Code No: RR321401 **Set No. 1**

III B.Tech II Semester Supplementary Examinations,
November/December 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) List the factors required to be taken into account for the selection of materials. [8]

   (b) Define the following terms:

   i. Ductility
   ii. Malleability
   iii. Brittleness
   iv. Resilience [4x2=8]

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. [16]

3. Select appropriate type of rolling contact bearing under the following condition of loading giving reasons for your choice.

   (a) Light radial load with high rotational speed.
   (b) Heavy axial and radial load with shock.
   (c) Light load where radial space is very limited.
   (d) Axial thrust only with medium speed. [4x4=16]

4. A 50mm diameter steel shaft is transmitted by means of a C.I flange rigid coupling. A tentative selection is made with 4 bolts on a bolt circle diameter of 150 mm if the bolts are made of the same material as the shaft with an ultimate tensile strength of 550 MPa and allowable shear stress of 550 MPa. Determine the necessary size of bolts to resist the shaft torque, also design the other dimensions of the coupling. Make a sketch of the coupling. [16]

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. [16]

6. Design and draw a trunk type of piston for a single cylinder four-stroke diesel engine running at 1000 rpm. Other data available are:

Maximum explosion pressure	= 3.5 MN/m^2
Mean effective pressure	= 0.65 MN/m^2
Diameter of piston	= 150 mm
Stroke length	= 200 mm
Connecting rod length	= 450 mm
bsfc	= 0.27 kg/kWh

[12+4=16]

7. A 50 kW motor running at 1000 rpm. is required to drive a pump pulley at 400 rpm. Motor pulley diameter is limited to 0.3 m. Center distance is to be around 2.5 m. Select a suitable V-belt and design the drive. [16]

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. [16]

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1. (a) Differentiate between preferred numbers and rounding of numbers. [8]
   (b) What you meant by design stress. How the design stress is determined for ductile and brittle materials. [4+4=8]

2. (a) With a neat sketch explain the function of feather keys.
   (b) A rectangular sunk key 14mm wide,10mm thick,75mm long is subjected to transmit 1200N-m torque from a 50 mm diameter solid shaft. Determine whether the length is sufficient or not if the permissible shear stress and crushing stress intensities are limited to 56 and 168MPa respectively. [8+8]

3. Design a bearing and journal to support a load of 6KN at 800 rpm using a hardened steel journal and bronze backed babbit bearing. An abundance of oil having a viscosity of 250 Stokes saybolt at 37.8^{o}C and a specific gravity of 0.90 at 15^{o}C is provided. The bearing is relieved for 20^o from the normal to the load line. Assume an oil temperature of 82^{o}C and a clearance of 0.0015 mm per mm of diameter. The bearing modulus for this type of bearing is about 48.3X10^{-6}. [16]

4. Design a muff coupling to connect two shafts transmitting 40 kW at 120 rpm. The permissible shear and crushing stress for the shaft and key material (mild steel) are 30 MPa and 80 MPa respectively. The material of muff is cast iron with permissible shear stress of 15 MPa. Assume that the maximum torque transmitted is 25 percent greater than the mean torque. [16]

5. A steel cantilever is 200 mm long. It is subjected to an axial load which varies from 150 N (compression) to 450 N (tension) and also a transverse load at its free end which varies from 80 N up to 120 N down. The cantilever is of circular cross-section. It is of diameter 2d for the first 50 mm and of diameter d for the remaining length. Determine its diameter taking a factor of safety of 2. Assume the following values:

Yield stress	= 330 MPa
Endurance limit in reversed loading	= 300 MPa
Correction factors	= 0.7 in reversed axial loading
	= 1.0 in reversed bending
Stress concentration factor	= 1.44 for bending
	= 1.64 for axial loading
Size effect factor	= 0.85
Surface effect factor	= 0.90
Notch sensitivity index	= 0.90 [16]

6. Determine the dimensions of an I-Section connecting rod for a petrol engine from the following data: Diameter of the piston = 110 mm; Mass of the reciprocating parts = 2 kg; Length of the connecting rod from center to center = 325 mm; Stroke length = 150 mm; R.P.M = 1500 with possible over speed of 2500; Compression ratio = 4:1; Maximum explosion pressure = 2.5 N/mm^2. [16]

7. Design a flat belt drive to transmit 20 kW at 730 rpm. to a rolling machine with a speed ratio of 3. The center distance is nearly 3.5 m. The diameter of rolling machine pulley is 1.2 m. [16]

8. A motor shaft rotating at 1440 rpm has to transmit 15 kW to a low speed shaft rotating at 500 rpm. The teeth are 20^0 involute with 25 teeth on the pinion. Both the pinion and gear are made of cast iron with a maximum safe stress of 56 MPa. A safe stress of 35 MPa may be taken for the shaft on which the gear is mounted. Design and sketch the spur gear drive to suite the above conditions. The starting torque may be assumed as 1.25 times the running torque. [12+4=16]

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1. A shaft is supported in bearings, the distance between their centers being 1 meter, It carries a pulley in the center and it weighs 1 kN. Find the diameter of the shaft, if the permissible bending stress for the shaft material is 40 MPa. [16]

2. (a) With a neat sketch explain the function of feather keys.
   (b) A rectangular sunk key 14mm wide,10mm thick,75mm long is subjected to transmit 1200N-m torque from a 50 mm diameter solid shaft. Determine whether the length is sufficient or not if the permissible shear stress and crushing stress intensities are limited to 56 and 168MPa respectively. [8+8]

