' MEC mech / Mach. Desi, sem - II
' Fracture mechanics

lib 27/04/15

Bharatiya Vidya Bhavan's

SARDAR PATEL COLLEGE OF ENGINEERING

(An Autonomous Institution Affiliated to University of Mumbai)

End sem-examination Apr-may 2015

Total Marks: 100 Duration:4 Hours

CLASS: M.E. (Machine Design)/ SEM-II SUB: FRACTURE MECHANICS (ME661)

- Question no. **one** is compulsory.
- Attempt any **Four** questions out of remaining **six** questions.
- Figures to the right indicate full marks.
- Answers to all sub questions should be grouped together
- Make any suitable assumption if needed with proper reasoning.

Master

Q.1 Answer any four from the following.

a) What do you mean by SIF? State the importance of the SIF concept. 5

b) Discuss the scope and limitation of Griffith theory. 5

c) What do you mean by stable crack growth (SCG), explain with load displacement diagram? Do ductile materials show any evidence of SCG, why? 5

d) Discuss the characteristics of brittle and ductile fracture. Explain the mechanism of ductile fracture. 5

e) What is crack closure? Why does it happen? How life is calculated w.r.t. stress ratio? 5

Q.2 a) What do you understand by soft loading and hard loading? Derive the expression for energy release rate in case of soft loading. (compliance approach) 8

b) With the advancing crack in a component, What are things that happens with the component? 4

c) Derive the expression for energy release rate G of a DCB specimen having depth h, thickness B, crack length a; discuss the effect of these parameters on G. 8

Q.3 a) Show that, $\Phi = \mathrm{Re}\,\bar{\bar{Z}}_1 + x_2\,\mathrm{Im}\,\bar{Z}_I$ 4+4+6

Chosen for mode-I crack problem satisfies the bi-harmonic equation. Determine the stress and displacement component in terms of Z_I.

b) Load on 30mm thick plate with an edge crack of 50mm length was increased very slowly and the displacement of the load point was monitored. It was observed that at the load of 2100 N and displacement u = 4.1mm, the crack started growing. The rate of crack growth was much faster than the rate of load increase and therefore the crack essentially was grown at the load of 2100 N. Through a rapid camera recording it was found that the crack grown up to 65mm length with the rapid increase in displacement to u – 7.5mm. Determine the critical energy release rate. 6

ME (Mechanical / Mach. Desi). Sem - II. Fracture mechanics., 27/4/15

Q.4 a) Derive the expression for plastic zone shape in plane stress condition using Mises and Tresca criterion. Draw suitable sketches of plastic zone shapes. 5+5

b) Derive the relation between K_I and G_I. 5

c) What is effective crack length? Show that plastic zone size in plane stress situation is nine times greater than plane strain. 2+3

Q.5 a) What is *J* integral? As a fracture parameter state is advantages. 2+3

b) For LEFM *J* integral is same as *G* (Griffith energy parameter), derive and prove with suitable example. 10

c) Determine the J-integral for a component loaded in mode-I, with a far field stress of 210 MPa and an edge crack of 30 mm length. The geometrical factors are, $\beta = 1.0583$, H=7; the material follows Ramberg-Osgood relation with material constants- E=207GPa, n=6.8 and F= $1*10^{18}$ $(MPa)^{6.8}$. 5

Q.6 a) State and explain two application of each constant and variable amplitude fatigue load. 4

b) How does the fatigue crack get initiated on smooth surface? Explain with suitable sketch. 4

c) An edge crack detected on a large plate is of length 40mm, under the fatigue load of 140 MPa to 0.0 MPa. Plate is made of HY-130 steel with K_{IC} = 150 MPa $m^{0.5}$. use Paris law with C = $7.2*10^{-12}$ MPa^{-3} $m^{-0.5}$ and *m*=3. Determine i) propagation life up to failure ii) propagation life if crack is not allowed to exceed 60% of the critical length. 6+6

Q.7 Answer the following:

a) Environment assisted fracture and factors influencing it. 5

b) Damage tolerant design. 5

c) Modes of fracture failure with practical examples. 5

d) Experimental determination of critical stress intensity factor. 5

ME (Mech / Mach. Desi); Sem-II
Advanced Finite Element Method.

