Ex/ChE/MDD/ME/T/211/2019

BACHELOR OF CHEMICAL ENGINEERING EXAMINATION, 2019

(2nd Year, 1st 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 and draw a knuckle joint to connect two mild steel rods under a tensile load of 35 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. Yield strength in compression can be considered as 1.5 times the yield strength in tension. All the evaluated dimensions should be presented together in a tabular form at the end of the problem. [16+04]

(*b*). Draw a schematic diagram of a standard tensile test specimen with representative dimensions. Show the stress-strain curves for both ductile and brittle materials. Indicate the important points on these stress-strain curves. [02+02+01]

2. (*a*). A crane runway bracket is fastened to the roof truss of two identical bolts/rivets as shown in Fig. Q2(a). Determine the size of the bolts, if the permissible tensile stress is limited to 75 N/mm^2. (Use given standard table for selection of appropriate size) [10]

(*b*). A bracket is fixed to the wall by means of 6 identical rivets as shown in Fig. Q2(b). Permissible shear stress of rivet material is 150 MPa. Determine: (*i*) Which rivet is subjected to maximum shear force, (*ii*) Magnitude of the maximum shear force (*iii*) Diameter of the rivet hole and rivet from standard table. [15]

(Relevant tables are provided at the end)

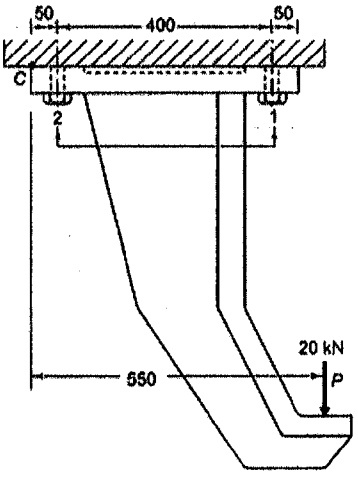


Fig. Q2(a)

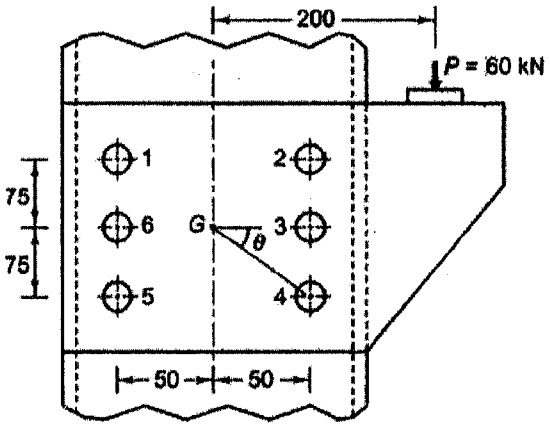


Fig. Q2(b)

3. (*a*). A bushed pin type flexible coupling is used to connect two shafts and transmit 12.5 kW power at 980 rpm. Shafts, keys and pins are made of C-steel (S_{yt} = S_{yc} = 240 N/mm^2) and the factor of safety is 2.5. The flanges are made of grey cast iron (S_{ut} = 200 N/mm^2) and the factor of safety is 5. The permissible bearing pressure for the rubber bushes is 1 N/mm^2. Design the coupling and tabulate the dimensions for shaft, flanges, keys and stepped pin. [20]

(*b*). Name a failure theory that is applicable for ductile materials. Write down its statement and draw the region of safety. [01+04]

4. (*a*). A cantilever beam made of steel (S_{ut} = 540 N/mm^2 and S_{yt} = 320 N/mm^2) is subjected to force P at its free end as shown in Fig. Q4(*a*). Magnitude of the force varies from -100 N to +200 N. The beam is machined and the reliability is 50%. The factor of safety is 2.0 and the notch sensitivity factor is 0.9. Calculate (*i*). Endurance limit at the fillet section, (*ii*). Diameter of the shaft using Soderberg, Goodman and Gerber equations. [16]

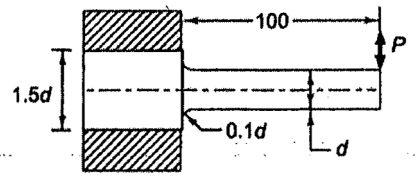


Fig. Q4(*a*)

(*b*). 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. [03]

(*c*). Write a short note on rotating beam test and determination of S-N diagram. [06]

