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ANNA UNIVERSITY (UNIVERSITY DEPARTMENTS)

B.E. /B.Tech / B. Arch (Full Time) - END SEMESTER EXAMINATIONS, NOV/ DEC 2023

Department of Mechanical Engineering
(Offered to Department of Manufacturing Engineering and Department of Industrial Engineering)

V Semester

ME5553 MACHINE DESIGN
(Regulation2019)

(Note: Use of PSG Design Data book may be permitted in the examination hall)

Time:3hrs Max.Marks: 100

Upon completion of this course, the students will be able to:

CO 1 Design machine members subjected to static loads.
CO 2 Design shafts, couplings, welded joints, riveted joints and bearings for various applications.
CO 3 Design helical springs, flywheels, connecting rods and crankshafts for various applications.
CO 4 Design flexible elements like belt, ropes and chain drives for engineering applications.
CO 5 Design spur, helical gear drives and multi speed gear box for power transmission.

BL – Bloom's Taxonomy Levels
(L1- Remembering, L2- Understanding, L3- Applying, L4- Analyzing, L5- Evaluating, L6- Creating)

PART- A(10x2=20Marks)

(Answer all the Questions)

Q.No	Questions	Marks	CO	BL
1	Define the following terms: a. Adaptive design, and b. Industrial design.	2	1	L1
2	The main bearing of an engine is shown in figure 1. Calculate the maximum and minimum clearances between the crank pin and bush.	2	1	L2

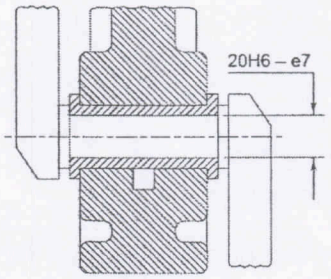

Figure 1: Main bearing of an engine

3	What do you mean by the equivalent bearing load? How do you calculate it?	2	2	L2
4	Calculate the torque transmitted by a coupling fastened by 6 bolts provided the force acting on each bolts is 310 N and the pitch circle diameter of the bolts is 220 mm.	2	2	L2
5	Differentiate the side crankshaft and centre crankshaft with a neat sketch.	2	3	L2

6	What are the forces with which a crankshaft may be subjected to bending and torsional moments?	2	3	L1
7	List down the advantages of flexible drives over rigid drives.	2	4	L2
8	Pen down any two materials with which the flat belt, V belts and round belt can be made.	2	4	L1
9	In a spur gear design, "Pinion design is given more priority when compared to the gear design". – Comment on it.	2	5	L2
10	In what aspect helical gears are more advantageous when compared to spur gears? Provide any one application of helical gear.	2	5	L2

PART- B(5x 13=65Marks)

Q.No	Questions	Marks	CO	BL
11 (a)	The load on a bolt consists of an axial pull of 10 kN together with a transverse shear force of 5 kN. Find the diameter of bolt required according to: Maximum principal stress theory; and Maximum distortion energy theory. Compare and justify the best among the above two theories. *[Take permissible tensile stress at elastic limit = 100 MPa and poisson's ratio = 0.3]*	13	1	L4
	OR			
11 (b)	A rectangular base plate is fixed at each of its four corners by a 20 mm diameter bolt and nut as shown in figure 2. The plate rests on washers of 22 mm internal diameter and 50 mm external diameter. Copper washers which are placed between the nut and the plate are of 22 mm internal diameter and 44 mm external diameter. If the base plate carries a load of 120 kN (including self-weight, which is equally distributed on the four corners), calculate the stress on the lower washers before the nuts are tightened. What could be the stress in the upper and lower washers, when the nuts are tightened so as to produce a tension of 5 kN on each bolt?	13	1	L4

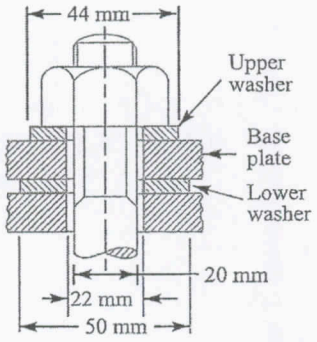

Figure 2: Bolt with washer setup

12 (a)	The figure 3 shows a shaft supported by two bearings placed 1 m apart. A 600 mm diameter pulley is mounted at a distance of 0.3m to the right of left hand bearing and this drives a pulley directly below it with the help of belt having maximum tension of 2.25 kN. Another pulley 0.4m diameter is placed 0.2m to the left of right hand bearing and is driven with the help of electric motor and belt, which is placed horizontally to the right. The angle of contact for both the pulleys is 180° and $\mu = 0.24$. Determine the suitable diameter for a solid shaft, allowing working stress of 63 MPa in tension and 42 MPa in shear for the material of shaft. Assume that the torque on one pulley is equal to that on the other pulley.	13	2	L3

