Code No: 07A60305 **R07** **Set No. 2**

III B.Tech II Semester Examinations,December 2010
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) Define endurance strength and endurance limit.
   (b) A pulley is keyed to a shaft midway between two bearings. The shaft is made of cold drawn steel for which ultimate strength is 550MPa and the yield strength is 400MPa.The bending moment at the pulley varies from -150 N-m to 400N-m as the torque on the shaft varies from -50N-m to + 150N-m.Obtain the diameter of the shaft for an indefinite life. The stress concentration factors for the keyway at the pulley in bending and in torsion are 1.6 and 1.3 respectively. Assume the following values :
   factor of safety = 1.5 load correction factor =1.0 in bending and 0.6 in torsion
   Size factor =0.85 and surface factor = 0.88. [4+12]

2. (a) Give specification of a helical compression spring.
   (b) Design a spring for a balance to measure 0 to 1000N over a scale of length 80mm. The spring is to be enclosed in a casing of 25mm diameter. Approximate number of turns is 30.G=$0.85\times10^5 N/mm^2$. Also calculate the maximum shear stress induced. [6+10]

3. (a) Name the cross sections of flat belt, V- belt, and rope.
   (b) An overhung cast iron pulley transmits 7.5kW at 300 r.p.m. the diameter of the pulley is 500mm and angle of lap is 180^0. Find:
      i. Diameter of the pulley. The density of cast iron is 7200kg/m^3.
      ii. Width of the belt, if the coefficient of friction between the belt and the pulley is 0.25.
      iii. Diameter of the shaft, if the distance of the pulley center line from the nearest bearing is 300mm.
      iv. Dimensions of the key for securing the pulley on to the shaft.
      v. Size of the arms 6 in number, the section may be taken as elliptical, the major axis twice the minor axis length. The following stresses may be taken for design purposes:

   Shaft and key : tension-80MPa, Shear -50MPa
   Belt : tension-2.5MPa
   Pulley rim : tension-4.5MPa
   Pulley arms : tension-15MPa. [2+14]

4. (a) Explain 'Hole basis' and shaft basis system, which one is preferred why?
   (b) What are the types of fits? Explain them with the help of neat diagrams. [6+10]

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5. (a) Show by neat sketches the various modes of failure of riveted joints.
   (b) The pull in the tie rod of an iron truss is 50kN.Design a suitable adjustable steel screwed joint. The permissible stresses are 75MPa in tension ; 45MPa in shear; and 90MPa in crushing. [8+8]

6. (a) What is meant by square bearing?
   (b) Specify a suitable deep groove ball bearing for a radial load of 2.5kN and a thrust load of 0.9kN.The operating speed is 3000 r.p.m. Assume steady load, and life of 15000 hours at 95% reliability. Recommend the bearing with the maximum possible bore size. [2+14]

7. (a) Write the expression for static strength, limiting wear load and dynamic load for helical gears and explain the various terms used.
   (b) Two precision cut forged helical gears have 20^0 full depth involute teeth. The angle of helix is 23^0. Permissible static bending stress 100MPa,module 3mm, face width 500mm. The speed of rotation of pinion 900rpm gear ratio 5:1, surface endurance strength 630MPa. Find the transmitted and wear load and state whether the design is safe. [8+8]

8. (a) What is the effect of keyway on
      i. Strength of shaft
      ii. Torsional rigidity of Shaft.
   (b) Make a neat sketch showing two views of a cotter joint and write equations showing the strength of the joint for the most probable methods of failure. [6+10]

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1. (a) What are the various types of keys? Discuss their merits and demerits.
   (b) Select a key for a 100mm dia shaft which transmits 750kW at 1000r.p.m. The allowable shear stress in the key is 100MPa and the a allowable compressive stress is 200MPa .What type of key should be used if the allowable shear stress is 30MPa and the compressive stress is 120 MPa. [8+8]

2. (a) Classify the chains.
   (b) A roller chain operating under steady load conditions, transmits 4kW from a shaft rotating at 600rev/min to one operating at 750rev/min.
      i. Determine the chain required using at least 15 teeth in the sprockets.
      ii. Determine the sprocket pitch diameters.
      iii. Determine the shortest advisable centre distance.
      iv. Determine the number of links of chain required. [4+12]

3. (a) Why leaf spring are made in layers instead of single plate?
   (b) Design a spring for a spring-loaded safety valve for the following conditions. operating pressure 10 bar. Diameter of the valve seat 100mm. Design shear stress for the spring material is 400N/mm^2. Modulus of rigidity is 8×10^4N/mm^2. The spring is to be kept in a casing of 120mm inner diameter and 350mm long. The spring should be at maximum lift to 6mm,when the pressure is at 11bar. [4+12]

