BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: B. TECH **SEMESTER: VI**
BRANCH: PRODUCTION **SESSION: SP/2023**

SUBJECT: PE303 DESIGN OF MACHINE ELEMENTS

TIME: 3 Hours **FULL MARKS: 50**

INSTRUCTIONS:
1. The question paper contains 5 questions, each of 10 marks and a total of 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
***4*. Before attempting the question paper, be sure that you have got the correct question paper.**
5. Tables/Data handbook/Graph paper etc., to be supplied to the candidates in the examination hall.

			CO	BL
Q.1(a)	Compare a designer and an artist.	[2]	1	4
Q.1(b)	Write R 10/3 series, and R 20/3 series for numbers between 10 and 100.	[3]	1	2
Q.1(C)	A load P = 44 kN is applied to a crankshaft at a distance of 200 mm from the bearing (Fig. 1). Material for the shaft is 30C4 steel with S_{yt} = 276 MPa. Using the factor of safety of 2 and maximum shear stress theory, find the diameter of the shaft.	[5]	1	3

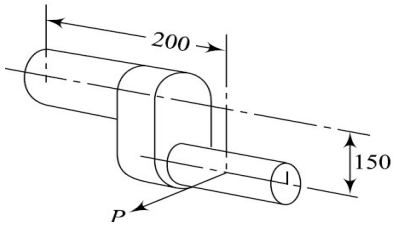

Fig. 1

Q.2(a)	(i) Cotter may not be designed for bending. Why? (ii) Explain the necessity of providing a taper on the cotter. Why the taper should not be too large or too small?	[2+3]	2	4
Q.2(b)	Find the size of the weld used for connecting the square bar of 150 mm x 150 mm size and loaded, as shown in Fig. 2. P = 25 kN, allowable shear stress = 75 MPa.	[5]	2	3

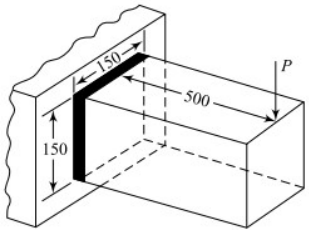

Fig. 2

Q.3(a)	A bolted assembly of two components is shown in Fig. 3. Initially, the nut is tightened by means of a spanner so as to induce a pre-load of 2.5 kN in the bolt. The external force P acting on the assembly is 5 kN. The bolt with coarse threads is made of plain carbon steel 30C8 (S_{yt} = 400 MPa), and the factor of safety is 2.5. The effective stiffness of the parts held together by the bolt is 2.5 times the stiffness of the bolt. Specify the size of the bolt.	[5]	3	3

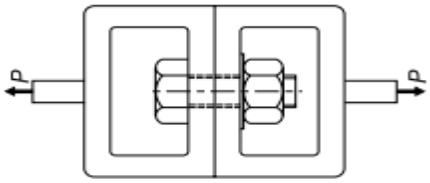

Fig. 3

Designation	*Tensile stress area (mm^2)*
M 4	8.78
M 5	14.20
M 6	20.10
M 8	36.60
M 10	58.00
M 12	84.30
M 16	157
M 20	245
M 24	353

PTO

Q.3(b) A boiler drum of an internal diameter of 1.5 m needs to be designed to sustain internal pressure of 2.0 MPa. The yield stresses for the plate and rivets in tension, shear, and compression are 420 MPa, 640 MPa, 330 MPa, respectively. Assume that rivets in double shear are 1.875 times stronger than in single shear.
(i) Taking the efficiency of the longitudinal joint as 75%, determine the thickness of the plate. Neglect the corrosion allowance in the plate.
(ii) Take the factor of safety as 5, and calculate the rivet diameter and joint efficiency for a double-strap, double-riveted butt joint along the length of the boiler drum taking the pitch length as 117 mm. [5] 3 3

Q.4(a) It is required to design a split muff coupling to transmit 50 kW power at 120 rpm. The shafts, key, and clamping bolts are made of plain carbon steel 30C8 (S_{yt} = 400 MPa). The yield strength in compression is 150% of the tensile yield strength. The factor of safety for shafts, keys, and bolts is 5. The diameter of the input and output shafts is 80 mm. The length and outer diameter of sleeve halves are 200 mm and 280 mm, respectively. The number of clamping bolts is 8. The coefficient of friction between the sleeve halves and the shaft is 0.3.
(i) Find out the diameter of clamping bolts, assuming that the power is transmitted by friction.
(ii) Specify the size of the key and check the dimensions for shear and compression criteria. [5] 4 3

Shaft diameter		*Key size*
Above	*Up to and including*	$b \times h$
6	8	2×2
8	10	3×3
10	12	4×4
12	17	5×5
17	22	6×6
22	30	8×7
30	38	10×8
38	44	12×8
44	50	14×9
50	58	16×10
58	65	18×11
65	75	20×12
75	85	22×14
85	95	25×14

Q.4(b) A compressor is to run by a motor pulley running at 1440 rpm, speed ratio is 2. Choose a flat belt open drive. The center distance between pulleys is 3 meters. Take belt speed 18 m/s (approx.). The load factor is 1.3. The arc correction factors are 1.04 for 170°, 1 for 180°, and 0.97 for 190° wrap angle. Take a 5-ply, flat Dunlop belt. The power to be transmitted is 25 kW. The high-speed load rating is 0.0118 kW/per ply/mm width at V = 5 m/s.
The preferred diameters (in mm) of cast iron and mild steel pulleys are as follows: 100, 112, 125, 140, 160, 180, 200, 224, 250, 280, 315, 355, 400, 450, 500, 560, 630, 710, 800, 900 and 1000.
Give the specifications (width and length) of the belt. [5] 4 4

Q.5 It is required to design a spur gear speed reducer for a compressor running at 250 rpm driven by a 7.5 kW, 1000 rpm electric motor. The center distance between the axes of the gear shafts should be precisely 250 mm. The starting torque of the motor can be assumed to be 150% of the rated torque. The gears are made of carbon steel 50C4 (S_{ut} = 700 MPa). The pressure angle is 20°. The factor of safety is 2 for the preliminary design based on the use of the velocity factor $C_v = 3/(3+v)$. Assume the face width is to be ten times that of the module and a Lewis form factor of 0.34.
(i) Calculate the pitch circle diameter of the pinion and gear.
(ii) Calculate the effective load for the preliminary design.
(iii) Determine beam strength, gear module, gear width, and the number of teeth in pinion and gear.
(iv) Assume that the gears are manufactured to meet the requirements of Grade 6 (e = 8.00 + 0.63ø microns) and calculate the dynamic load by using Buckingham's equation.
(v) Recalculate the effective load using Buckingham's equation and find the actual factor of safety against bending failure. [10] 5 3

Values of deformation factor: -

Materials		*14.5° full depth teeth*	*20° full depth teeth*	*20° stub teeth*
Pinion material	Gear material			
Grey CI	Grey CI	5500	5700	5900
Steel	Grey CI	7600	7900	8100
Steel	Steel	11 000	11 400	11 900