# SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar, Kattankulathur – 603 203

## DEPARTMENT OF MECHANICAL ENGINEERING

## QUESTION BANK

**V- SEMESTER**

**ME3564 – DESIGN OF MACHINE ELEMENTS**

**Regulation – 2023**

**Academic Year 2025 –2026**

*Prepared by*

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# SRM VALLIAMMAI ENGINEERING COLLEGE

**SRM Nagar, Kattankulathur – 603 203**

## QUESTION BANK

**SUBJECT/SUBJECT CODE : DESIGN OF MACHINE ELEMENT/ ME3564**
**SEM/YEAR : V SEM/III YEAR**

## UNIT I - FUNDAMENTAL CONCEPTS IN DESIGN

Design process-factors influencing machine design, selection of materials based on mechanical properties - Preferred numbers– Direct, Bending and torsional stress equations – Impact and shock loading – calculation of principle stresses for various load combinations, eccentric loading – curved beams – crane hook and 'C' frame- Factor of safety - theories of failure – Design based on strength and stiffness – stress concentration – Design for variable loading.

### PART - A (2Marks)

| S.No | QUESTIONS | LEVEL | COMPETENCE |
|---|---|---|---|
| 1. | Define "Design". | BT1 | Remember |
| 2. | List out the various phases of design process. | BT2 | Understand |
| 3. | List down the factors influencing machine design. | BT1 | Remember |
| 4. | Define optimum design. | BT1 | Remember |
| 5. | List any four mechanical properties. | BT1 | Remember |
| 6. | Describe material properties hardness, stiffness and resilience. | BT2 | Understand |
| 7. | Identify the steel designated as 50C4 as per BIS. | BT1 | Remember |
| 8. | Differentiate between hardness and toughness of materials. | BT1 | Remember |
| 9. | List at least two methods to improve the fatigue strength. | BT2 | Understand |
| 10. | Determine the force required to punch a hole of 20 mm diameter in a 5mm thickness plate with ultimate shear strength of 250 MPa. | BT3 | Apply |
| 11. | Define principal plane. | BT1 | Remember |
| 12. | Define principal stress. | BT2 | Understand |
| 13. | Give example for curved beams. | BT1 | Remember |
| 14. | State the difference between straight beams and curved beams. | BT1 | Remember |
| 15. | Define factor of safety. | BT1 | Remember |
| 16. | How is factor of safety defined for brittle and ductile materials? | BT1 | Remember |
| 17. | List the important factors that influence the magnitude of factor of safety. | BT1 | Remember |
| 18. | State Rankine's theory. | BT1 | Remember |
| 19. | State St. Venant theory of failure. | BT2 | Understand |
| 20. | Define the terms "equivalent torque and equivalent moment". | BT1 | Remember |
| 21. | State the various methods of finding stress concentration factors. | BT1 | Remember |
| 22. | Differentiate between static and variable stresses. | BT1 | Remember |

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| 23. | Differentiate between repeated stress and reversed stress. | BT1 | Remember |
| 24. | Distinguish between alternating stress and fluctuating stress. | BT1 | Remember |
| 25. | Define amplitude stress and stress ratio. | BT1 | Remember |

| | PART - B (16 Marks) | | | |
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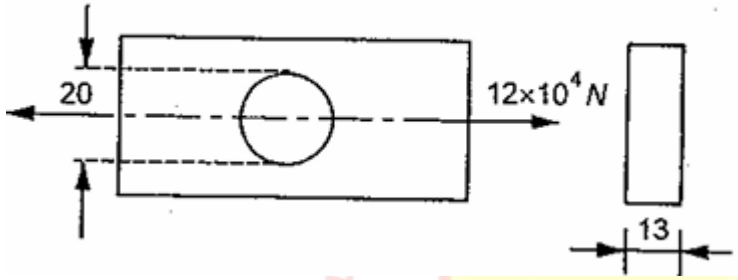
| **S.No** | **QUESTIONS** | **Marks** | **LEVEL** | **COMPETENCE** |
| 1. | A tie bar as shown in Fig.1 has to carry a load of 120000N. What must be the width of the bar 13mm thick if there is a hole of 20mm diameter on its centre line? Working stress for the tie bar is 75 MPa.   Fig.1 | 16 | BT4 | Analyze |
| 2. | An electric motor weighting 500N is mounted on short cantilever beam of uniform rectangular cross section. The weight of motor acts at a distance of 300mm from the support. The depth of the section twice the width. Determine the cross section of the beam. The allowable stress in the beam is 40MPa. | 16 | BT3 | Apply |
| 3. | A hypothetical machine member by 50mm in diameter and 250mm long is supported in one end as cantilever is subjected to various types of loadings as given below. Find the maximum normal stress and maximum shear stress at the top and bottom face of the fixed end in each case. Axial load 15 KN, Transverse load 3KN at the free end and Twisting moment of 1KN-m at the free end, clockwise, while viewing from free end side | 16 | BT4 | Analyze |
| 4. | An unknown weight falls from a distance of 15mm on to a collar rigidly attached to the lower end of a vertical bar 2.5m long and 500 $mm^2$ cross section. The maximum instantaneous extension is | 16 | BT4 | Analyze |

