MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
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DEPARTMENT OF MECHATRONICS
IV SEMESTER B.TECH. MECHATRONICS
END SEMESTER EXAMINATION, MAY 2024
SUBJECT: Design of Machine Elements **Subject Code: MTE 2222**
Date: 07/05/2024
Time: 180 Mins **Exam time: 2:30 pm – 5:30 pm** **MAX. MARKS: 50**

- Answer **ALL** questions.
- Missing data if any, maybe suitably assumed.

Q. No.		M	CO	PO	LO	BL
1A.	A cantilever beam of a circular cross-section is loaded, as shown in Fig Q1A below. If the beam has a diameter of 40 mm, select a suitable material from Table Q1A. Adopt maximum shear stress theory using a factor of safety 4.	**5**	**2**	**1,3**	**1,2**	**3**

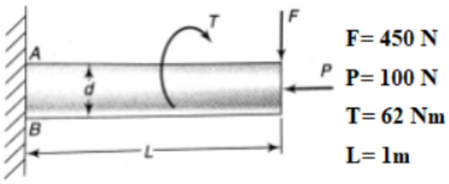


Fig Q1A

Material	Ultimate Strength (MN/m^2)	Yield strength (MN/m^2)
Wrought iron	332	186
Cast steel	414	218
SAE 1025 Annealed steel	462	234
SAE 1045 annealed steel	586	310
Water quenched steel	828	624
Oil quenched steel	952	700

Table Q1A

Q. No.		M	CO	PO	LO	BL
1B.	A non-rotating circular shaft made of a material with a yield stress of 300 MN/m^2 is subjected to a pull of 100KN, as shown below in Fig Q1B. Taking the safety factor as 3, determine the shaft dimensions.	**3**	**2**	**1,3**	**1,2**	**3**

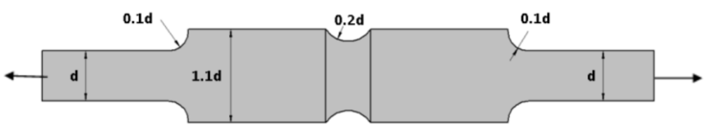
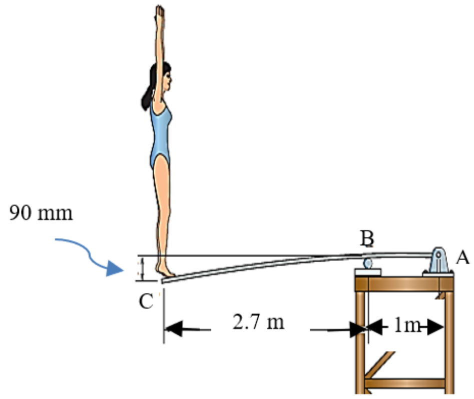
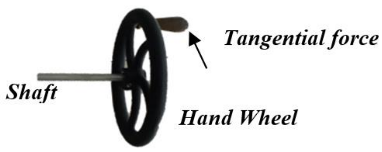


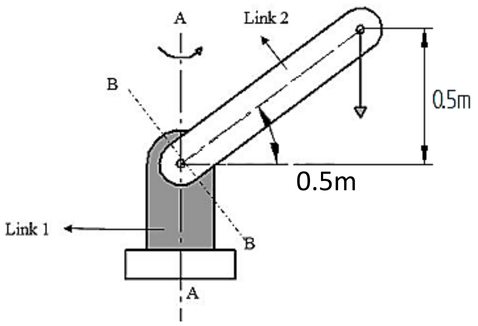
Fig Q1B

Q. No.		M	CO	PO	LO	BL
1C.	An SKF6315 bearing is used to support a shaft running at 125 RPM. If the bearing is subjected to a pure radial load of 21000N, calculate the expected life of the bearing in number of hours.	**2**	**4**	**1,3**	**1,2**	**3**

2A.	When the diver stands at end C of the diving board, it deflects downward by 90 mm, as shown in Fig Q2A. Analyze the scenario and determine the weight of the diver. The board is made of a material with a Modulus of Elasticity of E = 10 GPa. The board has a rectangular cross-section with a breadth of 457 mm and a depth of 50 mm. The board is simply supported at A and B. Use Macaulay's method to solve the beam deflection equation.  Fig Q2A	**5**	**1**	**1,3**	**1,2**	**4**
2B.	A shaft is placed between 2 bearings 1.5 m apart. A pulley weighing 2000N is placed at the centre of the shaft. The pulley transmits 15kW at 150 RPM to another pulley exactly below it. The total belt tension is 650N. If the allowable shear stress is 50 MN/m^2, estimate the diameter of the shaft. Take C_m=C_t=1.5. Use maximum shear stress theory.	**3**	**5**	**1,3**	**1,2**	**3**
2C.	A steel shaft 35 mm in diameter and 1.2m long is held rigidly at one end and has a hand wheel of 500 mm diameter keyed to it at the other end, as shown in Fig Q2C. If the modulus of rigidity of steel is 80 GPa, calculate the force applied along the tangent to the rim of the wheel that produces a torsional shear of 60 MPa in the steel shaft.  Fig Q2C	**2**	**1**	**1,3**	**1,2**	**3**
3A.	A pair of spur gears have 20˚ full depth involute teeth. The pinion is connected to a 35kW motor and rotates at 1440 RPM. The speed reduction is 10:1. The number of teeth on the pinion is 24. The pinion is made of C40 untreated steel, and the gear is made of case-hardened alloy steel. The gears are subjected to	**5**	**4**	**1,3**	**1,2**	**3**

<table>
<tr><td></td><td>steady loads and operate 8-10 hours per day. The gears should be ordinary cut gears. Calculate the face width and diameters of the gears.</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>3B.</td><td>A pair of spur gears have been designed with the following parameters. If the wear load is 7300 N, determine the safety of the design.