BHARATIYA VIDYA BHAVAN'S

SARDAR PATEL COLLEGE OF ENGINEERING

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

End-Sem

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

SUBJECT: **Advanced Finite Element Method** | Duration: **4 Hour**

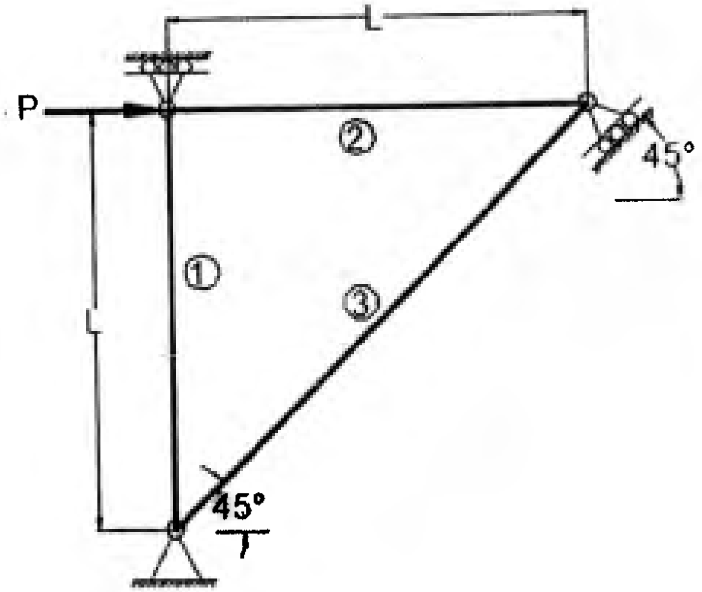
Date: **29th April 2015**

- Question **1** is compulsory
- Solve any **4** from Q. **2** to Q. **7**
- Assume suitable data if necessary.

Master

Q	Description	Split	Total
1.	a. Derive expressions for the shape functions of 2D three noded linear triangular element and write down displacement matrix for triangular element as multiplication of shape function matrix and nodal displacements.	(8)	(20)
	• Assume approximate functions for displacements	(2)	
	• Derive expression writing down individual element of shape function	(4)	
	• Write down displacement matrix for triangular element	(2)	
	b.	(7)	
	i. Write down relationship between elemental displacement and nodal displacements arranged in the form of matrices for an three noded 2D triangular element (Do not derive expression for shape functions Directly use the expressions).	(2)	
	ii. Derive relation between strain vector and displacement vector for the same element	(5)	
	c. Determine relation between stress and strain vectors for 2D plain strain condition	(5)	
2.	Consider truss shown below determine unknown displacements and reactions. For all the members of the truss $A = 6 \times 10^{-4}$ m^2, E = 210 GPa, P = 10^3 kN, L = 1m.	(20)	(20)
	i. Determine elemental stiffness matrix, force and displacement vectors for all three elements	(9)	
	ii. Determine global stiffness matrix, force and displacement vectors	(2)	
	iii. Estimate unknown displacements and forces	(6)	
	iv. Determine axial stress in individual member	(3)	

ME (Mech/Mech. Desi), sem-II, 29/4/15
Advanced finite Element method.



3. (a) Consider a thin annular circular plate with inner radius R1 and outer radius R2 and insulated top and bottom surfaces. The axisymmetric temperature distribution, T(r) in such a plate is given as **(15)** **(20)**

$\frac{d}{dr}\left(kr\frac{dT}{dr}\right)+rg=0$, R1 < r <R2, with boundary conditions (1) $\frac{dT}{dr}=0$ at r = R1, (2) T = T1 at r = R2 where, g is the constant heat source term, K is constant thermal conductivity and T1 is a constant.

i. Develop corresponding weak form of given governing equation (6)
ii. Identify the essential and natural boundary conditions (3)
iii. Solve the weak form approximately i.e. find T(r) as follows (6)
Assume $T(r)=\phi_0+b\phi_1(r)$, where is linear function of r and satisfies the essential boundary conditions. Find ϕ_0 such that T(r) satisfy the essential boundary conditions. Here b is unknown constant. Assume appropriate weight function, w(r) based on the expression of T(r). Substitute T(r) and w(r) in the weak form and solve for the unknown constants

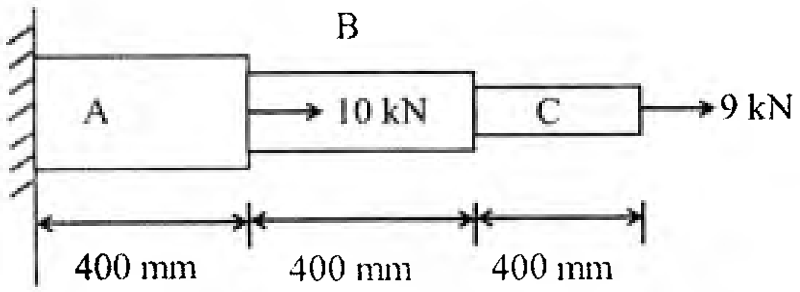
(b) Derive weak form for following **(5)**

$$\frac{d^2u}{dx^2}+\frac{du}{dx}-x=0;\quad 0\le x\le 1,\ u(0)=u(1)=0$$

4. (a) Solve to calculate nodal displacements and forces for each section of the following composite member using minimum number of elements. **(7)** **(20)**

(Continued on next page)

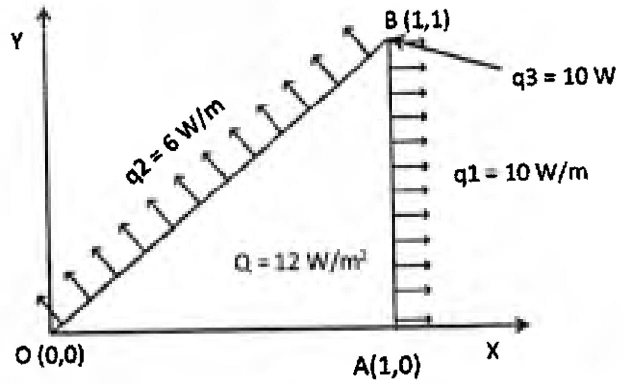
ME (Mech (Mach.-Desi), Sem-II, 29/4/15
Advanced Finite Element Method



