GOVT. POLYTECHNIC JAJPUR, RAGADI

QUESTION BANK

DESIGN OF MACHINE ELEMENTS

5^{TH} SEMESTER, MECHANICAL

Module 1

Introduction

SHORT ANSWER TYPE QUESTIONS (2 MARKS AND 5 MARKS)

1. How do you classify materials for engineering use?
2. What do you mean by 20C8.
3. What do you mean by factor of safety?
4. Formulate factor of safety for ductile and brittle materials.
5. List the important factors that influence the magnitude of factor of safety.
6. What is meant by working stress and how it is calculated from the ultimate stress or yield stress of a material?
7. Define the terms load and state various types of loads.
8. Define stress and strain. Discuss the various types of stresses and strain.
9. Draw and explain stress strain diagram for mild steel.
10. Draw stress strain diagram for cast iron.
11. What are the general modes of failure?
12. What are the factors to be considered for the selection of materials for the design of machine elements?
13. Distinguish clearly amongst cast iron, wrought iron and steel regarding their constituents and properties.
14. How is grey cast iron designated in Indian standards?
15. Define plain carbon steel. How it is designated according to Indian standards?
16. What are the common materials used in Mechanical Engineering Design? How can the properties of steel be improved?

LONG QUESTIONS (8 MARKS)

1. Write in details the general procedures followed in machine design

2. Define ‘mechanical property’ of an engineering material. State any six mechanical properties, give their definitions.
3. How cast iron is obtained? Classify and explain different types of cast irons.
4. State and explain the factors governing the design of machine elements.
5. Define the following properties of a material :
    a. Ductility, (*ii*) Toughness, (*iii*) Hardness, and (*iv*) Creep.
6. Enumerate the most commonly used engineering materials and state at least one important property and one application of each.

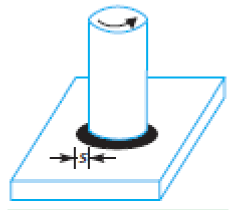
Module 2

Design of fastening elements

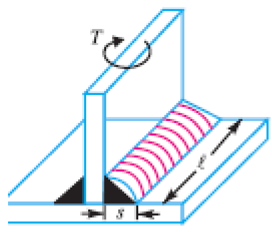
SHORT ANSWER TYPE QUESTIONS (2 MARKS AND 5 MARKS)

1. What do you mean by permanent fastening and temporary fastening?
2. Write down the materials used for making rivets.
3. Classify rivet heads according to I.S.
4. What are the types of riveted joints?
5. Draw a double strap double riveted butt joint.
6. What do you mean by pitch and diagonal pitch in a riveted joint?
7. What do you mean by caulking and fullering?
8. List out the various modes of failure of riveted joint.
9. What do you mean by strength of a riveted joint?
10. How efficiency of a riveted joint is calculated?
11. Write down the Assumptions in Designing Boiler Joints.
12. Write down the advantages of welded joint over riveted joint.
13. List down the types of welded joint.
14. What is a lap joint? Classify it.
15. What is butt joint? List out various butt joints.
16. A plate 100 mm wide and 10 mm thick is to be welded to another plate by means of double parallel fillets. The plates are subjected to a static load of 80 kN. Find the length of weld if the permissible shear stress in the weld does not exceed 55 MPa.

17. A 50 mm diameter solid shaft is welded to a flat plate by 10 mm fillet weld as shown in Fig. Find the maximum torque that the welded joint can sustain if the maximum shear stress intensity in the weld material is not to exceed 80 MPa.



18. A plate 1 m long, 60 mm thick is welded to another plate at right angles to each other by 15 mm fillet weld, as shown in Fig. Find the maximum torque that the welded joint can sustain if the permissible shear stress intensity in the weld material is not to exceed 80 MPa.



19. Sketch and discuss the various types of welded joints used in pressure vessels. What are the considerations involved?
20. What are the assumptions made in the design of welded joint?

<u>LONG QUESTIONS (8 MARKS)</u>

1. A Double riveted lap joint is made between 15 mm thick plates. The rivet diameter and pitch are 25 mm and 75 mm respectively. If the ultimate stresses are 400 MPa in tension, 320 MPa in shear and 640 MPa in crushing, find the minimum force per pitch which will rupture the joint. If the above joint is subjected to a load such that the factor of safety is 4, find out the actual stresses developed in the plates and the rivets.
2. Find the efficiency of the following riveted joints: A) Single riveted lap joint of 6 mm plates with 20 mm diameter rivets having a pitch of 50 mm. B) Double riveted lap joint of 6 mm plates with 20 mm diameter rivets having a pitch of 65 mm. Assume

Permissible tensile stress in plate = 120 MPa

Permissible shearing stress in rivets = 90 MPa

Permissible crushing stress in rivets = 180 MPa

3. A double riveted double cover butt joint in plates 20 mm thick is made with 25 mm diameter rivets at 100 mm pitch. The permissible stresses are : σt = 120 MPa; τ = 100 MPa; σc = 150 MPa.