3. (a) Define rating life.
   (b) A single row, deep groove ball bearing has a specific dynamic capacity of 46.3kN (for 1,000,000 revolutions or 500 hrs at 33.3 rpm that 90% of graph of bearings will complete or exceed).
      i. If the speed of rotation is 1800 rpm and the actual radial load applied to the bearing is 9 kN, what is the life in revolutions?
      ii. How many hours of operation can be expected for the above?
      iii. What is the average life that can be expected. [4+12]

4. A flanged protective type coupling is required to transmit 50 kW at 2000 rpm. Find
   (a) Shaft diameter if the driving shaft is hollow with $d_1/d_0 = 0.6$ and driven shaft is a solid shaft. Takeτ = 100 MPa.
   (b) Diameter of bolts, if the coupling uses four bolts. Take $\sigma_c = \sigma_t$ =70 MPa and τ = 25 MPa. Assume pitch circle diameter as about 3 times the outside diameter of the hollow shaft.
   (c) Thickness of the flange and diameter of the hub. Assume σ_c=100 MPa and τ = 125 MPa.
   (d) Make a neat free hand sketch of the assembled coupling showing a longitudinal sectional elevation with the main dimensions. The other dimensions assumed suitably. [4+4+4+4]

5. A bar of circular cross-section is subjected to alternating tensile forces varying from a minimum of 200 kN to a maximum of 500 kN. It is to be manufactured of a material with an ultimate tensile strength of 900 MPa and an endurance limit of 700

MPa. Determine the diameter of bar using safety factors of 3.5 related to ultimate tensile strength and 4 related to endurance limit and a stress concentration factor of 1.65 for fatigue load. Use Goodman straight line as basis for design. [16]

6. Design a piston for a four stroke diesel engine consuming 0.3 kg of fuel per kW of power per hour and produces a break mean effective pressure of 0.7 N/mm^2. The maximum gas pressure inside the cylinder is 5 N/mm^2 at a speed of 3500 rpm. The cylinder diameter is required to be 300 mm with stroke 1.5 times the diameter. The piston may have 4 compression rings and an oil ring. The following data can be used for design: Higher calorific value of fuel = 46 x 10^3 kJ/kg; Temperature at the piston center = 700 K; Temperature at the piston edge = 475 K; Heat conductivity factor = 46.6 W/m/K; Heat conducted through top = 5% of heat produced; Permissible tensile strength for the material of piston = 27 N/mm^2; Pressure between rings and
piston = 0.04 N/mm^2; Permissible tensile stress in rings = 80 N/mm^2; Permissible pressure on piston barrel = 0.4 N/mm^2; Permissible pressure on piston pin = 15 N/mm^2; permissible stress in piston pin= 85 N/mm^2.
Any other data required for the design may be assumed. [16]

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. [16]

8. A pair of spur gear is required to transmit 20 kW at a pinion speed of 1800 rpm. The gear runs at 600 rpm. Design the gear pair.
Material properties: [16]

Name	Material (Steel)	Design compressive stress (N/mm^2)	Design bending stress (N/mm^2)
Pinion	15 N I 2 Cr l M_0 15 C 45	950	320
Gear	C 45	500	140

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1. Design a hollow shaft required to transmit 11.2 MW at a speed of 300 rpm. The maximum shear stress allowed in the shaft is 80 Mpa and the ratio of the inner diameter to outer diameter is 3/4. [16]

2. A shaft 80 mm diameter transmits power at maximum shear stress of 63 MPa. Find the length of a 20 mm wide key required to mount a pulley on the shaft so that the stress in the key does not exceed 42 MPa. [16]

3. (a) Write the petroff's equation. In which application the petroffs equation is used.
   (b) A journal bearing 300mm long,150mm dia carries a radial load of 9KN at 1200 rpm. The power lost in friction is 6 Kw, Viscosity of oil at room temperature is 0.018 Pa-s. Find the diametral clearance. [4+12]

4. Design a compression coupling for a shaft to transmit 1300 N-m. The allowable shear stress for the shaft and key is 40 MPa and the number of bolts connecting the two halves are 4. The permissible tensile stress for the bolts material is 70 MPa. The coefficient of friction between the muff and the shaft surface may be taken as 0.3. [16]

5. A steel rod is subjected to a reversed axial load of 180 kN. Find the diameter of the rod for a factor of safety of 2. Neglect column action. The material has an ultimate tensile strength of 1070 MPa and yield strength of 910 MPa. The endurance limit in reversed bending may be assumed to be one-half of the ultimate tensile strength. Other correction factors may be taken as follows:
   For axial loading = 0.7; For machined surface = 0.8; For size = 0.85; For stress concentration = 1.0. [16]

6. Design and draw a trunk type of piston for a single cylinder four-stroke diesel engine running at 1000 rpm. Other data available are:

Maximum explosion pressure	= 3.5 MN/m^2
Mean effective pressure	= 0.65 MN/m^2
Diameter of piston	= 150 mm
Stroke length	= 200 mm
Connecting rod length	= 450 mm
bsfc	= 0.27 kg/kWh

[12+4=16]

7. A centrifugal water pump is driven by a 30 kW motor running at 1440 rpm. The speed of the pump is to be 360 rpm. The maximum size of the pulley permitted is 1 m and approximate center distance is 2.2 m. Design the V-belt drive. [16]

8. A pair of spur gear is required to transmit 20 kW at a pinion speed of 1800 rpm. The gear runs at 600 rpm. Design the gear pair.
Material properties: [16]

Name	Material (Steel)	Design compressive stress (N/mm^2)	Design bending stress (N/mm^2)
Pinion	15 N I 2 Cr l M_0 15 C 45	950	320
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