Ref. No.: Ex/ME(M2)/PC/B/T/314/2025

B.E. MECHANICAL ENGINEERING THIRD YEAR FIRST SEMESTER – 2025

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

Group A (CO1 + CO2) (Answer all)

1. Answer the following questions by selecting the correct option: [1 ×15]

a) Both Assertion (A) and Reason (R) are true, and (R) is the correct explanation of (A).
b) Both Assertion (A) and Reason (R) are true, but (R) is NOT the correct explanation of (A).
c) Assertion (A) is true, but Reason (R) is false.
d) Assertion (A) is false, but Reason (R) is true.

i. **Assertion (A):** Riveted joints are more durable than welded joints under dynamic loading.
Reason (R): Welded joints are weaker in withstanding fluctuating stresses.

ii. **Assertion (A):** Bolted joints are commonly used for temporary assemblies.
Reason (R): Bolted joints are maintenance-free.

iii. **Assertion (A):** Flexible couplings are preferred for shafts with misalignments.
Reason (R): Flexible couplings allow angular and axial flexibility.

iv. **Assertion (A):** Friction clutches can operate at extremely high speeds efficiently.
Reason (R): Friction clutches have low heat dissipation ability under continuous use.

v. **Assertion (A):** Drum brakes require more actuating force than disc brakes.
Reason (R): Drum brakes provide better cooling performance than disc brakes.

vi. **Assertion (A):** V-belts are preferred for compact drive systems.
Reason (R): V-belts provide higher friction due to wedging action in the grooves.

vii. **Assertion (A):** Chain drives are noisier than belt drives.
Reason (R): Chain drives operate with a constant velocity ratio without slip.

viii. **Assertion (A):** Fillet welds are weaker than butt welds under tensile loading.
Reason (R): Fillet welds have smaller effective cross-sectional areas.

ix. **Assertion (A):** Belt drives are preferred in high-speed power transmission systems.
Reason (R): Belt drives absorb shocks and vibrations effectively.

x. **Assertion (A):** Clutches are used to transmit power between non-parallel shafts.
Reason (R): Clutches allow smooth engagement and disengagement of power transmission.

xi. **Assertion (A):** Square threads are more efficient than Acme threads for power transmission
Reason (R): Square threads have lower friction due to the absence of radial components of force.

xii. **Assertion (A):** A self-locking screw can prevent back-driving under load.
Reason (R): Self-locking occurs when the thread's lead angle is less than the angle of friction.

xiii. **Assertion (A):** Acme threads are preferred in lifting machines over square threads.
Reason (R): Acme threads are stronger and easier to manufacture compared to square threads.

xiv. **Assertion (A):** A collar reduces the torque required to lift a load using a screw.
Reason (R): The collar reduces frictional losses at the interface.

[Turn over

xv. **Assertion (A):** The efficiency of a power screw decreases with an increase in the coefficient of friction.

Reason (R): Friction opposes the motion, increasing the energy losses in the system.

Group B (CO 3) (Answer any 3)

2. A power of 50kW needs to be transmitted from a shaft running at 300 rpm to a driven shaft connect with some equipment. Design a suitable flange coupling for this application. The materials may be chosen from the Table given below. Tabulate the dimensions at the end. Also produce a sketch of the coupling. [15+5]

3. (a) A bolted joint (M10 × 1.25) is used for supporting a tensile load of 5kN. Both the nut and bolt are made of 30C8. Assuming a FOS of 2.0, determine the nut height considering both tensile failure as well as stripping of the threads. The thread shear area along the pitch-line per millimetre of the bolt length may be taken as 4 mm^2. [6]

(b) Show that the pitch of the rivet in case of cylindrical pressure vessel is

$$\Rightarrow p = \frac{(n_1 + 1.875 n_2)\pi d^2 \tau}{4 t \sigma_t} + d$$

where n_1 = no. of rivets in single shear, n_2 = no. of rivets in double shear, d = rivet diameter, t = boiler wall thickness, τ = allowable shear stress for rivet, σ_t = allowable tensile stress for boiler material [8]

(c) A 200×150×10 mm angle is to be welded to a steel plate by fillet welds as shown in Fig. 3c. If the angle is subjected to a static load of 200 kN, find the length of weld at the top and bottom. The allowable shear stress for static loading may be taken as 75 MPa. [6]

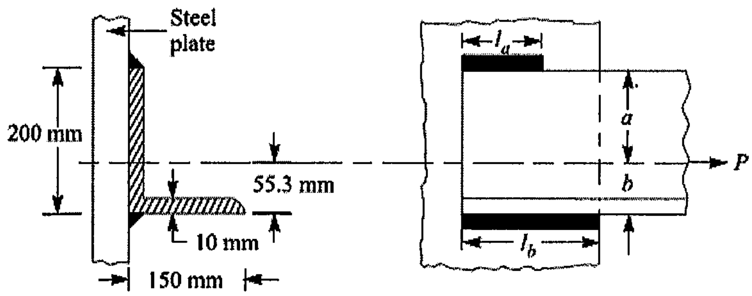

Fig 3c

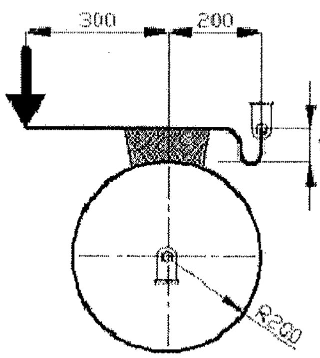

Fig 4a

4. (a) A single block brake with a torque capacity of 250 N-m is shown in Fig 4a. The drum rotates at 100 rpm and the coefficient of friction is 0.35. Calculate:

i) The actuating force and the hinge-pin reaction for clockwise rotation of the drum.
ii) The actuating force and the hinge-pin reaction for anti-clockwise rotation of the drum.
iii) The rate of heat generated during the above two braking actions. [03+03+04]