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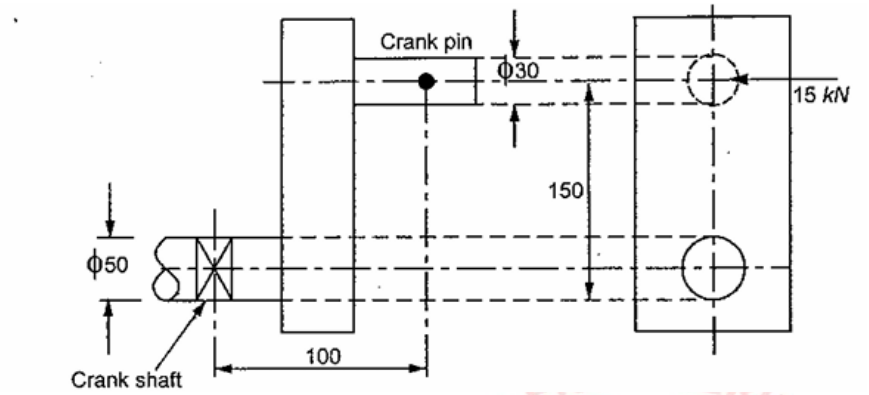
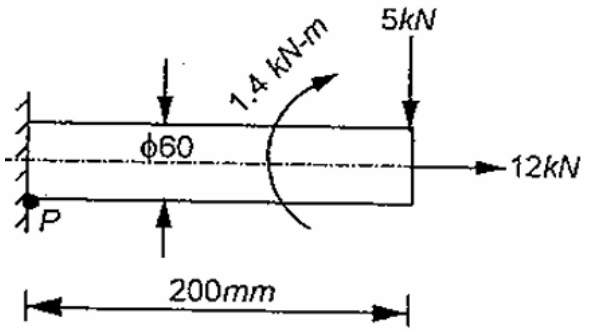
| | 2mm. Find the corresponding stress and the value of the weight falling. E= 2 x $10^5$ MPa. | | | |
| 5. | A crankshaft bearing is loaded as shown in the fig.2. Determine the maximum principal stress, minimum principal stress and maximum shear stress.<br>  <br><br>Fig.2 | 16 | BT4 | Analyze |
| 6. | A cylindrical bar 60mm diameter and 200 mm ling is fixed at one end. At the free end it is loaded as shown in firg.3, with an axial load of 12kN, a downward transverse load of 5kN and a torque of 1.4 kN-m. Calculate the maximum stress at point P of the bar.<br>  <br><br>Fig.3 | 16 | BT4 | Analyze |
| 7. | A steel column, square cross-section of 80mm side as shown in the fig.4 carries a load of 150kN at an eccentricity of 10mm in a plane bisecting the thickness. Find the maximum and minimum intensities of stress in the section. | 16 | BT4 | Analyze |

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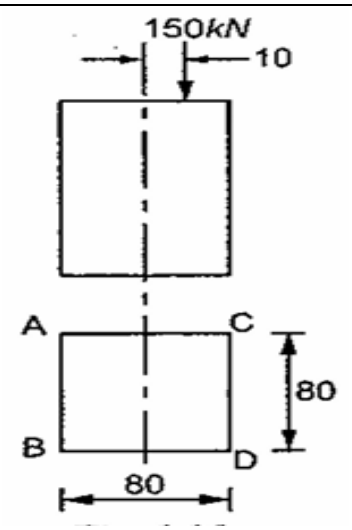
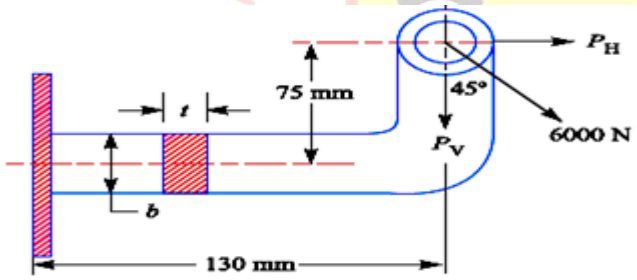
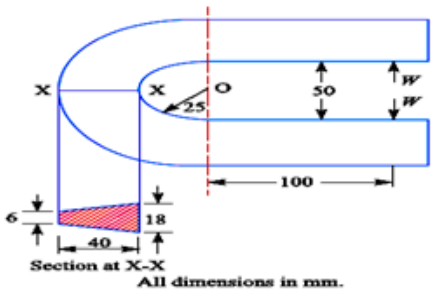
| |  <br>Fig.4 | | | |
| 8. | A mild steel bracket as shown in Fig 5. is subjected to a pull of 6000N acting at 45˚ to its horizontal axis. The bracket has a rectangular section whose depth is twice the thickness. Determine the cross-sectional dimensions of the bracket, if the permissible stress in the materials of the bracket is limited to 60 MPa.<br>  <br>Fig.5 | 16 | BT3 | Apply |
| 9. | The frame of a punch press is shown in fig.6. Find the stress at the inner and outer surface at section X-X of the frame, if W=5000N.<br>  <br>Fig.6 | 16 | BT3 | Apply |

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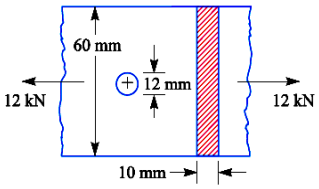
| 10. | The load on a bolt consists of an axial pull of 10kN together with a transverse shear force of 5kN. Find the diameter of bolt required according to 1. Maximum principle stress theory 2. Maximum shear stress theory; 3. Maximum principle strain theory; 4. Maximum strain energy theory; and 5. Maximum distortion energy theory. Take permissible tensile stress at elastic limit = 100 MPa and Poisson's ratio = 0.3. | 16 | BT4 | Analyze |
| 11. | A mild steel shaft of 50mm diameter is subjected to a bending moment of 2000 N-m and a torque T. If the yield point of the steel in tension is 200 MPa, Calculate the maximum value of this torque without causing yielding of the shaft according to 1. The Maximum principle stress; 2. The maximum shear stress and 3. The maximum distortion strain energy theory of yielding. | 16 | BT4 | Analyze |
| 12. | A rectangular plate 60mm x 10mm width a hole 12mm diameter is as shown fig.7 and subjected to a tensile load of 12kN. Find the maximum stress induced.<br>  <br><br>**Fig.7** | 16 | BT4 | Analyze |
| 13. | A machine component is subjected to a flexural stress which fluctuates between +300 MN/m$^2$ and -150 MN/m$^2$. Determine the value of minimum ultimate strength according to 1. Gerber relation; 2. Modified Goodman relation; and 3. Soderberg relation. Take yield strength = 0.55 Ultimate strength; Endurance strength= 0.5 Ultimate strength and factor of safety = 2. | 16 | BT4 | Analyze |
| 14. | A hot rolled bar of steel is subjected to a torsional load varying from -150Nm to 450Nm. Determine the required diameter of the bar using a factor of safety of 1.7. Properties of the material may be assumed as follows. Ultimate tensile stress = 450MPa and Yield stress = 300MPa. | 16 | BT4 | Analyze |