5. (*a*). Considering the effect of centrifugal tension, show that for maximum power transmission in belt pulley drive: $v = \sqrt{\frac{T_i}{3m}}$. (The symbols in the expressions have their usual meaning) [08]

(*b*). Derive an expression for length of belt in case of an open belt drive. [05]

(*c*). Why is the cross-section of the pulley arms made elliptical? A pulley, made of grey cast iron (S_{ut} = 260 N/mm^2), has four arms of elliptical cross section, in which the major axis is twice of the minor axis. The tensions on tight and slack sides of the belt are 750 and 250 N respectively. The mean diameter of the pulley is 300 mm, while the hub diameter 60 mm. Assume that half number of arms transmit torque at any time. The factor of safety is 5. Determine the dimensions of the cross-section of the pulley arm near the hub and rim section. [02+10]

6. (*a*). The inner diameter of a thick walled cylindrical tank for liquefied gas is 250 mm. The gas pressure is limited to 20 MPa. The closed tank is made of plain carbon steel (S_{ut} = 350 N/mm^2, S_{yt} = 250 N/mm^2 and Poisson's ratio 0.3). Factor of safety can be considered as 5. Calculate the cylinder wall thickness applying the appropriate equation. Also completely derive the expression used to calculate the cylinder wall thickness. [03+12]

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

(*i*). Autofrettage

(*ii*). Caulking and Fullering

(*iii*). Thread locking mechanisms

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 (mm)*		*Tensile stress area (mm^2)*
				d_c	D_c	
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: Rivet and Rivet hole Diameter as per Indian Standard

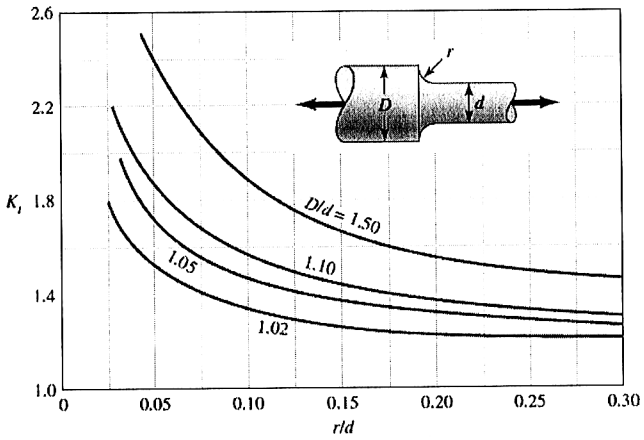
Rivet diameter (mm)	12	14	16	18	20	22	24	27	30	33	36
Rivet hole diameter (mm) **[For Boiler work]**	13	15	17	19	21	23	25	28.5	31.5	34.5	37.5
Rivet hole diameter (mm) **[For general purpose]**	13.5	15.5	17.5	19.5	21.5	23.5	25.5	29	32	35	38

Table 3: Surface Finish Modification Factor ($k_a = a(S_{ut})^b$)

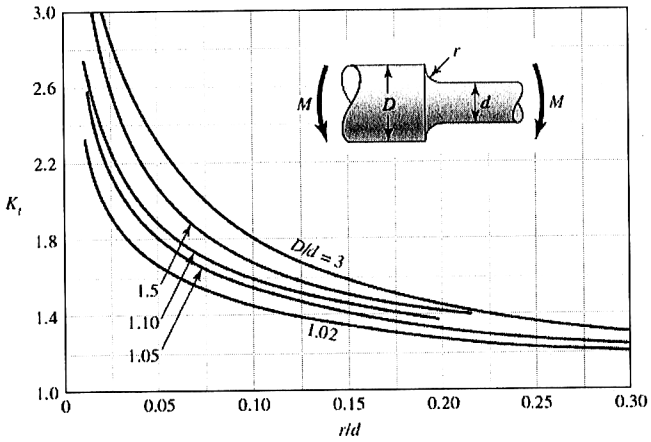
Surface Finish	Factor *a*	Exponent *b*
Ground	1.58	-0.085
Machined or Cold Drawn	4.51	-0.265
Hot Rolled	57.7	-0.718
Forged	272	-0.995

Table 4: 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



Round shaft with shoulder fillet in tension. $\sigma_0 = F/A$, where $A = \pi d^2/4$.



Round shaft with shoulder fillet in bending. $\sigma_0 = My/I$, where $y = d/2$ and $I = \pi d^4/64$.