(b) Explain how frequency of clutching operation is an important parameter in thermal analysis of clutches. [07]

(c) List the advantages of centrifugal clutch. [03]

5. (a) Explain the polygonal action in chain drive? How will you reduce it? [8+2]

(b) Write short notes on the following (any 2) [2×5]

(i) Preloading in bolted joint.
(ii) Misalignment in shafts
(iii) Leak proofing in riveted joint

Group C (CO 4) (Answer any one)

6. A Tech Fest has organised a student competition for designing the most efficient bell bottom screw jack for lifting a load of 25kN. All types of fabrication facilities are provided However, the coefficient of friction between the threads cannot be taken below 0.15. Design and draw the screw jack. Tabulate the dimensions at the end. [25]

7. a) A horizontal flat belt drive is to be designed such that it is capable of transmitting a rated load of 25kW from a motor at 720 rpm to a pump at 1450 rpm. The pulleys are made of Cast Iron (FG 200) and the motor pulley diameter is 300 mm. Abrasion resistant polyamide belts ($\sigma_{allowable}$= 3.0 N/mm^2, ρ = 1.0 g/cc, μ=0.35), joined by machine lacing (η_{joint} = 0.9) is available. Speed ratio is to be kept approximately around 2.0. Both the pulleys rotate in the same direction and the belt slip over both the pulleys is 2%. Consider an overload factor (K_{load}) of 1.20 and the load being transmitted with a jerk (K_s = 1.2). Arc of contact factor can be taken as 1.0. Select pulley diameters and a standard belt size appropriate for the present drive. Also specify the following parameters: Length of the belt, Initial belt tension, Belt tensions on both sides of the pulleys, centrifugal tension. [20]

b) Considering the pulley weight as 100N per 100mm pulley diameter, determine the suitable shaft diameter on which the larger pulley is to be mounted. [5]

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 Basic dimensions for ISO metric screw threads (fine series)

Designation	*Nominal or major dia d/D (mm)*	*Pitch (p) (mm)*	*Pitch diameter d_p/D_p (mm)*	*Minor diameter (mm)* d_c	D_c	*Tensile stress area (mm^2)*
M 6 × 1	6	1.00	5.350	4.773	4.917	20.1
M 6 × 0.75	6	0.75	5.513	5.080	5.188	22.0
M 8 × 1.25	8	1.25	7.188	6.466	6.647	36.6
M 8 × 1	8	1.00	7.350	6.773	6.917	39.2
M 10 × 1.25	10	1.25	9.188	8.466	8.647	61.2
M 10 × 1	10	1.00	9.350	8.773	8.917	64.5
M 12 × 1.5	12	1.50	11.026	10.160	10.376	88.1
M 12 × 1.25	12	1.25	11.188	10.466	10.647	92.1
M 16 × 1.5	16	1.50	15.026	14.160	14.376	167
M 16 × 1	16	1.00	15.350	14.773	14.917	178
M 20 × 2	20	2.00	18.701	17.546	17.835	258
M 20 × 1.5	20	1.50	19.026	18.160	18.376	272
M 24 × 2	24	2.00	22.701	21.546	21.835	384
M 24 × 1.5	24	1.50	23.026	22.160	22.376	401
M 30 × 3	30	3.00	28.051	26.319	26.752	581
M 30 × 2	30	2.00	28.701	27.546	27.835	621
M 36 × 3	36	3.00	34.051	32.319	32.752	865
M 36 × 2	36	2.00	34.701	33.546	33.835	915
M 42 × 4	42	4.00	39.402	37.093	37.670	1150
M 42 × 3	42	3.00	40.051	38.319	38.752	1210
M 48 × 4	48	4.00	45.402	43.093	43.670	1540
M 48 × 3	48	3.00	46.051	44.319	44.752	1600

Table 4 Unit Bearing pressure for power screws

Type of application	*Material* *Screw*	*Nut*	S_b *(N/mm^2)*	*Rubbing speed*
Hand press	Steel	Bronze	18–24	Low speed
Screw-jack	Steel	Cast iron	13–17	Low speed < 2.5 m/min
Screw-jack	Steel	Bronze	11–17	Low speed < 3 m/min
Hoisting screw	Steel	Cast iron	4–7	Medium speed 6–12 m/min
Hoisting screw	Steel	Bronze	5–10	Medium speed 6–12 m/min
Lead screw	Steel	Bronze	1–1.5	High speed > 15 m/min

Table 5 Proportions of square thread

Nominal diameter, d (mm)	*Pitch, p (mm)*
22, 24, 26, 28	5
30, 32, 36	6
40, 44	7
48, 50, 52	8
55, 60	9
65, 70, 75, 80	10
85, 90, 95, 100	12

Table 6 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 7 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.

Table 8 Standard Belt Dimensions

Standard belt thickness (mm)	Standard belt widths (mm)
5	25, 32, 40, 50, 63
6	50, 63, 71, 80, 90, 100, 112, 125, 140
8	90, 100, 112, 125, 140, 160, 180, 200, 224
10	125, 140, 160, 180, 200, 224, 250, 280, 315, 355, 400
12	250, 280, 315, 355, 400, 450, 500, 560, 600