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| 15. | A cantilever beam shown in fig.8 made of C40 steel of circular cross section is subjected to a load that varying from F (Compressive) to 3F (Tensile). Determine the value of F that this beam can withstand. Assume FOS = 2.1, stress concentration factor = 1.42, notch sensitivity factor = 0.3, surface finish factor =0.85, size factor=0.86. | 16 | BT5 | Evaluate |
| 16. | A bar of circular cross-section is subjected to alternating tensile forces varying from a minimum of 200kN to maximum of 500kN. It is to be manufactured of a material with an ultimate tensile strength of 900MPa. 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 | BT5 | Evaluate |
| 17. | A circular bar of 500mm length is supported freely at its two ends. It is acted upon by a central concentrated cyclic load having a minimum value of 20kN and a maximum value of 50kN. Determine the diameter of bar by taking a factor of safety of 1.5, size effect of 0.85, surface finish of 0.9. The material properties of bar are given by ultimate strength of 650 MPa, yield strength of 500 MPa and endurance strength of 350 MPa. | 16 | v | Evaluate |
| 18. | A pulley is keyed to a shaft midway between two bearings. The shaft is made of cold drawn steel for which the ultimate strength is 550 MPa and the yield strength is 400 MPa. The bending moment at the pulley varies from -150N.m to +400 N.m as the torque on the shaft varies from -50N.m to 150 N.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. Take the following values. Factor of safety=1.5, Load correction factors=1 and 0.6 in torsion, size effect factor=0.85 and surface effect factor=0.88 | 16 | BT4 | Analyze |

## UNIT II - SHAFTS AND COUPLINGS

Design of solid and hollow shafts based on strength, rigidity - Rigid and flexible couplings.

**PART - A (2Marks)**

| S.No | QUESTIONS | LEVEL | COMPETENCE |
|---|---|---|---|
| 1. | Define shaft. | BT2 | Understand |
| 2. | List down the types of shafts. | BT1 | Remember |
| 3. | Define simple torsion. | BT1 | Remember |
| 4. | What is simple bending moment? | BT1 | Remember |
| 5. | Write down the formula for finding equivalent twisting moment. | BT1 | Remember |
| 6. | List down the types of rigidity. | BT1 | Remember |
| 7. | What are the different measures followed to control the lateral defelction? | BT1 | Remember |
| 8. | Define the term critical speed. | BT2 | Understand |
| 9. | List out types of stresses are induced in shafts. | BT2 | Understand |
| 10. | Under what circumstances are hollow shaft preferred over solid shafts? | BT2 | Understand |
| 11. | Differentiate between rigid and flexible couplings. | BT2 | Understand |
| 12. | What are possible modes of failure of the pin (bolt) in a flexible coupling? | BT2 | Understand |
| 13. | Discuss the function of a coupling. | BT2 | Understand |
| 14. | Give at least three practical applications of flexible coupling. | BT1 | Remember |
| 15. | Under what circumstances flexible couplings are used? | BT1 | Remember |
| 16. | How does the working of a clamp coupling differ from that of a muff coupling? | BT1 | Remember |
| 17. | Different between keys and splines. | BT2 | Understand |
| 18. | How is a coupling specified? | BT2 | Understand |
| 19. | List the various failures occurred in flange. | BT2 | Understand |
| 20. | What is simple bending moment? | BT2 | Understand |
| 21. | Name any two of the rigid coupling. | BT2 | Understand |
| 22. | Name any two of the flexible coupling. | BT2 | Understand |
| 23. | List the advantage of flexible coupling over rigid coupling. | BT2 | Understand |
| 24. | List out the various materials used for flange coupling. | BT2 | Understand |
| 25. | What are the purposes in machinery for which coupling are used? | BT2 | Understand |

| | PART - B (15 Marks) | | | |
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| **S.No** | **QUESTIONS** | **Marks** | **LEVEL** | **COMPETENCE** |
| 1 | A shaft of 750mm long is subjected to shear stress of 40MPa and has an angle of twist equal to 0.017 radian. Determine the diameter of the shaft. Take $G=0.8x10^5$MPa. | 15 | BT4 | Analyze |
| 2 | A feed pump of a binary vapour cycle is of centrifugal type and delivers 20 $m^3$/min at 750 rpm against a dynamic head of 8m. Determine the power required to drive the motor, if the pump efficiency is 90%. If the maximum torque on the motor shaft is 30% more than the average torque, determine the diameter of the motor shaft. The permissible shear stress in the shaft material should not exceed 50 MPa. | 15 | BT3 | Apply |
| 3 | A solid shaft is subjected to a bending moment of 3.46 kN-m and a torsional moment of 11.5kN-m. the shaft is made of C45 steel and factor of safety is 6. Find the diameter of the shaft. | 15 | BT3 | Apply |
| 4 | Compare the weight, strength and stiffness of a hollow shaft of same internal diameter as that of a solid shaft. The inside diameter of the hollow shaft is being 0.6 times the external diameter. Both shaft have same material and length. | 15 | BT5 | Evaluate |
| 5 | A hollow steel shaft of 500 mm outside diameter and 300mm inside diameter is used to drive a propeller of a marine vessel. The shaft is mounted on bearings 6m apart and it transmits 5600kW at 150rpm. Maximum axial thrust is 500kN and the shaft weights 70kN. Determine maximum shear stress induced and angular twist of the shaft between the bearings. | 15 | BT3 | Apply |
| 6 | A mild steel shaft transmits 20kW at 200 rpm. It carries a central load of 900N and is simply supported between the bearings 2.5m apart. Determine the size of the shaft, if the allowable shear stress is 42 MPa and the maximum tensile or compressive stress is not to exceed 56MPa. | 15 | BT5 | Evaluate |
| 7 | A shaft is supported by two bearings placed 1m apart. A 600mm | 15 | BT4 | Analyze |