<table>
<tr><td>Type of gear</td><td>Spur</td></tr>
<tr><td>Power to be transmitted</td><td>2kW</td></tr>
<tr><td>Pinion material and speed</td><td>Cast iron (σ_d =48 N/mm^2, BHN=180) @1200 RPM
Youngs modulus=100 x10^3 N/mm^2</td></tr>
<tr><td>Gear material and speed</td><td>Cast iron (σ_d =56.4N/mm^2, BHN=180) @ 192 RPM
Youngs modulus=100 x10^3 N/mm^2</td></tr>
<tr><td>Gear Profile</td><td>20° full depth involute</td></tr>
<tr><td>Operation</td><td>8 hours/day with light shock loads. Carefully cut</td></tr>
<tr><td>Module</td><td>4</td></tr>
<tr><td>Pinion diameter</td><td>60 mm</td></tr>
<tr><td>Gear diameter</td><td>376 mm</td></tr>
<tr><td>Face width</td><td>38 mm</td></tr>
<tr><td>Weaker member</td><td>Pinion</td></tr>
</table></td><td>3</td><td>4</td><td>1,3</td><td>1,2</td><td>3</td></tr>
<tr><td>3C.</td><td>A helical cylindrical spring has a wire of 5 mm diameter and an allowable shear stress of 60N/mm^2. It has 12 active coils, and the spring index is 6. Calculate the maximum axial force it can carry and the corresponding axial compression.Take G=82x 10^3 N/mm^2</td><td>2</td><td>3</td><td>1,3</td><td>1,2</td><td>3</td></tr>
<tr><td>4A.</td><td>A shaft is supported by 2 bearings 600 mm apart. It carries a belt-driven pulley positioned at 200 mm to the left of the right-hand bearing. The pulley is between the bearing and receives 20 kW from a motor through a horizontal belt drive. Pulley weighs 500N and has a diameter of 400 mm. The allowable shear stress of shaft material is 65 N/mm^2, and loads are suddenly applied with minor shocks. Design the shaft for a speed of 800 RPM using maximum shear stress theory. The angle of the wrap is 178 degrees, and the coefficient of friction is 0.3.</td><td>5</td><td>5</td><td>1,3</td><td>1,2</td><td>3</td></tr>
<tr><td>4B.</td><td>The lead screw of a lathe has single start square threads of 52 mm nominal diameter and 8mm pitch. The screw is required to exert an axial force of 2 kN in order to drive the tool carriage during turning operation. The thrust is carried on a collar of 100 mm outer diameter and 60mm inner diameter. The values of the coefficient of friction at the screw threads and the collar are 0.15 and 0.12, respectively. The lead screw rotates at 30 RPM. Calculate a. Power required to drive the lead screw and b. The overall efficiency of the screw</td><td>3</td><td>4</td><td>1,3</td><td>1,2</td><td>3</td></tr>
<tr><td>4C.</td><td>Direct stresses of 80 N/mm^2 tension and 60 N/mm^2 compression are applied to an elastic material at a point on planes at right angles to one another. The maximum principal stress in the material is to be limited to 100 N/mm^2.</td><td>2</td><td>1</td><td>1,3</td><td>1,2</td><td>3</td></tr>
</table>

	Estimate the shearing stress the material might be subjected to on the given planes. Also, calculate the maximum shearing stress at that point.					
5A.	A helical spring is to be designed for an operating load range of 1 kN to 1.3 kN. The initial compression of the spring is 60 mm for a load of 1 kN. Assume the spring index as 10. The shear stress in the spring material is 500 MPa, and the modulus of rigidity is 82.7 GPa.	**5**	**3**	**1,3**	**1,2**	**3**
5B.	An industrial robot (shown by a simplified representation in FigQ5B) is used to pick and place objects. Link 1 rotates about A-A axis and link 2 swivels about B-B axis. The swiveling of link 2 is accomplished by an electric motor from behind (along axis B-B). The robot is currently at a position as shown in Fig Q7. If the robot is carrying a load of 50kN, estimate the diameter of the motor shaft if it is made of material with allowable stress of $40 MN/m^2$.  Fig Q5B	**3**	**1**	**1,3**	**1,2**	**3**
5C.	Select a suitable single-row deep groove ball bearing to support a pure radial load of 8 kN from a shaft that rotates at 500 RPM. The expected life of the bearing is 30000 hrs. The minimum acceptable diameter of the shaft is 90 mm.	**2**	**4**	**1,3**	**1,2**	**3**