Sections	E (GPa)	Area (mm^2)
A	210	5161
B	70	3870
C	100	2580

i. Write Elemental stiffness matrix and displacement and force vector for each element (3)
ii. Write global stiffness matrix, displacement and force vectors with boundary conditions (2)
iii. Calculate unknown displacements and reaction (2)

(b) Consider triangular plate OAB shown in the figure below. All dimensions are in meters. The edge OA maintained at 10 °C. A heat source of intensity 12 W/m2 is uniformly distributed in the plate. A point source of 10 W is located at point B. A constant outward heat flux of 10 W/m acts along the edge AB and constant outward flux of 6 W/m acts along OB. The conductivity of plate is 1 W/m°C. The plate is modelled using a single 3 node triangular element. (13)

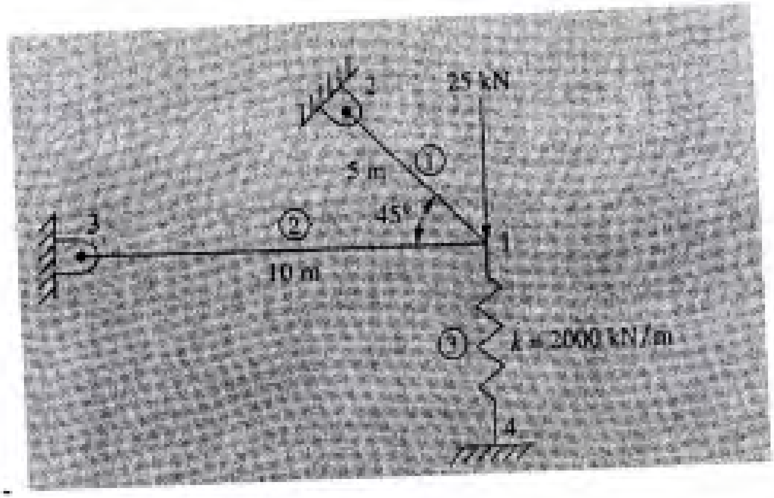


i. Calculate conductivity matrix (3)
ii. Calculate flux vectors due to individual heat sources (6)
iii. Calculate the total flux vector (2)
iv. Impose boundary condition and calculate temperature at point B (2)

ME (Mech/Mach. Des.), Sem-II, 29/4/15

Advanced Finite Element Method.

5. Solve the two-bar truss supported by a spring shown below. Both bars have E =210 GPa and A = 5.0 × 10^{-4} m^2. Bar one has a length of 5 m and bar two a length of 10 m. The spring stiffness is K = 2000 kN/m. **(20)** **(20)**



i. Calculate elemental stiffness matrix, displacement and force vectors for each element (9)

ii. Write global stiffness matrix, displacement and force vectors with boundary conditions (3)

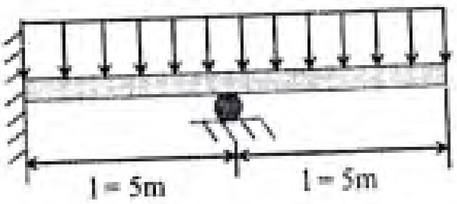
iii. Calculate displacements and force components (4)

iv. Calculate axial force in each element (4)

6. (a) Sketch variation of shape functions for 2 dimensional 4 noded bilinear quadrilateral element. **(4)** **(20)**

(b) Use minimum number of beam finite elements to analyse the beam configuration given below. **(16)**

q_0 = 400 N/m



EI = 4 x 10^6 N-m^2

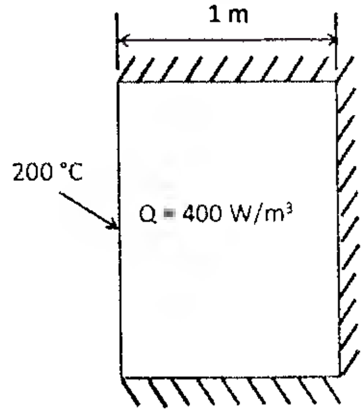
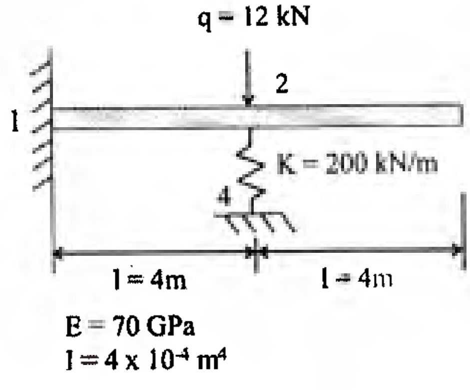
Give

i. Individual elemental stiffness matrix, displacement and force vectors (6)

ii. Assembled stiffness matrix, displacement and force vectors (4)

iii. The specified global displacements and forces and the equilibrium conditions (1.5)

iv. Compute unknown displacements, rotations, shear forces and momentums. (3+ 1.5)