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| | diameter pulley is mounted at a distance of 300mm to the right of left hand bearing and this drives a pulley directly below it with the help of belt having maximum tension of 2.25kN. another pulley 400mm diameter is placed 200mm to the left of right hand bearing and is driven with the help of electric motor and belt, which is placed horizontally to the right. The angle of contact for both the pulleys is 180˚ and $\mu = 0.24$. Determine the suitable diameter for a solid shaft, allowing working stress of 63 MPa in tension and 42 MPa in shear for the material of shaft. Assume that the torque on one pulley is equal to that on the other pulley. | | | |
| 8 | A shaft is supported on bearing A and B, 800 mm between centers. A 20˚ straight tooth spur gear having 600mm pitch diameter, is located 200 mm to the right of the left had bearing A, and a 700 mm diameter pulley is mounted 250 mm towards the left of bearing B. The gear is driven by a pinion with a downward tangential force while the pulley drives a horizontal belt having 180˚ angle of wrap. The pulley also serves as a flywheel and weights 2000N. The maximum belt tension is 3000 N and the tension ratio is 3:1. Determine the maximum bending moment and the necessary shaft diameter if the allowable shear stress of the material is 40 MPa. | 15 | BT4 | Analyze |
| 9 | A steel solid shaft transmitting 15kW at 200 rpm is supported on two bearing 750 mm apart and has two gears keyed to it. The pinion having 30 teeth of 5mm module is located 100 mm to the left of the right hand bearing and delivers power horizontally to the right. The gear having 100 teeth of 5mm module is located 150mm to the right of the left hand bearing and receives the power in vertical direction below. Using an allowable stress of 54MPa in shear, determine the diameter of the shaft. | 15 | BT4 | Analyze |
| 10 | Design and draw a neat dimensioned sketch of muff coupling which is used to connect two steel shafts transmitting 40kW at 350 rpm. 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 | 15 | BT3 | Apply |

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| | 80 MPa respectively. The material for the muff is cast iron for which the allowable shear stress may be assumed as 15 MPa. | | | |
| 11 | Design a cast iron protective type flange coupling to transmit 15kW at 900 rpm from an electric motor to a compressor. The service factor may be assumed s 1.35.The following permissible stresses may be used. Shear stress for shaft, bolt and key material=40MPa,Crushing stress for bolt and key=80 MPa, Shear stress for cast iron=8 MPa. | 15 | BT4 | Analyze |
| 12 | Design a cast iron flange coupling for a mild steel shaft transmitting 90 kW at 250 rpm, 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 meters. The allowable shear stress in the coupling bolt is 30 MPa. Take G = 84 kN/mm$^2$ | 15 | BT3 | Apply |
| 13 | Design a bushed-pin type of flexible coupling to connect a pump shaft to a motor shaft transmitting 32kW at 960 rpm. The overall torque is 20% more than mean torque. The material properties are as follows. The allowable shear and crushing stress for the shaft and key material is 40 MPa and 80 MPa. The allowable shear stress for cast iron is 15 MPa. The allowable bearing pressure for rubber bush is 0.8N/mm$^2$.The material of the pin is same as that of shaft and key. | 15 | BT4 | Analyze |
| 14 | Design and draw a protective type of cast iron flange coupling for a steel shaft transmitting 15kW at 200 rpm 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 the 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. | 15 | BT4 | Analyze |
| 15 | Design a bushed-pin type flexible coupling for connecting a motor shaft to a pump shaft for the following service conditions : Power to be transmitted = 40 kW ; speed of the motor shaft = 1000 r.p.m. ; diameter of the motor shaft = 50 mm ; diameter of the pump shaft = 45 mm. | 15 | BT5 | Evaluate |

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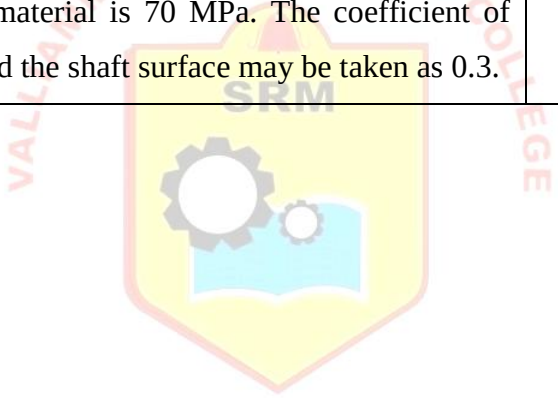
| 16 | Design a muff coupling to connect two shafts transmitting 40kW at 120 rpm. The permissible shear and crushing stress for the shaft and key material (mild steel) are 30 MPa. and 80MPa. respectively. The material of muff is cast iron with permissible shear stress of 15 MPa. Assume that the maximum torque transmitted is 25 per cent greater than mean torque. | 15 | BT5 | Evaluate |
| 17 | Design a muff coupling for the shaft to transmit 35kW at 350rpm. The safe shear stress for the steel shaft is $50N/mm^2$ and for the cast iron muff it is $15N/mm^2$. The allowable shear and crushing stresses for the key material are $42N/mm^2$ and $120N/mm^2$ respectively. | 15 | BT4 | Analyze |
| 18 | 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. | 15 | BT5 | Evaluate |



## UNIT III - TEMPORARY AND PERMANENT JOINTS

Bolted joints with eccentric loading, Knuckle joints, and Cotter joints – Welded joints, Stress in weld joint, transverse and Longitudinal weld joint-riveted joints, Lab joint and Butt joint.