4. (a) Distinguish between "Hydrodynamic lubrication" and "Hydrostatic bearings".
   (b) A shaft rotating at constant speed is subjected to variable load. The bearings supporting the shaft are subjected to stationary equivalent radial load of 3kN for 10% of time, 2kN for 20% of time,1kN for 30% of time and no load for remaining time of cycle. If the total life excepted for the bearing is 20×10^6 revolutions at 95% reliability, calculate dynamic load rating of the ball bearing. [4+12]

5. The following results were obtained in a tensile test on a mild steel specimen of original diameter 20 mm and gauge length 40 mm.
   Load at limit of proportionality = 80 kN
   Extension at 80 kN load = 0.048 mm
   Load at yield point = 85 kN
   Maximum load = 150 kN
   When the two parts were fitted together after being broken, the length was found

to be 55.6 mm and the diameter at the neck was 15.8 mm. Calculate young's modulus, yield stress, ultimate tensile stress, percentage elongation and percentage reduction in area. [16]

6. (a) Explain the effect of the following factors on the type of fatigue failure.
   i. Type of material
   ii. Range of imposed stress
   iii. Manner of loading.

   (b) Determine the size of a piston rod subjected to a total load of having cyclic fluctuations from 150 kN in compression to 25 kN in tension. The endurance limit is 360 MPa and yield strength is 400 MPa. Take impact factor = 1.25, factor of safety = 1.5, surface finish factor = 0.88 and stress concentration factor = 2.25. [6+10]

7. The cylinder head of a 200 mm × 350 mm compressor is secured by means of 12 studs of rolled mild steel having yield point stress of 350 MPa and endurance limit of 240 MPa. The gas pressure is 1.5 MPa. The initial tension in the bolts, assumed to be equally loaded such that a cylinder pressure of 3 MPa is required for the joint to be on the point of opening. The joint is made leak-proof by using copper gasket, which renders the effect of external load to be half. Determine the size of bolts, if factor of safety is 2 and stress concentration factor is 2.8. [16]

8. A pair of helical gears consists of a 20 teeth pinion meshing with a 100 teeth gear. The pinion rotates at 720 r.p.m. The normal pressure angle is 20^0 while the helix angle is 25^0. The face width is 40 mm and the normal module is 4mm.The pinion as well as the gear are made of steel having ultimate strength of 600MPa and heat treated to a surface hardness of 300B.H.N. The service factor and factor of safety are 1.5 and 2 respectively. Assume that the velocity factor accounts for the dynamic load and calculate the power transmitting capacity of the gears. [16]

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1. (a) Explain the reasons for preferring hollow shafts over solid shafts.
   (b) The cotter joint is commonly used for long pump rods and similar machine members. Design this joint to support a load varying from 28kN in compression. The material for all the components of the joint is steel with the allowable stresses in tension, compression and shear as 50.0N/mm^2,60N/mm^2 and 35 N/mm^2 respectively. [4+12]

2. A concentric spring for an air craft engine valve is to exert a maximum force of 5kN under an axial deflection of 40mm. Both the springs have same free length, same solid length and are subjected to equal maximum shear stress of 500N/mm^2. If the spring index for both the springs is 6, find
   (a) The load shared by each spring
   (b) The main dimensions of both the springs, and
   (c) The number of active coils of each spring. Assume G=$0.8\times10^5 N/mm^2$ and diametral clearance to be equal to the difference between the wire diameters. [16]

3. (a) What are the steps to be followed while designing a machine element?
   (b) A cast iron pulley transmits 15 kW at 350 rpm. The diameter of the pulley is 520mm and it has four straight arms of elliptical cross section in which the major axis is twice the minor axis. Find the dimensions of the arm, if the allowable bending stress is 25 MPa. [6+10]

4. (a) Define the term , "equivalent bearing load".
   (b) Select a suitable spherical roller from SKF series 222C to support a radial load of 4kN and an axial load of 2 kN. Minimum life required is 10,000 hours at 1000 rpm. For the selected bearing find
      i. the expected life under the given loads
      ii. the equivalent load that can be supported with a probability of survival of 95% with 10,000 hrs. [2+14]

5. Design riveted joints for the longitudinal and circumferential seams of a boiler having 1.25m diameter to withstand maximum pressure of 2.5N/mm^2.
   Assume Tensile stress in plates = 100 MPa, Shear stress in rivets = 75 MPa and bearing stresses in rivets and plates = 150 MPa. [16]

6. (a) Explain stress concentration with suitable examples.