	The stiffness matrix for the beam element is given as $$K=\frac{EI}{\ell^3}\begin{bmatrix}12 & 6\ell & -12 & 6\ell\\ 6\ell & 4\ell^2 & -6\ell & 2\ell^2\\ -12 & -6\ell & 12 & -6\ell\\ 6\ell & 2\ell^2 & -6\ell & 4\ell^2\end{bmatrix}$$		
7	(a) For the plane wall shown below determine the temperature distribution through the wall thickness. Analyse the wall using two equally spaced elements. Thermal conductivity of wall, K = 25 W/m °C. There is a uniform generation of heat inside the wall of Q = 400 W/m^3.	(8)	(20)
			
	i. Determine elemental stiffness matrix, temperature and heat flux vectors for each element	(4)	
	ii. Formulate global stiffness matrix, temperature vector and heat flux vector	(2)	
	iii. Determine temperatures and heat flow at each node	(2)	
	(b) For the beam shown below write	(12)	
			
	i. Stiffness matrix, displacement vector and force vector for individual element	(8)	
	ii. Global stiffness matrix, displacement and force vectors with boundary conditions.	(4)	

ME(Mech/Mach. Desi), Sem-II, Lib 02-05-15.

Bhartiya Vidya Bhavan's

SARDAR PATEL COLLEGE OF ENGINEERING

(An Autonomous Institution Affiliated to university of Mumbai)

Class/Sem : ME M/C Design / II

End Semester (May 2015)

Subject: Optimization Methods

Optimization Methods

Duration: 4Hours

Subject Code: ME 663

Master

- Question Number **ONE** is compulsory
- Attempt any **FOUR** questions out of remaining Six questions
- Assume suitable data, if necessary.
- Figure to the right indicate full marks

Q1) a) Explain the need of optimization in industry and organization with example. **05**

b) Determine nature quadratic equation $f(X) = 2X_1^2 + X_1X_2 + 2X_2^2 - 2X_1X_3 + 3X_3^2$ **05**

c) Use three iterations of the exhaustive search method in order to minimize the function in the interval (-3, 3). $F(X) = (X^2 - 1)^3 - (2X - 5)^4$ **05**

d) What are the effects of manufacturing error on optimum design? **05**

e) Maximize $f = 2x_1 + 6x_2$, Subject to $-x_1 + 2x_2 \le 1,\ 2x_1 + x_2 \le 2, x_1, x_2 \ge 0$, Solve Graphically **05**

Q2) a) A two-bar truss is to be designed to carry a load of 2 *W* as shown in Figure 1 Both bars have a tubular section with mean diameter *d* and wall thickness *t*. The material of the bars has Young's modulus *E* and yield stress σ_y. The design problem involves the determination of the values of *d* and *t* so that the weight of the truss is a minimum and neither yielding nor buckling occurs in any of the bars. Select suitable material then estimate optimum values of d and t **10**

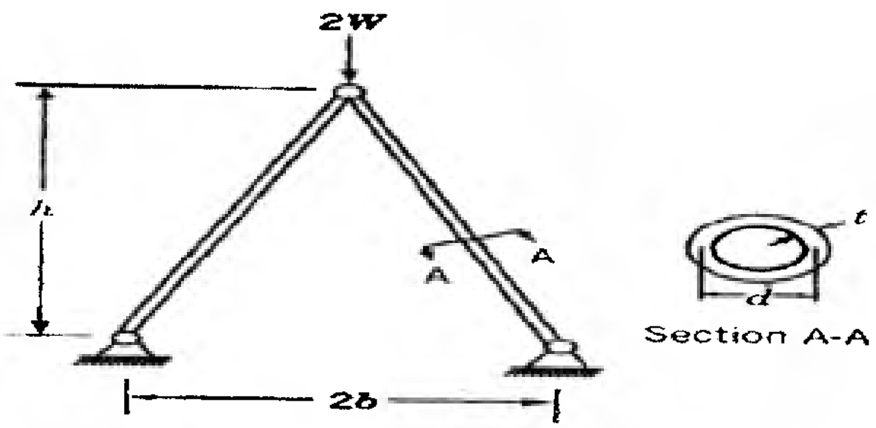


Figure 1

b) Calculate gradient vector, hessian matrix for the function and Taylor Series at point (1, 0,-2) and compare with exact. $F(X) = X_2^2X_3 + X_1e^{X_3}$ **10**

Q3) a) Use Simplex Method: Maximize $F(X) = X_1 + 2X_2 + X_3;\ Subject\ to,\ 2X_1 + X_2 - X_3 < 2,$ **10**