**PART - A (2Marks)**

| S.No | QUESTIONS | LEVEL | COMPETENCE |
|---|---|---|---|
| 1. | Explain how is a bolt designated? | BT1 | Remember |
| 2. | Discuss, why are ACME treads preferred over square thread for power | BT2 | Understand |
| 3. | What do you understand preloading of bolts? | BT2 | Understand |
| 4. | Explain the meaning of bolt M24 x 2. | BT1 | Remember |
| 5. | What do you understand by the single start and double start threads? | BT2 | Understand |
| 6. | Which type of thread would you suggest for the following?<br>a. Lead screw for a lathe<br>b. Fastening of a bracket to a wall<br>c. Screw jack. | BT2 | Understand |
| 7. | What is known as "bolt of uniform strength"? | BT1 | Remember |
| 8. | List out the materials used for rivets. | BT1 | Remember |
| 9. | What do you understand by the term efficiency of a riveted joint? | BT2 | Understand |
| 10. | What do you understand by the term welded joint? | BT1 | Remember |
| 11. | What is the total shear in a double strap butt joint with equal length of straps? | BT1 | Remember |
| 12. | Differentiate with a neat sketch the fillet welds subjected to parallel loading. | BT1 | Remember |
| 13. | What is the minimum size for fillet weld? If required weld size from strength consideration is too small how will you fulfill the condition of minimum weld size? | BT1 | Remember |
| 14. | What are the advantages of welded joints compared with riveted joints? | BT2 | Understand |
| 15. | List out the different types of cotter joints? | BT1 | Remember |
| 16. | Distinguish between cotter joint and knuckle joint. | BT2 | Understand |
| 17. | List out the various applications of a cottered joint. | BT1 | Remember |
| 18. | Why gibs are used in a cotter joint? Explain | BT1 | Remember |
| 19. | Name the possible modes of failure of riveted joint. | BT1 | Remember |
| 20. | What is a cotter joint? Explain with the help of a neat sketch, how a cotter joint is made? | BT1 | Remember |
| 21. | What are the various permanent and detachable fastenings? | BT2 | Understand |
| 22. | Enumerate the different types of riveted joints and rivets. | BT2 | Understand |
| 23. | What is an economical joint and where does it find applications? | BT2 | Understand |
| 24. | What do you understand by the term ‘efficiency of a riveted joint’? | BT2 | Understand |

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|---|---|---|---|
| 25. | What is an eccentric riveted joint? | BT2 | Understand |

| | PART - B (15 Marks) | | | |
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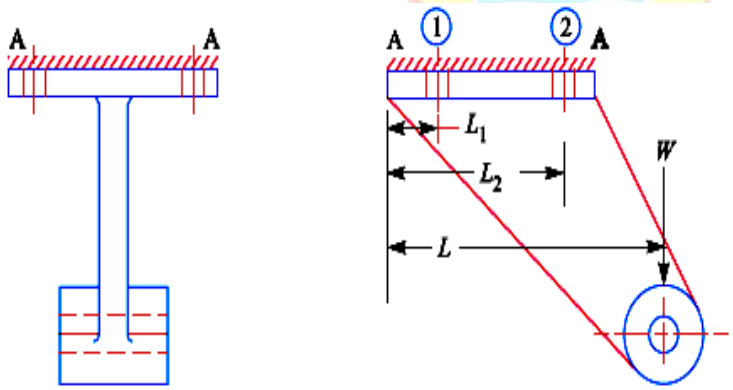
| **S.No** | **QUESTIONS** | **Marks** | **LEVEL** | **COMPETENCE** |
| 1 | The cylinder head of steam engine with 250mm bore is fastened by eight stud bolts made of 30C8 steel. Maximum pressure inside the cylinder is 1MPa. Determine the bolt size and approximate tightening torque. Take 20% overload. Assume yield stress = 300MPa. For bolt material. | 15 | BT3 | Apply |
| 2 | A cast iron cylinder head is fastened to a cylinder of 500mm bore with 8 stud bolts. The maximum pressure inside the cylinder is 2MPa. The stiffness of part is thrice the stiffness of the bolt. What should be the initial tightening load so that the point is leak proof at maximum pressure? Also choose a suitable bolt for the above application. | 15 | BT3 | Apply |
| 3 | A bracket as shown in fig.1. supports a load of 30kN. Determine the size of bolts, if the maximum allowable tensile stress in the bolt material is 60 MPa. the distances are: $L_1$ = 80 mm, $L_2$ = 250 mm and L = 500mm   Fig.1 | 15 | BT3 | Apply |

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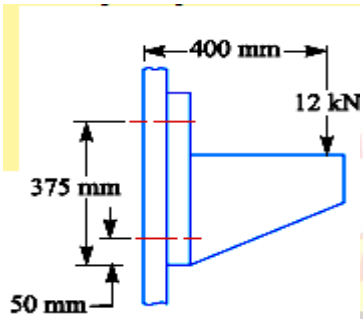
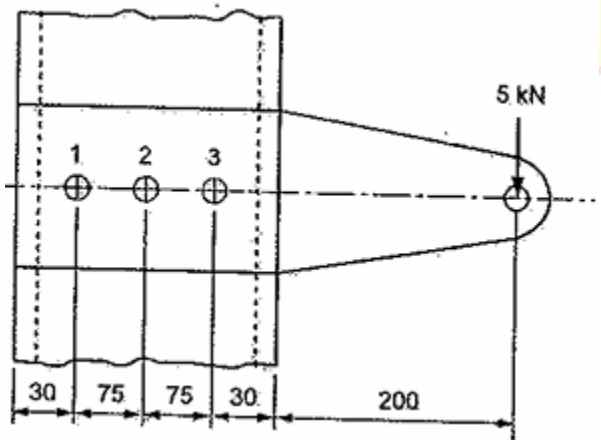
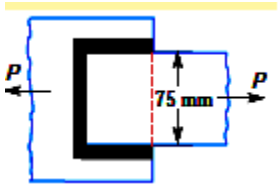
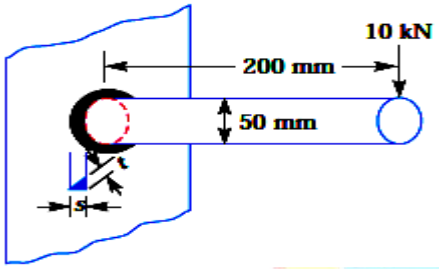
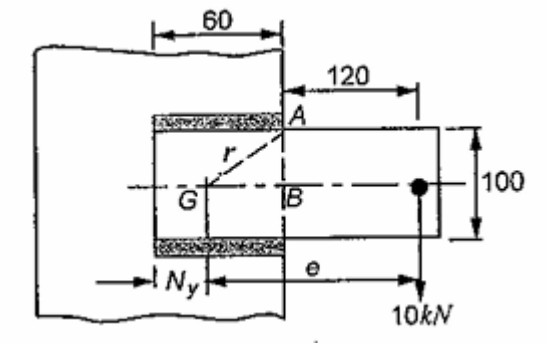
| 4 | For supporting the travelling crane in a workshop, the brackets are fixed on steel columns as shown in fig.2 The maximum load that comes on the bracket is 12kN acting vertically at a distance of 400 mm from the face of the column. The vertical face of the bracket is secured to a column by four bolts, in two rows (two in each row) at a distance of 50 mm from the lower edge of the bracket; determine the size of the bolts if the permissible value of the tensile stress for the bolt material is 84 MPa. Also find the cross-section of the arm of the bracket which is rectangular.<br>  <br><br>Fig.2 | 15 | BT3 | Apply |
| 5 | Find a suitable bolt for the application shown in fig.3<br>  <br><br>Fig.3 | 15 | BT3 | Apply |

