BACHELOR OF CHEMICAL ENGINEERING EXAMINATION, 2017

(2^{nd} Year, 1^{st} Semester)

MACHINE DESIGN

Time: **Three hours** Full Marks: **100**

Missing data, if any, are to be reasonably chosen.
Different parts of a question must be answered together.
Give sketches wherever applicable.
Answer any **Four (4)** questions

1. a) Design a knuckle joint to connect two mild steel (45C8) rods under a tensile load of 20 kN. The yield strength of the material is 380 N/mm^2. Factor of safety for fork and eye is 2.5, whereas factor of safety for knuckle pin is 2.0. Also draw a neat sketch of the joint. All the evaluated dimensions should be presented together in a tabular form at the end of the problem. [20]

   b) In the above problem, justify the use of lower factor of safety for knuckle pin. [02]

   c) Draw a schematic representation of the stress-strain curve as obtained from standard tensile test for ductile material and show the important points on it. [03]

2. a) A bracket is bolted to a column by 6 bolts of equal size as shown in Figure Q2a. It carries a load of 60 kN at a distance of 200 mm from the center of the column. Allowable shear stress in the bolts is to be limited to 150 N/mm^2. Select appropriate standard bolt size from the given table. [15]

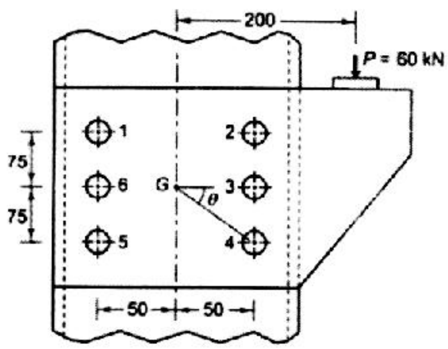

Figure Q2a

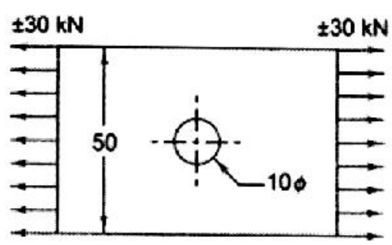

Figure Q3b

   b) Two plates of 15 mm thickness each are to be joined by means of a double riveted double strap butt joint with zigzag riveting. Determine the rivet diameter, rivet pitch, back pitch, margin and strap thickness. Also determine the strength and efficiency of the joint. Take the permissible stresses in tension, shearing and compression as 90 MPa, 65 MPa and 130 MPa respectively. [10]

3. a) A bar of steel has an ultimate tensile strength of 700 MPa and yield strength of 400 MPa. The corrected endurance limit is 220 MPa. The bar is subjected to a mean bending stress of 60 MPa and a stress amplitude of 80 MPa. Superimposed on it is a mean torsional stress and torsional stress amplitude of 70 MPa and 35 MPa respectively. Find the factor of safety following: (i). Soderberg Line (ii).Goodman Line and (iii). Gerber Line. [12]

   b) Write down the Marin's equation and name the different endurance limit modifying factors. [03]

   c) A steel plate (S_{ut} = 440 N/mm^2) in hot rolled condition is subjected to completely reversed axial load of 30 kN, as shown in Figure Q3b. The notch sensitivity factor can be taken as 0.8 and the expected reliability is 90%. Suitable load factor for axial loading is given as 0.85. The size factor is 0.85. The factor of safety is 2.0. Determine the thickness of the plate. [08]

   d) Theoretical stress concentration factor may not be required at all for design with ductile material under static loading, but it must be used for design with brittle materials subjected to static loads – Explain. [02]

[Turn over

4. a) A horizontal flat belt-pulley drive is capable of transmitting a rated power of 25 kW at 720 rpm. Consider a service factor value of 1.2 and an overload of 120%. The tensions on tight and slack sides of the belt are 5400 and 2367 N respectively. The small pulley is overhung in such a way that the pulley weight (300 N) acts at a distance of 150 mm from the support. The diameter and width of the pulley are 315 mm and 225 mm respectively. The pulley material is grey cast iron (S_{ut} = 260 N/mm^2). Shaft material is C-steel having allowable shear stress of 75 N/mm^2. Determine the following parameters considering a factor of safety of 5.0 for pulley: hub diameter, hub length, rim thickness and crowning height. The pulley has four arms of elliptical cross section, in which the major axis is twice of the minor axis. Assuming that half number of arms transmit torque at any time determine the dimensions of the cross-section of the pulley arm near the hub. [20]

b) Discuss the importance of initial tension in belt drive? Why the slack side is preferably kept on top in horizontal flat belt drives? Why is the cross-section of the pulley arms made elliptical? [01+02+02]