$-2X_1 + X_2 - 5X_3 > -6,\ 4X_1 + X_2 + X_3 < 6\ and\ X_1, X_2, X_3 > 0$

b) Find stationary point also find stationary point for minimum value of function by exact method. **10**

$$f(X) = X_1^2 + 4X_1X_2 + 2X_1X_3 - 7X_2^2 - 6X_2X_3 + 5X_3^2$$

Q4) The torque transmitted *(T)* by a cone clutch, shown in Figure 2, under uniform pressure condition is given by **20**

$$T = \frac{2\pi fp}{3\sin\alpha}(R_1^3 - R_2^3)$$

Page (1)

ME (mech / mech. Desi), Sem-II, 2/5/15
Optimization methods

where p is the pressure between the cone and the cup, f the coefficient of friction, a the cone angle, $R1$ the outer radius, and $R2$ the inner radius.

a) Find $R1$ and $R2$ that minimize the volume of the cone clutch with $\alpha = 30°$, F = 30 N, and f= 0.5 under the constraints: $T > 100$ Nm., $R1 > 2R2$, $0 < R1 < 18$cm., and $0 < R2 < 12$cm.

b) What is the solution if the constraint $R1 > 2R2$ is changed to $R1 < 2R2$?

c) Find the solution of the problem stated in part (a) by assuming a uniform wear condition between the cup and the cone. The torque transmitted (T) under uniform wear condition is given by

$$T = \frac{TfpR_2}{sin \propto}(R_1^2 - R_2^2)$$

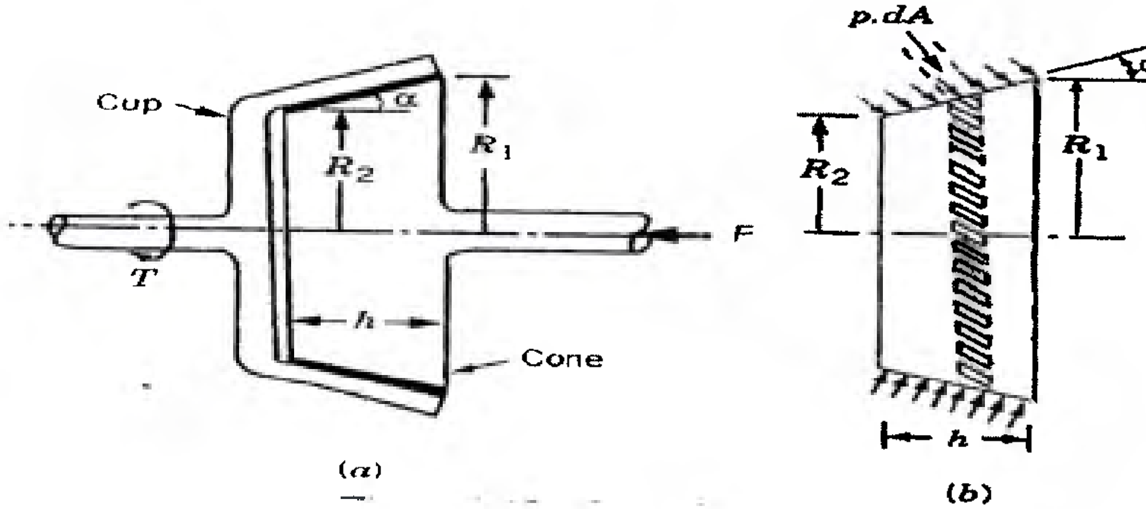


Figure 2

Q5) a) Find all the basic solutions corresponding to the system of equation using pivotal reduction method $2X_1 + 3X_2 - 2X_3 - 7X_4 = 1$, $X_1 + X_2 + X_3 + 3X_4 = 6$, $X_1 - X_2 + X_3 + 5X_4 = 4$ **10**

b) Explain the purpose of optimum design, What is LPP? What are the advantages of simplex method? **10**

Q6) Use Golden Search, Fibonacci Search and Bisection method for following equation and Compare with Box evolutionary optimization method to minimize the above functions. Assume $x_0 = x$. **20**

$$f(x_1, x_2) = 2x_1^2 + x_2^2 - 2x_1x_2 + 4 \ with \ S = (1,1)^T, x = (2,3)^T$$

Q7) a) Solve following optimization problems with equality constraint. Identify points satisfying Lagrange multiplier theorem. Check if they are optimum using graphical method. **05**

$$Mimimize \ f(X_1, X_2) = 4X_1^2 + 3X_2^2 - 5X_1X_2 - 8X_1, subject \ to \ X_1 + X_2 = 4$$

b) State Selection criteria for optimum configuration and explain with suitable example **07**

c) Use three iterations of the Newton Raphson and bounding Phase search method in order to maximize the function in the interval (-3, 3). $F(X) = X^3 - 10X - 2X^2 + 10$ **08**

-----*All The Best*-----

ME (mech/mech. Design), Sem-II, 5/5/15
Design of power Transmission Systems.