| | | | | |
|---|---|---|---|---|
| 6 | 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.4. The maximum tensile and shear stress are 70 MPa and 56 MPa respectively. Calculate the length of each parallel fillet weld if the joint is subjected to both static and fatigue loading.<br>  <br><br>Fig.4 | 15 | BT5 | Evaluate |
| 7 | A 50mm diameter solid shaft is welded to a flat plate as shown in fig.5. If the size of the weld is 15 mm; Calculate the maximum normal and shear stress in the weld.<br>  <br><br>Fig.5 | 15 | BT5 | Evaluate |
| 8 | A bracket shown in fig.6 caries a load of 10kN. Find the size of the weld if the allowable shear stress is not to exceed 75MPa.<br>  <br><br>Fig.6 | 15 | BT5 | Evaluate |
| 9 | Design and draw a cotter joint to support a load varying from 30kN in compression to 30kN in tension. The material used is carbon steel | 15 | BT5 | Evaluate |

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| | for which the following allowable stress may be used. The load is applied statically. Tensile stress = compressive stress = 50 MPa; Shear stress = 35 MPa and crushing stress = 90 MPa. | | | |
| 10 | Design a sleeve and cotter joint to resist a tensile load of 60 kN. All parts of the joint are made of the same material with the following allowable stresses: $\sigma_t$ = 60 MPa; $\tau$=70 MPa; and $\sigma_c$ = 125 MPa. | 15 | BT4 | Analyze |
| 11 | Design a knuckle joint for a tie rod of a circular cross section to sustain a maximum pull of 70kN.The ultimate, strength of the material of the rod against tearing is 420 Mpa. The ultimate tensile and shearing strength of the pin material are 510 MPa and 396 MPa respectively. Determine the tie rod section and pin section. Take factor of safety=6. | 15 | BT4 | Analyze |
| 12 | Design a knuckle joint to transmit 150 kN. The design stresses may be taken as 75 MPa. in tension, 60 MPa in shear and 150 MPa in compression. | 15 | BT4 | Analyze |
| 13 | A single riveted lap joint is made in 15 mm thick plates with 20 mm diameter rivets. Determine the strength of the joint, if the pitch of rivets is 60 mm. Take $\sigma t$ = 120 MPa; $\tau$ = 90 MPa and $\sigma c$ = 160 MPa | 15 | BT5 | Evaluate |
| 14 | A double riveted lap joint with chain riveting is to be made for joining two plates 10 mm thick. The allowable stresses are : $\sigma t$ = 60 MPa ; $\tau$ = 50 MPa and $\sigma c$ = 80 MPa. Find the rivet diameter, pitch of rivets and distance between rows of rivets. Also find the efficiency of the joint. | 15 | BT5 | Evaluate |
| 15 | A triple riveted lap joint with zig-zag riveting is to be designed to connect two plates of 6 mm thickness. Determine the dia. of rivet, pitch of rivets and distance between the rows of rivet. Indicate how the joint will fail. Assume : $\sigma t$ = 120 MPa ; $\tau$ = 100 MPa and $\sigma c$ = 150 MPa | 15 | BT4 | Analyze |
| 16 | Design a double riveted double strap butt joint for the longitudinal seam of a boiler shell, 750 mm in diameter, to carry a maximum steam pressure of 1.05 N/mm2 gauge. The allowable stresses are: $\sigma t$ | 15 | BT5 | Evaluate |

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| | = 35 MPa; $\tau$ = 28 MPa and $\sigma c$ = 52.5 MPa Assume the efficiency of the joint as 75%. | | | |
| 17 | Two mild steel rods 40mm diameter are to be connected by cotter joint. The thickness of the cotter is 12mm. Calculate the dimensions of the joint, if the maximum permissible stresses are 46 MPa; in tension 35MPa; in shear and 70 MPa in crushing. | 15 | BT4 | Analyze |
| 18 | Design a cotter joint to connect a piston rod to the crosshead. The maximum steam pressure on the piston rod is 35 kN. Assuming that the all parts are made of the same material having the following permissible stress: $\sigma_1$= 50MPa; $\tau$ = 60 MPa; $\sigma$ = 90 MPa. | 15 | BT4 | Analyze |

## UNIT IV - ENERGY STORING ELEMENTS AND BEARINGS

Design of helical springs - Leaf springs - Sliding contact and rolling contact bearings - Hydrodynamic journal bearings- Selection of Rolling Contact bearings

**PART - A (2Marks)**

| S.No | QUESTIONS | LEVEL | COMPETENCE |
|---|---|---|---|
| 1. | List out the various function of a spring. | BT2 | Understand |
| 2. | In which type of sprig the behavior is non-linear? | BT1 | Remember |
| 3. | Describe the type of spring is used to maintain an effective contact between a cam and a reciprocating roller or flat faced follower? | BT2 | Understand |
| 4. | While designing helical springs K is introduced in the shear stress equation, why? | BT1 | Remember |
| 5. | Define surge in a spring. | BT2 | Understand |
| 6. | Discuss the utility of the centre bolt, U- clamp, rebound clip and camber in a leaf spring. | BT2 | Understand |
| 7. | What are the applications of multi-leaf spring? | BT2 | Understand |
| 8. | What are the applications of concentric spring? | BT2 | Understand |
| 9. | What type of stress is induced in helical torsion spring? | BT1 | Remember |
| 10. | What is helical torsion spring? | BT2 | Understand |
| 11. | What do you understand by full length and graduated leaves of a leaf spring? | BT1 | Remember |
| 12. | The extension springs are in considerably less use than the compression springs. Why? | BT2 | Understand |
| 13. | What do you understand stiffness of spring? | BT1 | Remember |
| 14. | What is nipping in a leaf spring? Discuss its role. | BT2 | Understand |
| 15. | List the advantages of hydrostatic bearings. | BT1 | Remember |
| 16. | List any two advantages of rolling contact bearings. | BT1 | Remember |
| 17. | Define static capacity of bearing. | BT2 | Understand |
| 18. | Define bearing characteristic number. | BT2 | Understand |
| 19. | List out the application of angular contact and self-aligning ball bearings. | BT2 | Understand |
| 20. | Describe basic static load rating. | BT1 | Remember |
| 21. | Define critical pressure. | BT2 | Understand |
| 22. | Write down the formula to calculate sommerfield number. | BT1 | Remember |
| 23. | State the theory of lubrication. | BT1 | Remember |
| 24. | List the important physical characteristics of good beating material. | BT1 | Remember |
| 25 | What is meant by hydrodynamics lubrication? | BT1 | Remember |

