e2,m)
  % x0=initial point, e1,e2= error tolerances, m=max.iterations
  f=inline("(x1^2+x2-11)^2+(x1+x2^2-7)^2");
  xk=x0;
  k=0;
  while k<m
    [delf1 delf2]=gradient_func(xk);
    printf('Gradient @xk = (%10.3f,%10.3f)\n',delf1,delf2);
    %st is search direction vector
    st=[CODE-1];

    [xk1 xk2] = unisearch_2d(xk,st);

    printf(Itr no.%3d:minima=(%10.3f,%10.3f)\n',k,xk1,xk2);
    xk=[CODE-2];
    k=k+1;
  endwhile
endfunction
```

M. E. (Mechanical) Machine Design Sem-II Optimization Methods

```
function [y1, y2] = gradient_func (yk)
  f=inline("(x1^2+x2-11)^2+(x1+x2^2-7)^2");
  dy=0.001;
  y1=CODE-3;
  y2=(f(yk(1),yk(2)+dy)-f(yk(1),yk(2)-dy))/(2*dy);
endfunction

function [u1,u2] = unisearch_2d (xt,st)
  f=inline("(x1^2+x2-11)^2+(x1+x2^2-7)^2");

  %Bracketing using Bounding phase method
  alp0=0;
  delta=0.01;
  max_iter=10;
  k=0;

  alp1=alp0-abs(delta);
  alp2=alp0;
  alp3=alp0+abs(delta);

  fx1=f(xt(1)+alp1*st(1),xt(2)+alp1*st(2))
  fx2=f(xt(1)+alp2*st(1),xt(2)+alp2*st(2))
  fx3=f(xt(1)+alp3*st(1),xt(2)+alp3*st(2))

  if (fx1<=fx2 && CODE-4)
     delta=-abs(delta);
   elseif (fx1>=fx2 && CODE-5)
     delta=abs(delta);
   else
     display('Enter new values of x0 and delta.')
     return
   endif

   alp(1)=alp0;
   fx(1)=f(xt(1)+alp(1)*st(1),CODE-6);

  printf('%s\n','Bracketing by Bounding Phase Method');
  printf('%s\n',repmat('_',1,70));
  printf('%15s%15s%15s\n','k','alpha(K+1)','f(alpha(k+1))');
  printf('%s\n',repmat('_',1,70));
  printf('%15d%15.3f%15.3f\n',k,alp(1),fx(1));
   while k<max_iter
     alp(2)=alp(1)+CODE-7*delta;
     fx(2)=f(xt(1)+alp(2)*st(1),xt(2)+alp(2)*st(2));
     printf('%15d%15.3f%15.3f\n',k+1,alp(2),fx(2));
     if (fx(2)<fx(1))
       k=k+1;
       alp(1)=alp(2);
       fx(1)=fx(2);

