Ref. No.: Ex/ME(M2)/PC/B/T/314/2024

B.E. MECHANICAL ENGINEERING THIRD YEAR FIRST SEMESTER – 2024

DESIGN OF MACHINE ELEMENTS-II

Time: 3 hours **Full Marks: 100**

Data if missing may be assumed reasonably
The symbols used in the questions, bear their usual meaning

Answer Question 1 and any 6 from the rest

1.Choose and write the correct answer [10x1]

(i) If a bolted joint is tightend too much with a spanner, which among the following is more likely to happen:

a) The bolt may fail in tension
b) Bolt may fail in compression
c) Bolt threads may shear
d) Bolt may fail in torsion.

(ii) The types of stresses developed in the key is/are:

a) Shear stress only
b) Bearing stress only
c) Both shear and bearing stresses
d) Shearing, bending and bearing.

iii) The cone clutch is hardly used because of:

a) Small cone angle
b) Exposure to dirt and dust
c) Difficulty in disengaging
d) All of these

iv) In case of multiple disc clutch, if n_1 are the number of discs on the driving shaft and n_2 are the number of discs on the driven shaft, then the number of pars of contact surfaces will be:

a) $n_1 + n_2$
b) $n_1 + n_2 - 1$
c) $n_1 + n_2 + 1$
d) $n_1 / n_2 - 1$

v) A flexible coupling may be used for:

a) Axial misalignment
b) Angular misalignment
c) Both the above
d) Can only be used for aligned shafts.

vi) Most common cone angle of cone clutch used in design is:

a) 12.5°
b) 20.5°
c) 25.5°
d) 30.5°

vii) Select the correct answer with respect to the statements regarding the desirable properties of a good friction material for brakes:

I) It should have high coefficient of friction
II) It should have poor resilience
III) It should have low wear rate.

a) (I) and (II) are correct
b) (I) and (II) and (III) are correct
c) (II) and (III) are correct
d) (I) and (III) are correct

[Turn over

viii) Caulking helps in the improvement of:
a) Shearing strength
b) Tearing strength
c) Crushing strength
d) Pressure tightness

ix) A screw is said to be self-locking if:
a) A positive torque is obtained
b) Its efficiency is less than 50%
c) The coefficient of friction is equal to or greater than the tangent of the thread lead angle.
d) All of the above

x) The relative motion between the belt and the pulley surfaces developed because of the difference in tension on the tight side and the slack side is known as:
a) Creep
b) Slip
c) Steadiness
d) Slackness

2. (a) What is longitudinal joint and what is its purpose in the construction of boiler shell? Why the longitudinal joint is preferably made of butt rivet joint? [2+3]

(b)A double riveted lap joint with zig-zag riveting is to be designed for 18 mm thick plates. Assume σ_t = 85 MPa; τ = 65 MPa; and σ_c = 120 MPa. State the modes of failure of the joint and find its efficiency. [5]

(c) A circular shaft, 50 mm in diameter, is welded to the support by means of circumferential fillet weld as shown in Fig. Q2c. It is subjected to torsional moment of 2500 N-m. Determine the size of the weld, if the permissible shear stress in the weld is limited to 140 N/mm^2. [5]

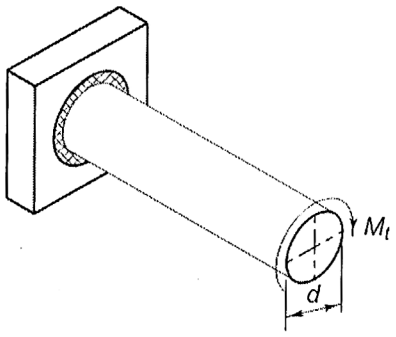

Fig. Q2c

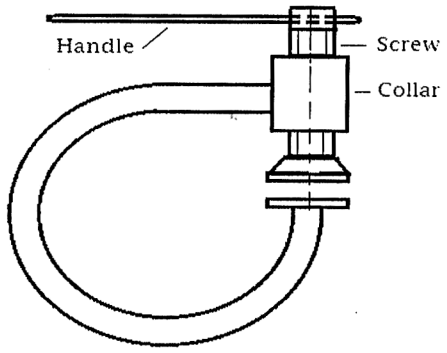

Fig. Q3a

3. (a) The Fig. Q3a shows a workshop-based C-clamp with single start thread of the specification Sq 22 x 5. The following details are known: (i) μ at thread & collar = 0.15, (ii) mean radius of friction collar = 15 mm, (v) capacity of the clamp = 750 N, (vi) for material of handle S_{yt} = 400 N/mm^2. If the operator's capacity is to exert a force of 20 N on the handle, determine:

(i) the torque is required to tighten the clamp to full capacity, and
(ii) the length and the diameter of the handle such that it will bend with a permanent set when the rated capacity of the clamp is exceeded. [10]

(b) What is overall efficiency in screw jack? Derive the expression for the same assuming suitable notations. [5]