**PART - B (15 Marks)**

| S.No | QUESTIONS | Marks | LEVEL | COMPETENCE |
|---|---|---|---|---|
| 1 | Design a helical compression spring to sustain an axial load of 3KN. | 15 | BT3 | Apply |

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| | The deflection is 60mm. Spring index is 6. The shear stress is not to exceed 300 MPa. Rigidity modulus for spring material is 81 GPa. | | | |
| 2 | A spring loaded safety value for a boiler is required to blow-off at a pressure 1.2 $N/mm^2$. The diameter of the value is 60 mm. Design a suitable compression spring for the safety value, assuming spring index to be 5, and 35 mm initial compression. The maximum lift of the valve is 10 mm. The shear stress in the spring material is to be limited to 500 MPa. Take $G = 0.8 \times 10^5$ MPa. | 15 | BT4 | Analyze |
| 3 | Design closed coiled helical spring subjected a tensile load of magnitude varying from 2250N to 2750 N and the axial deflection of spring for this range of load is 6 mm. Design the spring, taking the spring index as 5 and safe shear stress for material equal to 420 MPa. $G=84kN/mm^2$ | 15 | BT4 | Analyze |
| 4 | Design and draw a valve spring of a petrol engine for the following operating conditions.<br>Spring load when the valve is open = 400 N<br>Spring load when the valve is closed = 250 N<br>Maximum inside diameter of spring = 25mm<br>Length of the spring when the valve is open = 40mm<br>Length of the spring when the valve is closed = 50mm<br>Maximum permissible shear stress = 400 MPa | 15 | BT3 | Apply |
| 5 | Design a leaf spring for the following specifications: Total load = 140 kN ; Number of springs supporting the load = 4 ; Maximum number of leaves = 10; Span of the spring = 1000 mm ; Permissible deflection = 80 mm. Take Young's modulus, E = 200 $kN/mm^2$ and allowable stress in spring material as 600 MPa. | 15 | BT4 | Analyze |

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| 6 | A semi-elliptical laminated vehicle spring to carry a load of 6000N is to consist of seven leaves 65mm wide, two of the leaves extending the full length of the spring. The spring is to be 1.1m in length and attached to the axle by two U-bolts 80mm apart. The bolts hold the central portion of the spring so rigidly that they may be considered equivalent to a band having a width equal to the distance between the bolts. Assume the design stress for spring material as 350 MPa. Determine thickness of the leaves, deflection of spring, diameter of eye, length of leaves and radius to which leaves should initially bent. | 15 | BT4 | Analyze |
| 7 | A vertical spring loaded valve is required for a compressed air receiver. The valve is to start opening at a pressure of 1 $N/mm^2$ gauge and must be fully open with a lift of 4 mm at a pressure of 1.2 $N/mm^2$ gauge. The diameter of the port is 25 mm. Assume the allowable shear stress in steel as 480 MPa and shear modulus as 80 $kN/mm^2$. Design a suitable close coiled round section helical spring having squared ground ends. Also specify initial compression and free length of the spring. | 15 | BT4 | Analyze |
| 8 | A railway wagon weighing 50 kN and moving with a speed of 8 km per hour has to be stopped by four buffer springs in which the maximum compression allowed is 220 mm. Find the number of turns in each spring of mean diameter 150 mm. The diameter of spring wire is 25 mm. Take G = 84 $kN/mm^2$. | 15 | BT4 | Analyze |
| 9 | A helical compression spring made of oil tempered carbon steel, is subjected to a load which varies from 600 N to 1600 N. The spring index is 6 and the design factor of safety is 1.43. If the yield shear stress is 700 MPa and the endurance stress is 350 MPa, find the size of the spring wire and mean diameter of the spring coil. | 15 | BT3 | Apply |
| 10 | A full journal bearing of 50 mm diameter and 100 mm long has a bearing pressure of 1.4 MPa. The speed of the journal is 900 rpm and the ratio of journal diameter to the diametrical clearance is 1000. The bearing is lubricated with oil whose absolute viscosity at | 15 | BT5 | Evaluate |

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| | the operating temperature of 75˚C may be taken as 0.011 kg/m-s. The room temperature is 35˚C. Calculate (i) The amount of artificial cooling required and (ii) The mass of the lubricating oil required, if the difference between the outlet and inlet temperature of the oil is 10˚C. Take specific heat of the oil as 1850 J/kg/˚C. | | | |
| 11 | The load on the journal bearing is 150kN due to turbine shaft of 300mm diameter running at 1800 rpm. Determine the following. Length of the bearing if the allowable bearing pressure is 1.6N/mm$^2$ and amount of heat to be removed by the lubricant per minute if the bearing temperature is 60ºC and viscosity of the oil at 60ºC is 0.02 kg/m.s and the bearing clearance is 0.25 mm. | 15 | BT3 | Apply |
| 12 | Design a journal bearing for a centrifugal pump from the following data: Load on the journal = 20000N; Speed of the journal = 900 rpm; Type of oil is SAE 10 for which the absolute viscosity at 55˚C = 0.017 kg/m-s; Ambient temperature of oil = 15.5˚C; Maximum bearing pressure for the pump = 1.5 N/mm2. Calculate also mass of the lubricating oil required for artificial cooling, if rise of temperature of oil be limited to 10˚C. Heat dissipation coefficient = 1232 W/m2/˚C | 15 | BT3 | Apply |
| 13 | A 100mm diameter full journal bearing supports a radial load of 5000N. The bearings is 100 mm long and operates at 400 rpm. Permissible min film thickness 25 micron. Diametral clearance 152 micron using Raimond & Boyd curves find (i) viscosity of suitable oil (ii) μ (iii) heat generation rate (iv) amount of oil pumped through bearing (v) amount of end leakage (vi) rise in temperature | 15 | BT4 | Analyze |
| 14 | Select a single row deep groove ball bearing for a radial load of 4000N and an axial load of 5000N, operating at a speed of 1600 rpm for an average life of 5 year at 10hours per day. Assume uniform and steady load. | 15 | BT4 | Analyze |
| 15 | The rolling contact ball bearings are to be selected to support the overhung countershaft. The shaft speed is 720 rpm. The bearings are to have 99% reliability corresponding to a life of 24000 hours. The | 15 | BT3 | Apply |