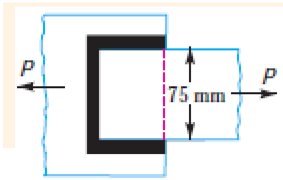
Find the efficiency of joint, taking the strength of the rivet in double shear as twice than that of single shear.

4. A double riveted lap joint with zig-zag riveting is to be designed for 13 mm thick plates. Assume σt = 80 MPa ; τ = 60 MPa ; and σc = 120 MPa. State how the joint will fail and find the efficiency of the joint.
5. Two plates of 7 mm thick are connected by a triple riveted lap joint of zig-zag pattern. Calculate the rivet diameter, rivet pitch and distance between rows of rivets for the joint. Also state the mode of failure of the joint. The safe working stresses are as follows : σt = 90 MPa ; τ = 60 MPa ; and σc = 120 MPa.
6. Two plates of 10 mm thickness each are to be joined by means of a single riveted double strap butt joint. Determine the rivet diameter, rivet pitch, strap thickness and efficiency of the joint. Take the working stresses in tension and shearing as 80 MPa and 60 MPa respectively.
7. Design a double riveted butt joint with two cover plates for the longitudinal seam of a boiler shell 1.5 m in diameter subjected to a steam pressure of 0.95 N/mm2. Assume joint efficiency as 75%, allowable tensile stress in the plate 90 MPa ; compressive stress 140 MPa ; and shear stress in the rivet 56 MPa.

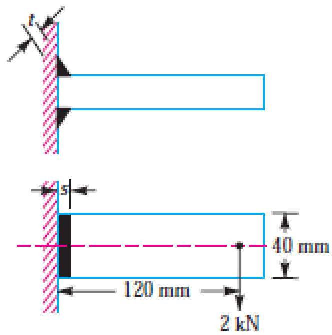
8. Design the longitudinal joint for a 1.25 m diameter steam boiler to carry a steam pressure of 2.5 N/mm2. The ultimate strength of the boiler plate may be assumed as 420 MPa, crushing strength as 650 MPa and shear strength as 300 MPa. Take the joint efficiency as 80%. Sketch the joint with all the dimensions. Adopt the suitable factor of safety.

9. A plate 100 mm wide and 12.5 mm thick is to be welded to another plate by means of parallel fillet welds. The plates are subjected to a load of 50 kN. Find the length of the weld so that the maximum stress does not exceed 56 MPa. Consider the joint first under static loading and then under fatigue loading.

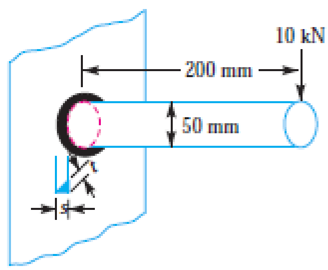
10. A plate 75 mm wide and 12.5 mm thick is joined with another plate by a single transverse weld and a double parallel fillet weld as shown in Fig. The maximum tensile and shear stresses are 70 MPa and 56 MPa respectively. Find the length of each parallel fillet weld, if the joint is subjected to both static and fatigue loading.



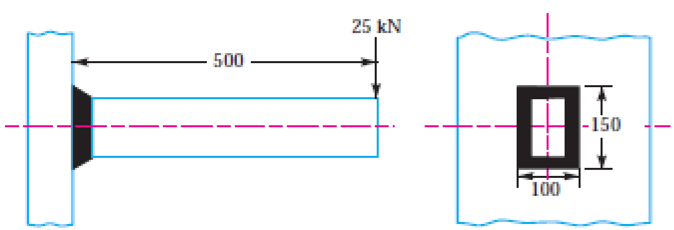
11. A welded joint as shown in Fig is subjected to an eccentric load of 2 kN. Find the size of weld, if the maximum shear stress in the weld is 25 MPa.



12. A 50 mm diameter solid shaft is welded to a flat plate as shown in Fig. If the size of the weld is 15 mm, find the maximum normal and shear stress in the weld.



13. A rectangular cross-section bar is welded to a support by means of fillet weld as shown in Fig. Determine the size of the welds, if the permissible shear stress in the weld is limited to 75 MPa.