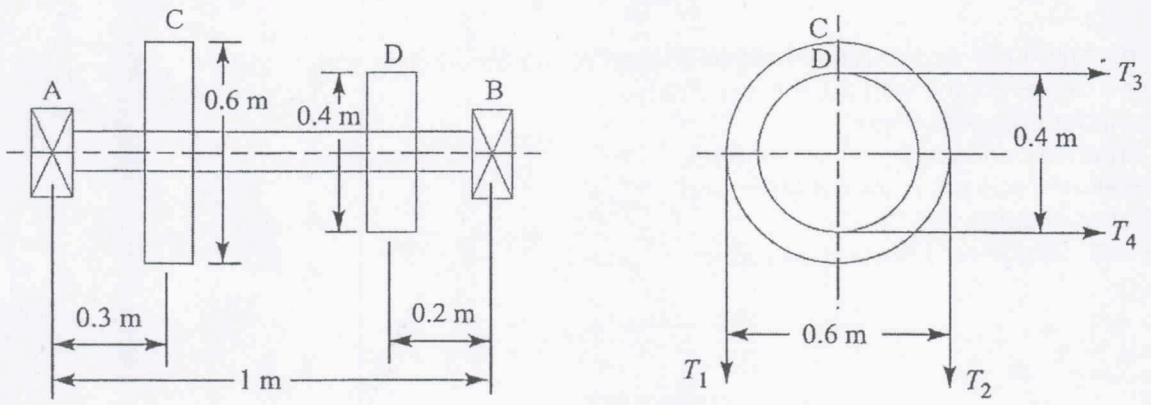

Figure 3: Shaft with pulleys and bearings

OR

12 (b)	A welded connection, as shown in figure 4 is subjected to an eccentric force of 7.5 kN. Determine the size of welds if the permissible shear stress for the weld is 100 N/mm^2. Assume static conditions.	**13**	2	L3

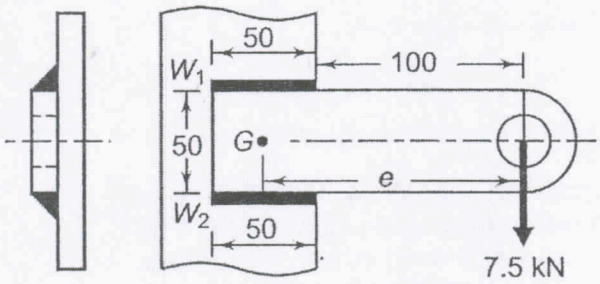

Figure 4: Welding connection

13 (a)	Design a helical spring for a spring loaded safety valve (*Ramsbottom safety valve*) for the following conditions: Diameter of valve seat = 65 mm; Operating pressure = 0.7 N/mm^2; Maximum pressure when the valve blows off freely = 0.75 N/mm^2; Maximum lift of the valve when the pressure rises from 0.7 to 0.75 N/mm^2 = 3.5 mm; Maximum allowable stress = 550 MPa; Modulus of rigidity = 84 kN/mm^2; Spring index = 6. Identify, draw and mark the dimensions as mentioned in figure 5.	**13**	3	L3

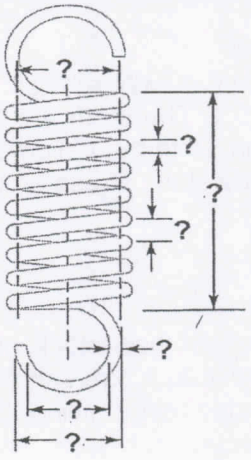

Figure 5: A helical spring

OR

13 (b)	Determine the dimensions of cross-section of the connecting rod for a diesel engine with the following data: Cylinder bore = 100 mm; Length of connecting rod = 350 mm; Maximum gas pressure = 4 MPa; and Factor of safety = 6 *[Note: Design for I Section as shown in figure 6]*	**13**	3	L3

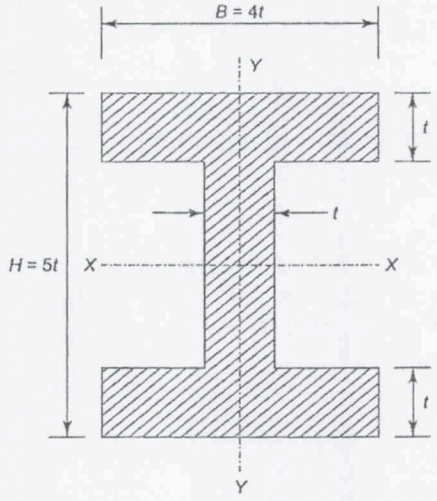

Figure 6: I section proportion with respect to web thickness 't'