     else
     endif
     if (fx(2)>fx(1))
       break;
     endif
   endwhile

   %Find minima by Fibonacci method
   %  ------- code truncated ------------

endfunction
```

---------- oXo ----------

lib
9/5/14

MASTER

BHARATIYA VIDYA BHAVAN'S

SARDAR PATEL COLLEGE OF ENGINEERING

(An Autonomous Institution Affiliated to University of Mumbai)
MUNSHI NAGAR, ANDHERI (WEST), MUMBAI- 400 058

M. E. (Mechanical) with Machine Design Sem -II

END-SEMESTER

CLASS/SEM: **M.E.(Machine Design) Sem II** Total Marks: **100**

SUBJECT: **Process Equipment Design** Duration: **4 Hours**

Date: **May 2014**

- Attempt any FIVE out of seven questions.
- Answers to all sub questions should be grouped together.
- Figures to the right indicate full marks.
- Refer Annexure 1 for additional data. Assume suitable data if necessary.

1. a) Classify process equipment based on function, geometry, construction and service. Explain with sketches where appropriate. (5)
   b) Describe properties of ferrous and non-ferrous materials employed in design of process equipment. (5)
   c) Explain with sketches design of cylindrical storage tanks. Describe construction of bottom closure, cylindrical shell, wind girders and roofs. (5)
   d) Write a short note on design of saddle supports for horizontal vessels. (5)

2. a) Explain different criteria used in the design of process equipment. Provide list of various loadings considered in their design. (5)
   b) A carbon steel pressure vessel has shell of 2000 mm inside diameter, 14 mm thickness and 5200 mm straight unsupported length. The shell is subjected to external pressure of 0.15 MPa at 260° C due to fluid in its external jacket. Check whether the provided thickness of the shell is sufficient. It is required to maintain the thickness of shell to 10 mm by providing stiffeners at estimated spacing of 2600 mm. Assess suitability of stiffener spacing. Modify the spacing if required and calculate size of the stiffeners. Corrosion allowance is zero. (15)

3. a) A vertical chemical reactor of welded construction has following design specification. (10)

Inside diameter = 1800 mm	Material = Carbon steel
Straight length of shell = 10,000 mm	Liquid level = 7,000 mm from bottom straight line
Type of heads = 2:1 ellipsoid	Liquid specific gravity = 1.20
Design internal pressure = 5.5 MPa	Allowable stress = 125 MPa
Design temperature = 150° C	Corrosion allowance = 3 mm
Joint efficiency = 0.85	Hydrotest pressure = nil

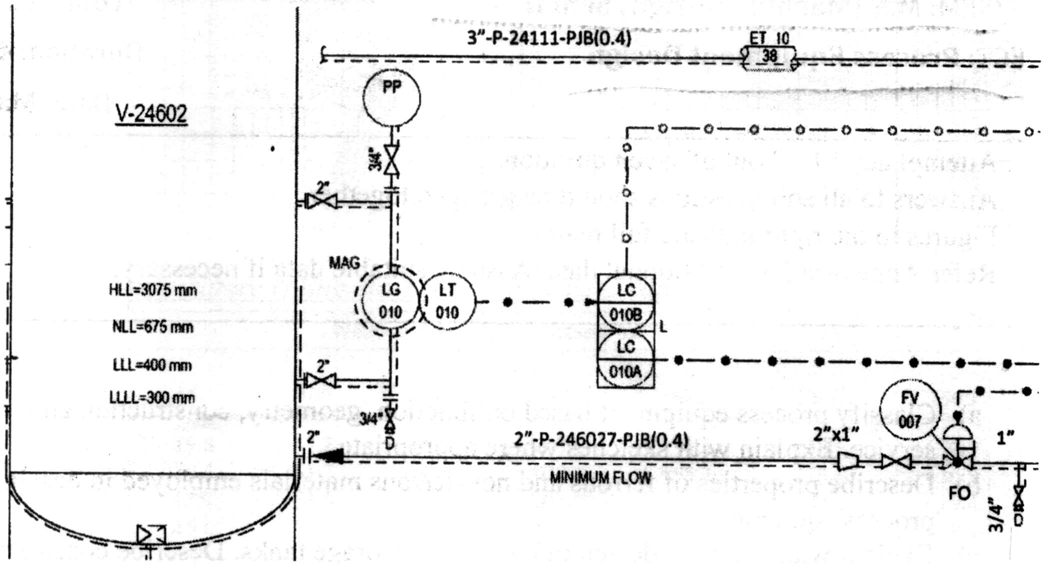
Calculate: (i) Thickness of shell and top/bottom heads, (ii) Pressure-