All dimensions in mm

14. What is an eccentric loaded welded joint? Discuss the procedure for designing such a joint.

Module 3

Design of shafts and Keys

SHORT ANSWER TYPE QUESTIONS (2 MARKS AND 5 MARKS)

1. What is the function of a shaft?
2. What is an axle?
3. What are the materials used for shaft? State their properties.
4. List down the stresses that a shaft is subjected to while in operation.
5. A line shaft rotating at 200 r.p.m. is to transmit 20 kW. The shaft may be assumed to be made of mild steel with an allowable shear stress of 42 MPa. Determine the diameter of the shaft, neglecting the bending moment on the shaft.
6. A solid shaft is transmitting 1 MW at 240 r.p.m. Determine the diameter of the shaft if the maximum torque transmitted exceeds the mean torque by 20%. Take the maximum allowable shear stress as 60 MPa.
7. Discuss the various types of shafts and the standard sizes of transmissions shafts.
8. How the shaft is designed when it is subjected to twisting moment only?
9. Define equivalent twisting moment and equivalent bending moment. State when these two terms are used in design of shafts.
10. What do you understand by torsional rigidity and lateral rigidity?
11. A hollow shaft has greater strength and stiffness than solid shaft of equal weight. Explain.
12. Under what circumstances are hollow shafts preferred over solid shafts?
13. What is the function of a key?
14. List down various types of keys. State their applications.
15. What do you mean by splines?
16. Write a short note on effect of keyways.
17. Write short note on the splined shaft covering the points of application, different types and method of manufacture.

LONG QUESTIONS (8 MARKS)

1. Find the diameter of a solid steel shaft to transmit 20 kW at 200 r.p.m. The ultimate shear stress for the steel may be taken as 360 MPa and a factor of safety as 8. If a hollow shaft is to be used in place of the solid shaft, find the inside and outside diameter when the ratio of inside to outside diameters is 0.5.

2. A pair of wheels of a railway wagon carries a load of 50 kN on each axle box, acting at a distance of 100 mm outside the wheel base. The gauge of the rails is 1.4 m. Find the diameter of the axle between the wheels, if the stress is not to exceed 100 MPa.
3. A solid circular shaft is subjected to a bending moment of 3000 N-m and a torque of 10 000 N-m. The shaft is made of 45 C 8 steel having ultimate tensile stress of 700 MPa and a ultimate shear stress of 500 MPa. Assuming a factor of safety as 6, determine the diameter of the shaft.
4. A shaft supported at the ends in ball bearings carries a straight tooth spur gear at its mid span and is to transmit 7.5 kW at 300 r.p.m. The pitch circle diameter of the gear is 150 mm. The distances between the centre line of bearings and gear are 100 mm each. If the shaft is made of steel and the allowable shear stress is 45 MPa, determine the diameter of the shaft. Show in a sketch how the gear will be mounted on the shaft; also indicate the ends where the bearings will be mounted? The pressure angle of the gear may be taken as 20°.
5. A shaft made of mild steel is required to transmit 100 kW at 300 r.p.m. The supported length of the shaft is 3 metres. It carries two pulleys each weighing 1500 N supported at a distance of 1 metre from the ends respectively. Assuming the safe value of stress, determine the diameter of the shaft.
6. A line shaft is driven by means of a motor placed vertically below it. The pulley on the line shaft is 1.5 metre in diameter and has belt tensions 5.4 kN and 1.8 kN on the tight side and slack side of the belt respectively. Both these tensions may be assumed to be vertical. If the pulley be overhang from the shaft, the distance of the centre line of the pulley from the centre line of the bearing being 400 mm, find the diameter of the shaft. Assuming maximum allowable shear stress of 42 MPa.
7. A steel spindle transmits 4 kW at 800 r.p.m. The angular deflection should not exceed 0.25° per metre of the spindle. If the modulus of rigidity for the material of the spindle is 84GPa, find the diameter of the spindle and the shear stress induced in the spindle.
8. Design the rectangular key for a shaft of 50 mm diameter. The shearing and crushing stresses for the key material are 42 MPa and 70 MPa.
9. A 45 mm diameter shaft is made of steel with a yield strength of 400 MPa. A parallel key of size 14 mm wide and 9 mm thick made of steel with a yield strength of 340 MPa is to be used. Find the required length of key, if the shaft is loaded to transmit the maximum permissible torque. Use maximum shear stress theory and assume a factor of safety of 2.
10. A 15 kW, 960 r.p.m. motor has a mild steel shaft of 40 mm diameter and the extension being 75 mm. The permissible shear and crushing stresses for the mild steel key are 56 MPa and 112 MPa.

Design the keyway in the motor shaft extension. Check the shear strength of the key against the normal strength of the shaft.

Module 4

Design of Coupling

SHORT ANSWER TYPE QUESTIONS (2 MARKS AND 5 MARKS)

1. What are the purposes of using couplings?
2. Write down the requirements of a good shaft coupling.
3. Classify shaft couplings.
4. Write a short note on sleeve or muff coupling.
5. What is Clamp or Compression Coupling? Write down its advantages.
6. What is flange coupling?
7. Discuss the function of a coupling. Give at least three practical applications.
8. How does the working of a clamp coupling differ from that of a muff coupling? Explain.