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| | 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 has 90% reliability. | | | |
| 16 | The ball bearings are to be selected for an application in which the radial load is 2000N during 90 percent of the time and 8000N during the remaining 10 percent. the shaft is to rotate at 150 rpm. Determine the minimum value of the basic dynamic load rating for 5000 hours of operation with not more than 10 percent failures. | 15 | BT3 | Apply |
| 17 | A single row deep groove ball bearing operating at 2000 rpm is acted by a 10 kN radial load and 8kN thrust load. The bearing is subjected to a tight shock load and the outer ring is rotating. Determine the rating life of the bearing. | 15 | BT3 | Apply |
| 18 | A ball bearing subjected to a radial load of 4000 N is expected to have a satisfactory life of 12 000 hours at 720 r.p.m. with a reliability of 95%. Calculate the dynamic load carrying capacity of the bearing, so that it can be selected from manufacturer's catalogue based on 90% reliability. If there are four such bearings each with a reliability of 95% in a system, what is the reliability of the complete system? | 15 | BT3 | Apply |

## UNIT V - PRODUCT ENGINEERING AND DESIGN THINKING

Introduction to Product design, product engineering, and design thinking; Product Design Specification and Planning- Integrating the Fuzzy Front End of complex product development aligned

**PART - A (2Marks)**

| S.No | QUESTIONS | LEVEL | COMPETENCE |
|---|---|---|---|
| 1. | Define product design. | BT2 | Understand |
| 2. | List out the main goal of product design | BT2 | Understand |
| 3. | Define product engineering. | BT2 | Understand |
| 4. | What activities does product engineering include? | BT1 | Remember |
| 5. | Define design thinking. | BT2 | Understand |
| 6. | Name the main stages of design thinking. | BT1 | Remember |
| 7. | What does a Product Design Specification (PDS) contain? | BT2 | Understand |
| 8. | Why is a PDS important? | BT2 | Understand |
| 9. | What does planning in product development involve? | BT1 | Remember |
| 10. | What is the Fuzzy Front End (FFE)? | BT1 | Remember |
| 11. | How is FFE integrated into product planning? | BT1 | Remember |
| 12. | Why is the Fuzzy Front End called ‘fuzzy’? | BT2 | Understand |
| 13. | What are typical activities in the FFE? | BT1 | Remember |
| 14. | How does design thinking help the FFE? | BT2 | Understand |
| 15. | What is the benefit of integrating FFE with structured design processes? | BT1 | Remember |
| 16. | Name one method used to gather user needs during FFE. | BT1 | Remember |
| 17. | What role does prototyping play in the FFE? | BT1 | Remember |
| 18. | What is concept generation? | BT1 | Remember |
| 19. | Why is cross-functional teamwork important in FFE? | BT2 | Understand |
| 20. | What is the link between PDS and FFE? | BT1 | Remember |
| 21. | How does planning reduce risk in product development? | BT1 | Remember |
| 22. | Give an example of a constraint in a PDS. | BT1 | Remember |
| 23. | What is the final aim of product design and engineering? | BT1 | Remember |
| 24. | What ensures product feasibility during development? | BT2 | Understand |
| 25. | How does design thinking benefit complex product development? | BT2 | Understand |

**PART - B (15 Marks)**

| S.No | QUESTIONS | Marks | LEVEL | COMPETENCE |
|---|---|---|---|---|
| 1 | Explain the concept of product design and discuss its significance in today’s competitive market. | 15 | BT3 | Apply |
| 2 | Describe the main stages involved in product design and their purpose. | 15 | BT3 | Apply |
| 3 | Explain product engineering and how it complements product design. | 15 | BT3 | Apply |

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| 4 | Explain how design thinking supports product innovation. | 15 | BT3 | Apply |
| 5 | Compare and contrast traditional problem-solving methods with design thinking. | 15 | BT3 | Apply |
| 6 | Discuss the structure and purpose of a Product Design Specification (PDS). | 15 | BT3 | Apply |
| 7 | What are the consequences of not having a clear PDS during product development? | 15 | BT3 | Apply |
| 8 | Explain the concept of the Fuzzy Front End (FFE) and its challenges. | 15 | BT3 | Apply |
| 9 | How does integrating the Fuzzy Front End with structured planning improve complex product development? | 15 | BT3 | Apply |
| 10 | Describe tools and methods used to manage the Fuzzy Front End effectively. | 15 | BT3 | Apply |
| 11 | What is the role of prototyping in the Fuzzy Front End and how does it add value? | 15 | BT3 | Apply |
| 12 | How does cross-functional collaboration contribute to success during early product development? | 15 | BT3 | Apply |
| 13 | Why is planning important in product development, and what does it typically include? | 15 | BT3 | Apply |
| 14 | How does market research influence product design and the PDS? | 15 | BT3 | Apply |
| 15 | Discuss how sustainability can be integrated into product design and engineering. | 15 | BT3 | Apply |
| 16 | Explain how continuous iteration supports successful product development. | 15 | BT3 | Apply |
| 17 | What challenges can arise when integrating creative design thinking with strict engineering requirements, and how can they be overcome? | 15 | BT3 | Apply |
| 18 | Summarize the importance of aligning product design, product engineering, and planning with the Fuzzy Front End for complex product development. | 15 | BT3 | Apply |