Lib
05/05/15

Bhartiya Vidya Bhavan's
Sardar Patel College of Engineering
(An Autonomous Institution affiliated to University of Mumbai)

End Sem. Exam. **Second Half 2014-15**
Class/Sem.: **M.E. (Machine Design)/II** (mech) 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. Following data relates to the hoisting mechanism of an EOT crane:

Load lifting capacity	80 kN
Lifting speed	5.8 m/min
Rope drum diameter	320 mm
Duty	Class II
Number of rope falls	4

(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 last stage of gearing of the of the power transmission system suggested in part (a) and draw dimensional sketches. **10**

2.(a) Select the size and number of V-belts to transmit power from a 5.5 kW, 730 rpm motor to a multi-cylinder reciprocating air compressor shaft operating at 200 rpm. Design also the driven pulley and sketch the same with dimensions. **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, back pressure valve, indicating their function.

3. Design a worm and worm gear unit to transmit power from an electric motor 6 pole,11kW with a speed reduction ratio 40 approximately. The load is with mild shock, duty 16 hr/day. Draw dimensional sketches of assembly, including housing, worm, worm gear, bearings etc. **20**

4.(a)Design a suitable brake for an EOT crane hoisting mechanism to be fitted on motor shaft. The motor is rated at 11 kW at 960 rpm. Draw neat sketches with leading dimensions. **10**

(b) The last stage of a belt conveyor drive is chain drive with a speed reduction ratio of 3.6, conveyor shaft speed of 80 rpm and motor power of 5.5 kW. Design and sketch the drive. **10**

[TURN OVER

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 at 200 bar for15 sec.
(d) retract 150 mm at 30 bar in 4 sec.
(e) remain retracted at zero 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 pump and an 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) Discuss the scope of using hydraulic power transmission for different operations of tractor. **05**
(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. **15**
The details of the tractor and the design requirements are as follows:
The weight of the fully loaded vehicle is 2200 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 drive engine 2000 rpm, maximum design speed 18kmph on level ground and a speed of 9 kmph is acceptable when vehicle is ascending maximum gradient of 1 in 4. Assume volumetric efficiency 0.98 and overall efficiency 0.9 for hydraulic pumps and motors. Draw hydraulic circuit diagram and explain the working.

Lib
08/05/15

M.E. (Machine Design) sem II

Process Equipment Design

BHARATIYA VIDYA BHAVAN'S

SARDAR PATEL COLLEGE OF ENGINEERING

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MUNSHI NAGAR, ANDHERI (WEST), MUMBAI- 400 058

END-SEMESTER

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

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

Date: **May 2015**

- Question no. 1 is **compulsory**. Attempt any **four** out of remaining six questions.
- Answers to all sub questions should be grouped together.
- Figures to the right indicate full marks.
- Refer Annexure 1 for additional design data. Assume suitable data if necessary.

MASTER FILE

1. a) Draw an illustrative sketch of typical vertical process equipment. Tag at least 8 different types of pressure- or non-pressure components in the sketch. **(4)**
   b) Describe different types of bolted flanges employed in process equipment with neat sketches. What type of considerations you would recommend in design of high pressure bolted flange joints? **(4)**
   c) Explain important phases during execution of a typical project for a process plant in an EPC organization. Describe nature of interactions of process equipment design department with other departments. **(4)**
   d) Describe different causes of loss of volatile fluid from a storage vessel. **(4)**
   e) Write short note on arrangement of baffles in heat exchanger design. Mention about function of baffles, types of baffles, baffle hole size, thickness of baffles and tie rod design. **(4)**

2. a) A vertical process column of welded construction has following design specification. **(15)**

Inside diameter = 2100 mm	Material = Carbon steel
Straight length of shell = 22,000 mm	Liquid level = 10,000 mm from bottom straight line
Type of heads = 2:1 ellipsoidal at top and hemispherical at bottom end	Liquid specific gravity = 1.10
Design internal pressure = 1.3 MPa	Allowable stress = 115 MPa
Design temperature = 250° C	Corrosion allowance = 3 mm
Joint efficiency = 0.90	Hydrotest pressure = nil

   Calculate: (i) Thickness of shell and top/bottom heads, (ii) Pressure-temperature rating class of flanges fitted on the vessel and (iii) suitable schedule for 550 mm nominal diameter nozzle pipe for the vessel.

   b) Write a short note on various parts of heat exchanger. Illustrate with a neat sketch. **(5)**