LONG QUESTIONS (8 MARKS)

1. Design and make a neat dimensioned sketch of a muff coupling which is used to connect two steel shafts transmitting 40 kW at 350 r.p.m. The material for the shafts and key is plain carbon steel for which allowable shear and crushing stresses may be taken as 40 MPa and 80 MPa respectively. The material for the muff is cast iron for which the allowable shear stress may be assumed as 15 MPa.
2. Design a clamp coupling to transmit 30 kW at 100 r.p.m. The allowable shear stress for the shaft and key is 40 MPa and the number of bolts connecting the two halves are six. The permissible tensile stress for the bolts is 70 MPa. The coefficient of friction between the muff and the shaft surface may be taken as 0.3.
3. Design a cast iron protective type flange coupling to transmit 15 kW at 900 r.p.m. from an electric motor to a compressor. The service factor may be assumed as 1.35. The following permissible stresses may be used: Shear stress for shaft, bolt and key material = 40 MPa Crushing stress for bolt and key = 80 MPa, Shear stress for cast iron = 8 MPa. Draw a neat sketch of the coupling.

4. Design and draw a protective type of cast iron flange coupling for a steel shaft transmitting 15 kW at 200 r.p.m. and having an allowable shear stress of 40 MPa. The working stress in the bolts should not exceed 30 MPa. Assume that the same material is used for shaft and key and that the crushing stress is twice the value of its shear stress. The maximum torque is 25% greater than the full load torque. The shear stress for cast iron is 14 MPa.
5. Design and draw a cast iron flange coupling for a mild steel shaft transmitting 90 kW at 250 r.p.m. The allowable shear stress in the shaft is 40 MPa and the angle of twist is not to exceed 1° in a length of 20 diameters. The allowable shear stress in the coupling bolts is 30 MPa.
6. Describe, with the help of neat sketches, the types of various shaft couplings mentioning the uses of each type.

Module 4

Design a closed coil helical spring

SHORT ANSWER TYPE QUESTIONS (2 MARKS AND 5 MARKS)

1. Define a spring.
2. State various applications of spring.
3. Classify springs and state their applications.
4. What are the advantages of helical springs over other springs?
5. Write down the materials that are used to manufacture springs.
6. What do you mean by active turns and total number of turns?
7. Write a short note on Wahl’s stress factor.
8. Derive an expression for load stress relation in a helical compression spring.
9. Derive an expression for load deflection relation in a helical compression spring.
10. Briefly explain surge in springs and how it can be eliminated.
11. Classify springs according to their shapes. Draw neat sketches indicating in each case whether stresses are induced by bending or by torsion.

LONG QUESTIONS (8 MARKS)

1. Explain these terms used in a compression spring. (i) solid length (ii) free length (iii) spring index (iv) spring rate (v) pitch.

   Derive an expression for each.

2. A compression coil spring made of an alloy steel is having the following specifications : Mean diameter of coil = 50 mm ; Wire diameter = 5 mm ; Number of active coils = 20. If this spring is subjected to an axial load of 500 N ; calculate the maximum shear stress (neglect the curvature effect) to which the spring material is subjected.
3. A helical spring is made from a wire of 6 mm diameter and has outside diameter of 75 mm. If the permissible shear stress is 350 MPa and modulus of rigidity 84 kN/mm2, find the axial load which the spring can carry and the deflection per active turn.
4. Design a spring for a balance to measure 0 to 1000 N over a scale of length 80 mm. The spring is to be enclosed in a casing of 25 mm diameter. The approximate number of turns is 30. The modulus of rigidity is 85 kN/mm2. Also calculate the maximum shear stress induced.
5. A mechanism used in printing machinery consists of a tension spring assembled with a preload of 30 N. The wire diameter of spring is 2 mm with a spring index of 6. The spring has 18 active coils. The spring wire is hard drawn and oil tempered having following material properties: Design shear stress = 680 MPa Modulus of rigidity = 80 kN/mm2 Determine : 1. the initial torsional shear stress in the wire; 2. spring rate; and the force to cause the body of the spring to its yield strength.
6. Design a helical compression spring for a maximum load of 1000 N for a deflection of 25 mm using the value of spring index as 5. The maximum permissible shear stress for spring wire is 420 MPa and modulus of rigidity is 84 kN/mm2.
7. Design a close coiled helical compression spring for a service load ranging from 2250 N to 2750 N. The axial deflection of the spring for the load range is 6 mm. Assume a spring index of 5. The permissible shear stress intensity is 420 MPa and modulus of rigidity, G = 84 kN/mm2. Neglect the effect of stress concentration. Draw a fully dimensioned sketch of the spring, showing details of the finish of the end coils.