14 (a)	Design a cast iron pulley to transmit 20 kW at 300 r.p.m. The diameter of the pulley is 500 mm and the angle of lap is 180^0. The pulley has four arms of elliptical cross-section with major axis twice the minor axis. The coefficient of friction between the belt and the pulley surface is 0.3. The allowable belt tension is not to exceed 250 N in 10 mm width. The allowable sheer stress for the shaft material may be taken as 50 N/mm^2.	**13**	4	L4

OR

14 (b)	A truck equipped with a 9.5 kW engine uses a roller chain as the finaldrive to the rear axle. The driving sprocket runs at 900 r.p.m. and the driven sprocket at 400 r.p.m. with a centre distance of approximately 600 mm. Design the roller chain for this application.	**13**	4	L4
15 (a)	Design a spur gear drive required to transmit 45 kW at a pinion speed of 800 r.p.m. The velocity ratio is 3.5:1. The teeth are 20° full depth involute with 18 teeth on the pinion. Both the pinion and gear are made of steel with a maximum safe static stress of 180 N/mm^2. Assume medium shock conditions.	**13**	5	L4

OR

15 (b)	Design a 12 speed gearbox for an all geared headstock of a lathe. Maximum and minimum speeds are 600 r.p.m. and 25 r.p.m. respectively. The drive is from an electric motor giving 2.23 kW at 1440 r.p.m.	**13**	5	L4

PART- C(1x 15=15Marks)

(Q.No.16 is compulsory)

Q. No	Questions	Marks	CO	BL
16.	A geared crank type press consists of a mechanism similar to one illustrated in figure 7. It absorbs 25 kN-m of work from flywheel during the last 30° of crank rotation. The crank rotates at 120 rpm. The flywheel rotates three times faster. The flywheel has rimmed type construction with four spokes and a hub. It is made of grey cast iron FG200 (S_{ut} = 200 N/mm^2 and ρ = 7100 kg/m^3). The outer diameter of the flywheel should be within 1200 mm. The flywheel is to keep down the fluctuations in speed within 12% of normal speed. Assume linear variation of the torque during 30° of crank rotation when punching takes place.	5 + 3 + 7 =15	1 2 3	L5

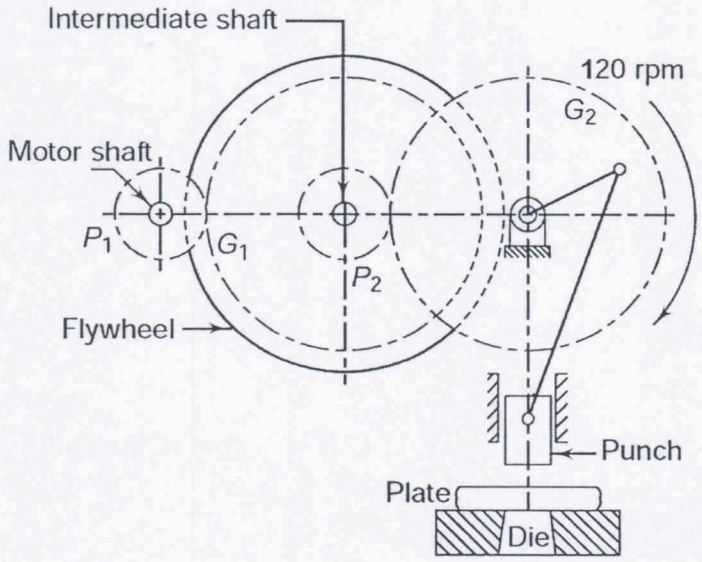

Figure 7: Flywheel assisted pressing mechanism

i. The rim contributes 90% of the required moment of inertia. Determine the dimensions of the cross-section of the rim, if it has a square cross-section.
(CO3 – 4 Marks)

ii. Determine the stress in the rim treating it as a free rotating ring.
(CO3 – 3 Marks)

iii. The flywheel is keyed to a shaft made of plain carbon steel 40C8 (S_{ut} = 650 N/mm^2 and S_{yt} = 380 N/mm^2). Neglecting bending moment, determine the shaft diameter as per ASME code if K_t = 2.0 and determine the hub diameter.
(CO2 – 3 Marks)

iv. The spokes have elliptical cross-section with major axis of the ellipse equal to twice of the minor axis. Each spoke transmits equal load from the mean radius of the rim to the surface of the hub. Assume that the spoke acts as a cantilever beam fixed at the hub surface and subjected to force at the mean radius of the rim. Determine the dimensions of the cross-section of the spokes based on simple bending theory if the factor of safety is 2.5.
(CO1 – 5 Marks)