M.E. (Machine Design) sem II

Process Equipment Design

pt 08/5/15

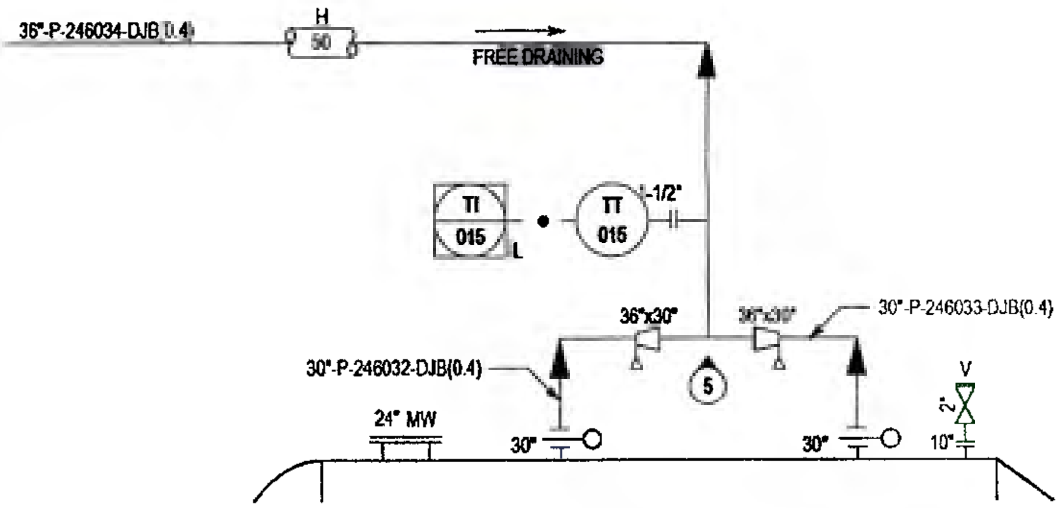
3. a) A carbon steel pressure vessel has shell of 1900 mm inside diameter, 12 mm thickness and 3800 mm straight unsupported length. The shell is subjected to external pressure of 0.17 MPa at 370° C due to fluid in its external jacket. Check whether the provided thickness of the shell is sufficient. **(15)**
If it is required to maintain the thickness of shell to 8 mm by providing stiffeners at estimated spacing of 2700 mm. Assess suitability of stiffener spacing. Modify the spacing if required and calculate size of the stiffeners. Corrosion allowance is zero.

b) Explain in detail the design of saddle supports for horizontal vessels. **(5)**

4 a) A cylindrical vessel of 2300 mm ID is subjected to an internal pressure of 1.8 MPa. Design the reinforcing pad for a nozzle opening with following data. The nozzle axis makes an angle of 80° with the axis of shell. **(15)**

Internal dia. Of nozzle = 400 mm	Noz. height above vessel = 250 mm
Thickness of vessel = calculate and round to the nearest even integer value	Permissible stress for shell and nozzle = 135 MPa
Thk. of nozzle wall = calculate and round to the nearest even integer value	Corrosion allowance = 1 mm

b) Following figure shows part of P&ID for a process plant. Reproduce the diagram and describe function/type of instrument/valve/fitting symbols, nature of connection lines, interpretation of pipeline tag and other information. **(5)**



5. a) Explain physical meaning of factor A, factor B in the design of cylindrical shells subjected to external pressure. How these factors are related to vessel geometry and material property? **(5)**

b) Explain design of half-coil jacketed vessel with neat sketch and relevant design equations. **(7)**

c) Describe and compare construction of different types of roofs used in variable volume storage tanks. Draw neat sketches to illustrate the construction. **(8)**

6. a) Design flange with flat face as per following data. **(10)**

Design pressure = 3.4 MPa	Flange inside diameter= 650 mm
Allowable flange stress = 110 MPa	Gasket = PTFE (m=2.75, y=25.5 MPa)
Allowable bolt stress (operating and gasket seating condition) = 175 MPa	

page no. 2

M.E. (Machine Design) Sem II

Process Equipment Design

Dt. 08/5/15

b) Design skirt support for a vertical vessel with the data given below. **(10)**

Vessel ID/thickness = 2800 / 10 mm Skirt ID = 2800 mm	Permissible stress, skirt = 125 MPa (tension), 30 MPa (compression)
Total height of vessel = 75 m	Permissible bending stress, base plate = 150 MPa
Operating weight of vessel = 4500 kN	Permissible stress, bolts = 140 MPa
Empty weight of vessel = 3000 kN	Permissible compressive stress, foundation = 20 MPa
Wind pressure, H>20m = 1600 N/m^2 Wind pressure, H<20m = 800 N/m^2	Seismic factor, C = 0.10

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

7. a) A single pass fixed-tubesheet heat exchanger has following specification. **(10)**

Number of tubes = 250	Outside dia. of tubes = 32 mm
Tube side design pressure = 0.9 MPa	Shell side design pressure = 0.4 MPa
Pitch = triangular	Corrosion allowance = nil
Allowable stress (shell/tube)= 95 MPa	Tubesheet design factor, F = 1.0

Determine thickness of tubesheet.