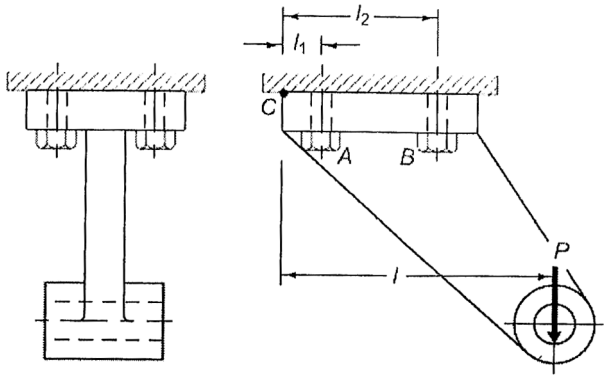

Fig. Q4a

4. (a) A cast iron bracket is fixed to the steel structure is shown in Fig. Q4a. It is supposed to support a maximum load (P) of 25 kN. There are two bolts (M36 x 2) each at A and at B and the same are made of plain carbon steel (30C8). The distances are as follows, l_1 = 50 mm, l_2 = 200 mm, l = 400 mm. Determine the factor of safety (FOS) of the system considering the failure of the bolts. What is the % gain in FOS if the bolt material is changed to 55C8 ? [10]

(b) Discuss couple of locking methodologies followed against loosening of bolted joints. Use rough sketches if required. [5]

5. Power of 15kW is to be transmitted between two parallel shafts separated by a distance of approximately 1.60m. A leather flat belt of width 125mm and length 5.0m is available for use. The motor shaft is rotating at 1440 rpm while the rotation of the driven shaft is to be limited within 500 rpm. Assuming suitable materials, design the pulley (including the arm dimensions) to be installed on the driven shaft. Also determine the diameter of the driven shaft taking the pulley weight as 100 N for 100 mm pulley diameter and the distance of the pulley (mounted at the end of shaft) from the nearest bearing to be 125 mm. (Necessary Tables are provided at the end). [15]

6. (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 bear their usual meaning) [8]

(b) What is the importance of initial tension in belt drives? [2]

(c) Write a short note on caulking and fullering. [5]

7. Design and draw a pin type flexible coupling to connect two shafts to transmit power of 22 kW at 1000 rpm. Select suitable materials for the pin, key, flange and the shaft as well as suitable factor of safety. The crushing strength may be taken as 1.3 times the allowable strength, while the shear strength as 0.55 times (tabulate the dimensions at the end.) [15]

8. a) Using uniform pressure theory, derive the following equation for a friction disc of a single plate clutch. All the notations have usual meaning.

$$M_t = (\mu P/3)\ \{(D^3-d^3)/\ (D^2-d^2)\}$$ [7]

b) A multi disc clutch consists of five steel plates and four bronze plates. The inner and outer diameters of the friction disc are 75 and 150 mm respectively. The coefficient friction is 0.15 and the force required to engage the clutch is 2.7 kN. Calculate: i) the intensity of pressure on friction lining; and ii) the pressure transmitting capacity at 750 rpm. [8]

9. a) An automobile car of four wheel of total mass of 1200 kg travelling at speed of 90 km/h on a plane road. The car decelerates at 5 m/sec^2, when all the four brakes on the four wheels are applied. Consider the following:

- The moment of inertia of each wheel about a transverse axis through its centre of gravity =0.5 kg-m^2.
- The rolling radius of the wheel = 350 mm.
- The equivalent moment of inertia of the rotating and reciprocating parts (which rotates at five times the road wheel speed) of the engine and the transmission system = 2.5 kg-m^2.

Calculate the energy absorbed by each brake and the torque capacity of each brake. [11]

b) Write the properties of the friction materials used for brakes and clutches. Give example of a couple of friction materials. [4]

Data for Reference

Table 1 List of materials and their properties

Grade	Tensile strength (N/mm^2)	Yield strength (N/mm^2)
Cast Iron		
FG 150	150	--
FG 200	200	--
FG 260	260	--
Plain carbon steel		
7C4	320	--
10C4	340	--
30C8	500	400
40C8	580	380
45C8	630	380
50C4	660	460
55C8	720	460

Table 2: Proportions of standard parallel, tapered and gib head keys

Shaft diameter (mm) upto and including	*Key cross-section*		*Shaft diameter (mm) upto and including*	*Key cross-section*	
	Width (mm)	*Thickness (mm)*		*Width (mm)*	*Thickness (mm)*
6	2	2	85	25	14
8	3	3	95	28	16
10	4	4	110	32	18
12	5	5	130	36	20
17	6	6	150	40	22
22	8	7	170	45	25
30	10	8	200	50	28
38	12	8	230	56	32
44	14	9	260	63	32
50	16	10	290	70	36
58	18	11	330	80	40
65	20	12	380	90	45
75	22	14	440	100	50

Table 3 Relation between belt and pulley widths

Belt width in mm	*Width of pulley to be greater than belt width by (mm)*
upto 125	13
125-250	25
250-375	38
475-500	50

Table 4 Standard pulley diameters

Standard Pulley Diameters (mm)
40, 45, 50, 56, 63, 71, 80, 90, 100, 112, 125, 140, 160, 180, 200, 224, 250, 280, 315, 355, 400, 450, 500, 560, 630, 710, 800, 900, 1000, 1120, 1250, 1400.