M.E. (Mechanical) with Machine Design Sem-II
Process Equipment Design 29/05/2014.

temperature rating class of flanges fitted on the vessel and (iii) suitable schedule for 600 mm nominal diameter nozzle pipe for the vessel.

b) List different types of end closures (heads) used in process equipment. Explain with sketches, design formulae used to determine thickness against internal pressure for any three types of heads. **(4)**

c) Following figure shows part of P&ID for a process plant. Sketch the diagram and describe function/type of instrument/valve symbols, nature of connection lines, interpretation of pipeline tag and any other information. **(6)**



4. a) List different types of jacketed vessels. Explain with a sketch, design of half-coil jacket including applicable design formulae. **(6)**

b) A single pass fixed-tubesheet heat exchanger has following specification. **(14)**

Number of tubes = 150	Design temperature of tube = 370° C
Outside dia. of tubes = 25 mm	Joint efficiency = 1.0
Pitch = triangular	Baffle spacing = 1000 mm
Tube side design pressure = 0.5 MPa	Corrosion allowance = nil
Shell side design pressure = 0.7 MPa	Tubesheet design factor, F = 1.0
Allowable stress (shell/tube)= 80 MPa	

Determine thickness of tubesheet and tube. Comment on baffle arrangement.

5. a) A cylindrical vessel of 1500 mm ID is subjected to an internal pressure of 1.0 MPa. Design the reinforcing pad for a nozzle opening with following data. **(8)**

Internal dia. Of nozzle = 250 mm	Height of nozzle above vessel wall = 200 mm
Thickness of vessel = 8 mm	Permissible stress for shell and nozzle = 125 MPa
Thickness of nozzle wall = 4 mm	Corrosion allowance = 1 mm

b) Design skirt support for a vertical vessel with the data given below. **(12)**

Vessel ID/thickness = 3100 / 12 mm Skirt ID = 3100 mm	Permissible stress, skirt = 135 MPa (tension), 35 MPa (compression)
Total height of vessel = 50 m	Permissible bending stress, base plate = 155 MPa

M. E. (Mechanical) with machine Design Sem-II
Process Equipment Design 09/05/2014.

Operating weight of vessel = 2700 kN	Permissible stress, bolts = 100 MPa
Empty weight of vessel = 2000 kN	Permissible compressive stress, foundation = 20 MPa
Wind pressure, H>20m = 1500 N/m^2 Wind pressure, H<20m = 1000 N/m^2	Seismic factor, C = 0.08

Determine thickness of skirt and base plate and number/size of anchor bolts.

6. a) Describe various types of nozzles and show typical nozzle attachment details. (4)
   b) Write short note on different types of gaskets used in flanged joints. (4)