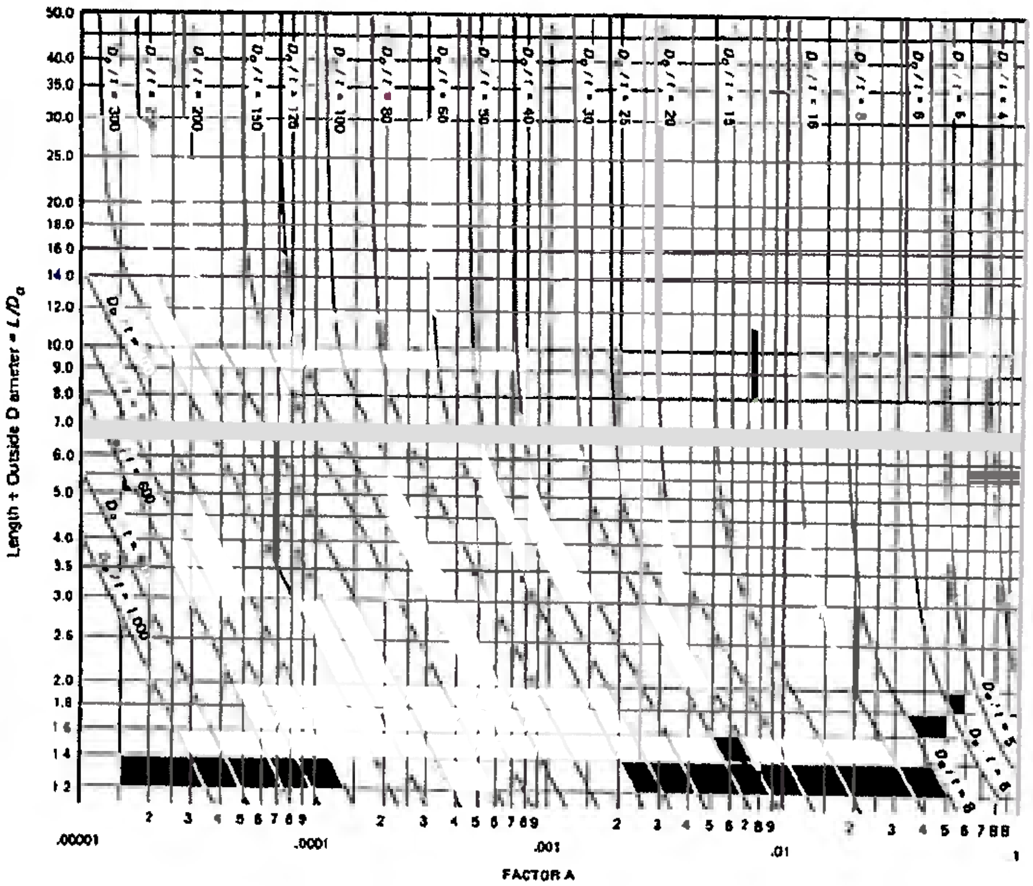
b) Write short notes on followings.

(i) Operating, design, hydrotest pressure and MAWP. **(5)**

(ii) Material types and their selection for process equipment. **(5)**

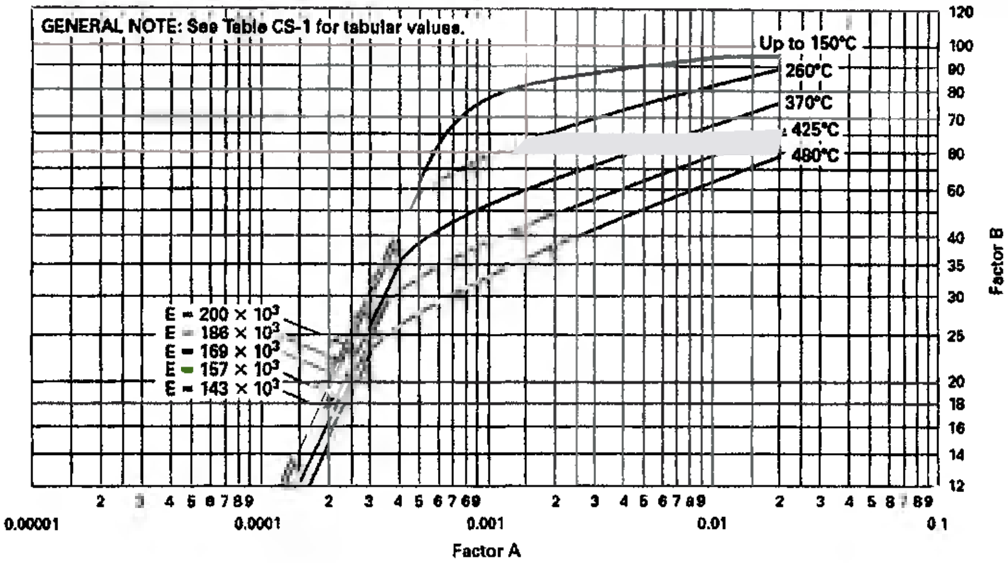
Annexure 1

External pressure design charts for carbon steel



M.E (Machine Design) sem II
process Equipment Design.

Dt. 08/5/15



Pressure-temperature rating class for carbon steel flanges

Class / Temp., °C	150	300	400	600	900	1500	2500
	Working Pressure by Classes, bar						
-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
200	13.8	48.6	64.8	97.2	145.8	243.2	405.4
250	12.1	46.3	61.7	92.7	139.0	231.8	386.2
300	10.2	42.9	57.0	85.7	128.6	214.4	357.1
325	9.3	41.4	55.0	82.6	124.0	206.6	344.3

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	36.69	46.02	52.37	59.54	-
26	650	660.4	7.92	12.70	-	9.52	-	-	12.7	-	-	-	-	-	-

Useful expressions for tubesheet design

$$D_{bundle} \approx d_0\left(\frac{N_t}{0.319}\right)^{1/2.142}$$

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

Useful expressions for flange design

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

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