III B.Tech. II Semester Regular Examinations, April/May -2005
PRINCIPLES OF MACHINE DESIGN
(Mechatronics)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. A mild steel shaft is to transmit 75 kW at 200 rpm. The allowable shear stress in the shaft is limited to 40 N/mm^2 and the angle of twist is not to exceed 1 degree in a length of 20 diameters. Calculate the suitable diameter for the shaft.

2. A steel shaft has a diameter of 25 mm. The shaft rotates at a speed of 600 rpm. and transmits 30 kW through a gear. The tensile and yield strength of the material of shaft are 650 MPa and 353 MPa respectively. Taking a factor of safety 3, select a suitable key for the gear. Assume that the key and shaft are made of the same material.

3. Select a suitable spherical roller bearing from SKF series 222C to support a radial load of 4 kN and an axial load of 2 kN. Minimum life required is 10,000 hours at 1000 rpm. For the selected bearing find.
   (a) The expected life under the given loads.
   (b) The equivalent load that can be supported for a life of 10000 hours.
   (c) The load that can be supported with a probability of survival of 95% with 10,000 hours.

4. . Design a clamp coupling to connect two shaft transmitting 20% over load. The shaft and key materials are the same having allowable shear stress 50 MPa and allowable crushing stress is being double that of allowable shear stress. The allowable shear stress for the sleeve materials is 15 MPa. Allowable stress in bolt material is 75 MPa. Take the coefficient of friction between the shaft and the muff as 0.3, draw a neat sketch of the muff coupling designed above.

5. A hot rolled steel shaft is subjected to a torsional moment that varies from 330 N-m clockwise to 110 N-m counterclockwise and an applied bending moment at a critical section varies from 440 N-m to 220 N-m. The shaft is of uniform cross-section and no keyway is present at the critical section. Determine the required shaft diameter. The material has an ultimate strength of 550 MN/m^2 and a yield strength of 410 MN/m^2. Take the endurance limit as half the ultimate strength, factor of safety of 2, size factor of 0.85 and a surface finish factor of 0.62.

6. Design a cast iron trunk type piston for a single acing four stroke engine developing 75 kW per cylinder when running at 600 rpm. The other available data is as follows:
   Maximum gas pressure=4.8 N/mm^2;
   Indicated mean effective pressure=0.65 N/mm^2;
   Mechanical efficiency 95%; Radius of crank = 110 mm;

Fuel consumption = 0.3 kg/BP/hr;
calorific value of fuel (higher) = 44 x 10^3 kJ/kg;
Differences of temperatures at the center and edges of the piston head = 200^0C;
Allowable stress of the material of the piston = 33.5 MPa;
Allowable stress of the material of the piston rings and gudgeon pin = 80 MPa;
Allowable bearing pressure on the piston barrel = 0.4 N/mm^2 and allowable bearing pressure on the gudgeon pin = 17 N/mm^2.

7. The following particulars refer to a belt drive using a cast iron pulley mounted on a shaft:
   Power: 25 kW
   Speed of driving shaft: 300 rpm
   Speed of driven shaft: 100 rpm
   Allowable tension: 10 N/mm width
   Design suitable belt drive.

8. A spur gear drive is used to drive a camshaft by the crankshaft with a speed reduction of 2 in a 5 kW engine. The center distance is to be not more than 160 mm. Design the drive for 10,000 hours. Crankshaft speed is 1500 rpm. Assume pinion, gear are C 15 steel and cast iron grade 30, pressure angle 20^0, Design compressive stress for pinion, gear are 772 N/mm^2, 350 N/mm^2, design bending stresses for pinion, gear are 85 N/mm^2, 55 N/mm^2.

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1. (a) What do you mean by white hearth and black hearth cast iron?
   (b) What are the modes of failure of a component?
   (c) Discuss the importance of preferred numbers.

2. A shaft is supported on two bearings 600 mm apart. The shaft supports a pulley 500 mm in diameter located 250 mm to the right of the left hand bearing and the belt drives a pulley directly below. Another pulley of 375 mm diameter is located 125 mm to the left of the right hand bearing and the belt is driven from a pulley horizontally to the right. The maximum tension in the belt on the small pulley is 3500 N. Find the shaft diameter taking allowable tensile stress 55 N/mm^2 and shear stress 41 N/mm^2.

3. (a) What are the rolling contact bearings? Discuss their advantages over sliding contact bearings.
   (b) Write short note on different types of antifriction bearings.

4. The split muff coupling is to be designed to transmit 67.5 kW at 180 rpm. Determine the diameter of the solid shaft if the permissible shear in the shaft material is limited to 42 MPa. Assuming that the two halves of the coupling are connected by 8 bolts, determine the diameter of each clamping bolt if the permissible tensile stress intensity for the bolt material is limited to 70 MPa. The coefficient of friction between the shaft and muff may be taken as 0.3.

5. A carbon steel rod of circular cross-section having σ_u =600MN/m^2, σ_y=450 MN/m^2, $\sigma_e^{'}$= 300 MN/m^2 is subjected to a bending moment which varies between 300 to 500 Nm and axial load which varies between 5 to 10 kN. Assuming that the bending moment and axial load are in phase determine the diameter of the rod to have a factor of safety of 2.

6. The following projected data refer to a four cylinder petrol engine of a car:

Diameter of the piston	= 68 mm
Stroke length	= 75 mm
Maximum pressure	= 2.5 MN/m^2
Connecting rod length	= 175 mm
Brake power	= 32 kW at 5000 rpm
bsfc	= 0.33 kg/kWh

   Design a suitable piston.

7. The drive from a motor to a machine consists of three V-belt of size B. The motor pulleys has a pitch diameter 200 mm and the machine pulley diameter is 500 mm. If the center distance is 1.3 m, give the full specification details of the belt.