   c) Design flange with flat face as per following data. (12)

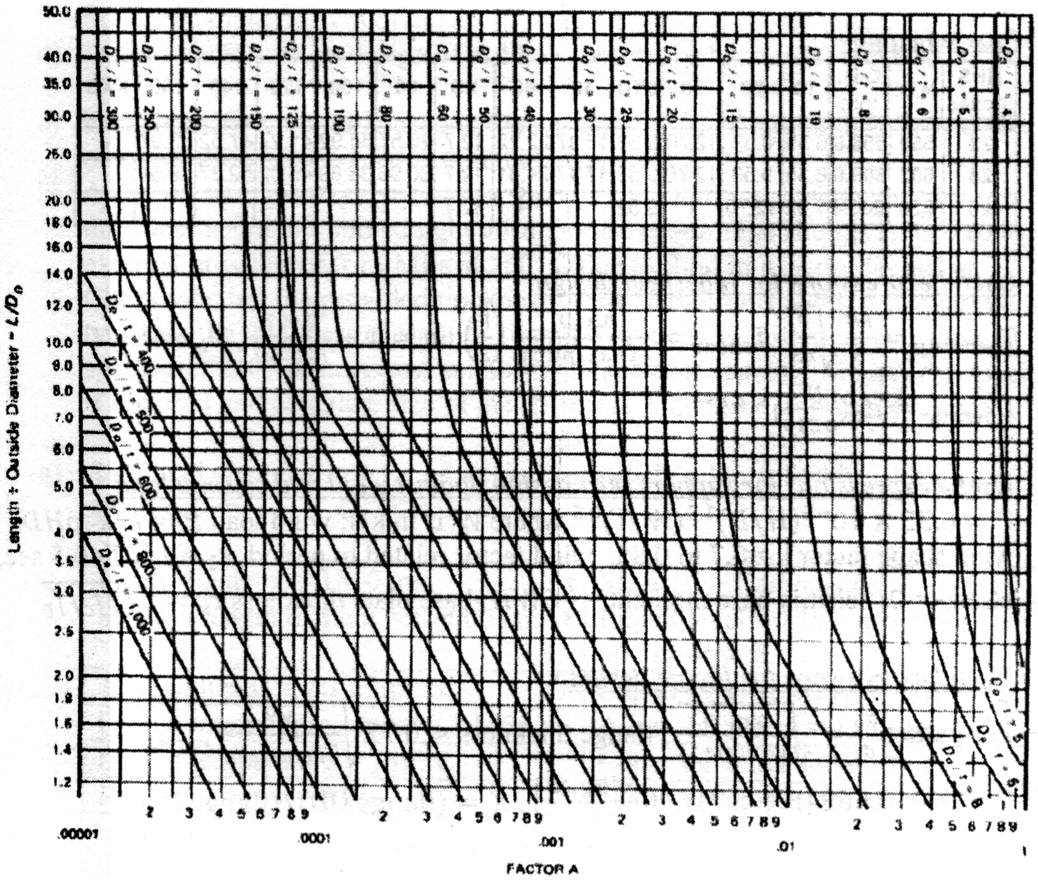
Design pressure = 2.25 MPa	Flange inside diameter= 775 mm
Allowable flange stress = 90 MPa	Gasket = PTFE (m=2.75, y=25.5 MPa)
Allowable bolt stress (operating and gasket seating condition) = 145 MPa	

7. a) Write short notes on following.
   (i) Part and construction details of heat exchanger. (5)
   (ii) Various types of flanges employed in process equipment. (5)
   (iii) Causes of loss of volatile fluids from storage tanks. (5)
   (iv) Design pressure, hydrotest pressure and MAWP of process vessel. (5)

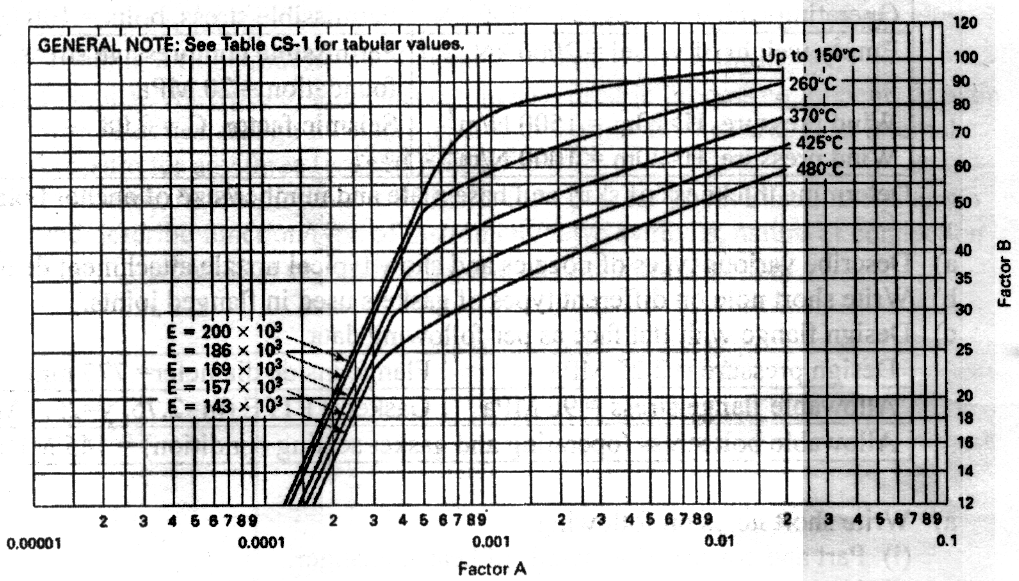
Annexure 1

Useful expressions for external pressure design and data for carbon steel

$$B = \frac{PD_o}{\left(t+\frac{A_y}{\ell}\right)}; \; I_{stiffener} = \frac{D_o^2 \ell}{14}\left(t + \frac{A_y}{\ell}\right) \varepsilon$$



M. E. (Mechanical) with Machine design Sem-II
Process Equipment design 03/05/2014.



Pressure-temperature rating class for carbon steel flanges

Class / Temp., °C	Working Pressure by Classes, bar						
	150	300	400	600	900	1500	2500
-29 to 38	19.8	51.7	68.9	103.4	155.1	258.6	430.9
50	19.5	51.7	68.9	103.4	155.1	258.6	430.9
100	17.7	51.5	68.7	103.0	154.6	257.6	429.4
150	15.8	50.2	66.8	100.3	150.5	250.8	418.1

Pipe schedule

NPS inches	N.D.	O.D. mm	10	20	30	STD	40	60	XS	80	100	120	140	160	XXS
22	550	558.8	6.35	9.53	12.70	9.52	15.87	22.22	12.7	28.57	34.92	41.27	47.62	53.97	-
24	600	609.6	6.35	9.53	12.70	9.52	17.47	24.61	12.7	30.96	38.89	46.02	52.37	59.54	-
26	650	660.4	7.92	12.70	-	9.52	-	-	12.7	-	-	-	-	-	-

Useful expressions for tubesheet design

$$T_{bending} = \frac{FG}{3}\sqrt{\frac{P}{\eta S}}, \; T_{shear} = \frac{0.31 D_L}{(1-d_o/pitch)}\left(\frac{P}{S}\right); \; \eta = 1 - \frac{0.907}{(\frac{pitch}{d_o})^2}, \; D_L = 4A/C,$$

$$D_{bundle} \approx d_o\left(\frac{N_t}{0.319}\right)^{1/2.142}$$

Useful expressions for support skirt design against wind and seismic load

$T = 6.35 \times 10^{-5}(H/D)^{1.5}(W/t)^{0.5}$ where W is in kN; wind load $P = k_1 k_2 p H D_0$, wind shape factor k_1=0.7 to 0.85, wind factor related to period, $k_2 = 1$ if T<0.5 sec, else $k_2 = 2$; seismic base moment $= \frac{2}{3} CWH$; base plate thickness $t_b = l\sqrt{3f_c/f_b}$

Useful expressions for flange design

For gasket $\frac{d_o}{d_i} = \sqrt{\frac{y-pm}{y-p(m+1)}}$, flange thickness $\approx 0.72\sqrt{\frac{MY}{Bf_{allowable}}}$,

$Y = \frac{1}{K-1}\left[0.66845 + 5.71690\frac{K^2\log_{10}K}{K^2-1}\right]$, K = (flange OD)/(flange ID)

---------- oXo ----------