5. a) A bushed pin type flexible coupling is used to connect two shafts and transmit 5 kW power at 720 rpm. Shafts, keys are pins are made of C-steel ($S_{yt} = S_{yc}$ = 240 N/mm^2) and the factor of safety is 3. The flanges are made of grey cast iron (S_{ut} = 200 N/mm^2) and the factor of safety is 6. There are 4 pins and the pitch circle diameter for the pins is 4 times the shaft diameter. The permissible bearing pressure for the rubber bushes is 1 N/mm^2. Calculate the following parameters: diameter of the shaft, dimensions of the keys, diameter of the pins and outer diameter and effective length of the bushes. [15]

b) Write short notes on the following: (***any 2***) [05×2=10]

i) Caulking and Fullering

ii) Elastic creep in belt-pulley drives

iii) Uniform strength bolt

6. a) Deduce the expressions for radial, tangential and longitudinal stresses for a thick cylinder subjected to internal pressure only. Also determine the expression for cylinder wall thickness according to Lame's equation. [10+06]

b) In relation to determining the wall thickness of cylinders, state the conditions where the following equations are employed: Lame's equation, Birnie's equation and Clavarino's equation. [03]

c) Briefly state the following theories of failure: Maximum normal stress theory, Maximum shear stress theory and Distortion energy theory. [06]

Table 1: Basic dimensions for ISO Metric thread (Coarse Series)

Designation	Nominal or major dia d/D (mm)	Pitch (p) (mm)	Pitch diameter d_p / D_p (mm)	Minor diameter d_c (mm)	Minor diameter D_c (mm)	Tensile stress area (mm²)
M 4	4	0.70	3.545	3.141	3.242	8.78
M 5	5	0.80	4.480	4.019	4.134	14.20
M 6	6	1.00	5.350	4.773	4.917	20.10
M 8	8	1.25	7.188	6.466	6.647	36.60
M 10	10	1.50	9.026	8.160	8.376	58.00
M 12	12	1.75	10.863	9.853	10.106	84.30
M 16	16	2.00	14.701	13.546	13.835	157
M 20	20	2.50	18.376	16.933	17.294	245
M 24	24	3.00	22.051	20.319	20.752	353
M 30	30	3.50	27.727	25.706	26.211	561
M 36	36	4.00	33.402	31.093	31.670	817
M 42	42	4.50	39.077	36.479	37.129	1120
M 48	48	5.00	44.752	41.866	42.587	1470
M 56	56	5.50	52.428	49.252	50.046	2030
M 64	64	6.00	60.103	56.639	57.505	2680
M 72	72	6.00	68.103	64.639	65.505	3460

Table 2: Surface Finish Modification Factor ($k_a = a(S_{ut})^b$)

Surface Finish	Factor *a*	Exponent *b*
Ground	1.58	-0.085
Machined or Cold Drawn	4.51	-0.265
Hot Rolled	57.7	-0.718
Forged	272	-0.995

Table 3: Reliability Factor

Reliability (%)	Reliability Factor
50	1.000
90	0.897
95	0.868
99	0.814
99.9	0.753
99.99	0.702

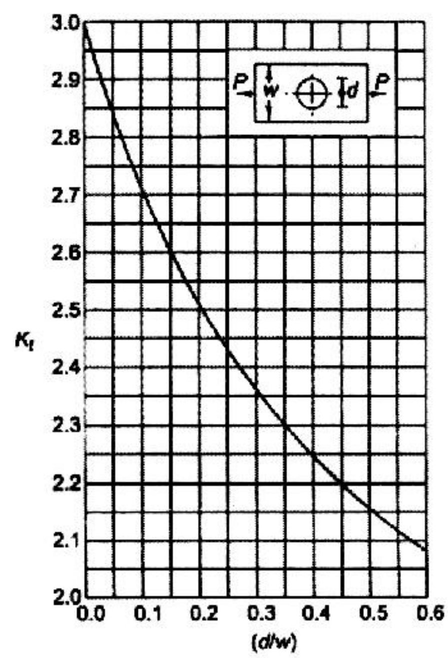

Chart: Stress Concentration Factor: Flat rectangular plate with transverse hole in simple tension or compression