8. A micarta pinion rotating 1200 rpm is to transmit 1 kW to a cast iron gear at a speed of 192 rpm. Assuming a starting overload of 20% and using 20^0 full depth involute teeth, determine the module, number of the teeth on the pinion and gear and face width. Take allowable static strength of micarta as 40 MPa and for cast iron as 53 MPa. Check the pair in wear.

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Code No: RR321401 **Set No.3**

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1. (a) What are the composite materials? How composite materials differ from alloys.
   (b) Explain the Bureau of Indian Standards Designation of copper and copper alloys.

2. A 63 mm diameter shaft has a key 16 x 16 mm. The shaft material has a yield strength of 324 N/mm^2. Assume shear yield strength to be half of the tensile yield strength and factor of safety is to be equal to 2. The shaft fits into a cast iron hub for which the working stress in compression is 125 MPa. Determine the length of the key in the hub to carry the torque of the solid shaft.

3. Design a hydrodynamic full journal bearing of 200 mm x 200 mm to support 20 kN. Calculate the operating parameters and check for necessity for cooling. Speed of journal is 1500 rpm.

4. The split muff coupling is to be designed to transmit 67.5 kW at 180 rpm. Determine the diameter of the solid shaft if the permissible shear in the shaft material is limited to 42 MPa. Assuming that the two halves of the coupling are connected by 8 bolts, determine the diameter of each clamping bolt if the permissible tensile stress intensity for the bolt material is limited to 70 MPa. The coefficient of friction between the shaft and muff may be taken as 0.3.

5. Determine the diameter of a circular rod made of ductile material with a fatigue strength (complete stress reversal) σ_e = 265 MPa and a tensile yield strength of 350 MPa. The member is subjected to a axial load varies from-300 x 10^3 N to 700 x 10^3 N and has a stress concentration factor = 1.8. Use factor of safety as 2.0.

6. Design a suitable connecting rod for a car with the following data:

Piston diameter	= 68 mm
Stroke length	= 80 mm
Length of the connecting rod	= 160 mm
Maximum explosion pressure	= 3.5 N/mm^2
Weight of the reciprocating part	= 2.5 kg
Speed	= 4000 rpm
Compression ratio	= 8:1

7. A 50 kW, 1200 rpm, high torque squirrel-cage motor is used to drive a punch press. The speed of the punch press flywheel is 300 rpm. If the center distance is 2.5 m, select a suitable leather belt.

8. A spur gear drive is used to drive a camshaft by the crankshaft with a speed reduction of 2 in a 5 kW engine. The center distance is to be not more than 160 mm. Design the drive for 10,000 hours. Crankshaft speed is 1500 rpm. Assume pinion, gear are C 15 steel and cast iron grade 30, pressure angle 20^0, Design compressive stress for pinion, gear are 772 N/mm^2, 350 N/mm^2, design bending stresses for pinion, gear are 85 N/mm^2, 55 N/mm^2.

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Code No: RR321401 **Set No.4**

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1. (a) What are the composite materials? How composite materials differ from alloys.
   (b) Explain the Bureau of Indian Standards Designation of copper and copper alloys.

2. (a) Discuss the materials used for the shafts.
   (b) A shaft made of mild steel is required to transmit 100kW at 300 rpm. The supported length of the shaft is 3m.It carries two pulleys each weighing 1500N supported at a distance of 1m from the ends respectively. Assuming safe shear stress as 60MPa, determine the diameter of the shaft.

3. Briefly explain the following:
   (a) Journal bearing
   (b) Viscosity
   (c) Sommer-field number

4. Two shafts made of plain carbon steel are connected by a rigid protective type flange coupling. The shafts are running at 500 rpm and transmit 25 kW power. Design the coupling completely for overload capacity 25 percent in excess of mean transmitted torque capacity.
   Assume the following permissible stresses for the coupling components:
   Shaft - Permissible tensile stress = 60 MPa; Permissible shear stress = 35 MPa
   Keys -Rectangular form end sunk key having permissible compressive strength = 60 MPa
   Bolts - Six numbers made of steel having permissible shear stress = 28 MPa
   Flanges - cast iron having permissible shear stress = 12 MPa
   Draw two views of the coupling.

5. A hot rolled steel shaft is subjected to a torsional moment that varies from 330 N-m clockwise to 110 N-m counterclockwise and an applied bending moment at a critical section varies from 440 N-m to 220 N-m. The shaft is of uniform cross-section and no keyway is present at the critical section. Determine the required shaft diameter. The material has an ultimate strength of 550 MN/m^2 and a yield strength of 410 MN/m^2. Take the endurance limit as half the ultimate strength, factor of safety of 2, size factor of 0.85 and a surface finish factor of 0.62.

6. The following projected data refer to a four cylinder petrol engine of a car:

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Stroke length	= 75 mm
Maximum pressure	= 2.5 MN/m^2
Connecting rod length	= 175 mm
Brake power	= 32 kW at 5000 rpm
bsfc	= 0.33 kg/kWh

   Design a suitable piston.

7. Design a fabric belt to transmit 15 HP at 450 rpm from an engine to a line shaft at 1200 rpm. The diameter of the engine pulley is 600 mm and the distance between the shafts is 2 meters.

8. A pair of spur gear is to be designed to transmit 15 kW. Pinion has 24 teeth runs at 250 rpm. Velocity ratio is 2.8:1. Assume pinion is made by alloy steel has design compressive stress 950 N/mm^2, design bending stress 320 N/mm^2 and hardness number 280. Assume wheel is made by C 45 steel has design compressive stress 500 N/mm^2, design bending stress 140 N/mm^2 and hardness number 175.

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