(b) A steel link having a rectangular section is subjected to a repeated axial load of 50,000 N with a medium shock. Determine the section if the endurance limit be 250 MPa with a design factor 1.5. Take side ratio as 2:1. Size factor may be taken as 0.85 and surface finish factor as 0.88. [6+10]

7. Design a V-belt drive actuated by an electric motor and driving a belt conveyor. The power supplied by the electric motor is 4kW and the angular speed at the input shaft is 150rad/sec.The speed ratio of the drive is to be approximately 2.8. The drive will be used for two shifts daily and subjected to a moderately varying load with a start up over load of 150%. [16]

8. A motor shaft rotating at 1500rpm had to transmit 15kW to a low speed shaft with a speed reduction of 3:1. The teeth are 14^0 involute with 24 teeth on the pinion. Both the pinion and spur gear are made of steel with a maximum safe stress of 200MPa. A safe stress of 40MPa may be taken for the shaft on which the gear is mounted and for the key.
Design a spur gear drive to suit the above conditions. Also sketch the spur gear drive. Assume starting torque to be 25% higher than the running torque. [16]

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1. (a) Select suitable materials for the manufacture of the following:
   i. Machine tool spindle
   ii. Valve spring
   iii. Condenser tubes
   iv. Connecting rod.
   (b) What are alloy steels? Discuss the effect of adding different alloying elements in steel. [4+12]

2. (a) Explain the following methods of reducing stress concentration.
   i. Drilled holes
   ii. Using large fillet radius
   iii. Added grooves
   (b) A shaft is made of steel with ultimate tensile strength 700 MPa and yield point 420 MPa is subjected to a torque varying from 200N m anti-clockwise to 600 N m clockwise. Calculate the diameter of the shaft if the factor of safety is 2 and it is based on the yield point and the endurance strength in shear.[6+10]

3. (a) What is herringbone gear? State its applications.
   (b) A pair of helical gear has 20^0 stub teeth in the diameteral plane. Helix angle is 45^0. The pinion rotates at 8,000rpm and transmits 12kW. Gear ratio is 4:1.Safe static stress for the material for pinion and gear 100MPa.The BHN for the pinion 300 and that of gear 200.Find the module and face width , if the center distance is 200mm. And check the design for dynamic load and wear strength if error is 0.01mm. [4+12]

4. (a) What requirements must be satisfied by a spring?
   (b) A weight of 800N is to drop on the center of a planet from a height of 30cm. The planet is supported on four helical springs. Assuming that deflection allowed for each spring is 6cm, spring index of 5 and maximum allowable stress equal to $4000kg/cm^2$; determine the diameter of wire, outside diameter of the coils and the number of active coils. [4+12]

5. (a) Compare ball and roller bearings.
   (b) The rolling contact ball bearing are to be selected to support the overhung countershaft. The shaft speed is 720r.p.m.The bearing are to have 99% reliability corresponding to a life of 24000 hours.The bearing is subjected to an

equivalent radial load of 1kN. Consider life adjustment factors for operating condition and material as 0.9 and 0.85 respectively. Find the basic dynamic load rating of the bearing from manufacturer's catalogue, specified at 90% reliability. [4+12]

6. Power is transmitted to a shaft supported on bearings , 900mm apart ,by a belt drive, running on a 450mm pulley, which overhangs the right bearing by 200mm.Power is transmitted from the shaft through a belt drive, running on a 250mm pulley ,located mid-way between the bearings .The belt drives are at right angle to each other , and the ratio of belt tensions is 3; with the maximum tension in both the belts being limited to 2kN. Determine the diameter of the shaft ,assuming permissible stress as 60MPa. Indicate the assumptions made, if any. Draw the BM & S.F diagrams. [16]

7. A CI flat pulley transmits 20kW at a sped of 560 rpm. The pulley overhangs the nearest bearing by 200mm. assuming the ratio of the belt tension as 2: determine

   (a) Shaft diameter

   (b) Pulley diameter and

   (c) Cross section of eight arms. [16]

8. (a) What are the relative advantages and disadvantages of welded joints over riveted joints?

   (b) A 125 × 95 × 10 mm angle is joined to a frame by two parallel fillet welds along the edge of 125 mm length. If the angle is subjected to a static load of 180 kN, find the length of weld at the top and bottom. The allowable static load per mm weld length is 430N. [8+8]

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