# KNOWLEDGE INSTITUTE OF TECHNOLOGY,SALEM.

**(Affiliated by AICTE, New Delhi and Affiliated to Anna University, Chennai)**

**Kakapalayam (PO), Salem – 637504.**


**Question Bank**

# Design of Machine Elements

## Department of Mechanical Engineering

# DESIGN OF MACHINE ELEMENTS
# UNIT –I STEADY STRESSES AND VARIABLE STRESSES IN MACHINE MEMBERS
## PART-A

**TWO MARK QUESTIONS AND ANSWERS**

**1.Define: Factor of safety?**

The ratio between maximum stresses to working stress is known as factor of safety.

**2. Define endurance limit?**

Endurance limit is the maximum value of completely reversed stress that the standard specimen can sustain an infinite number (106) of cycles without failure.

**3. What is impact load?**

If the time of load application is less than one third of the lowest natural period of vibration of the part, it is called an impact load.

**4. What are the various phases of design process?**

- Recognition of need.
- Definition of problem
- Synthesis
- Analysis and optimization
- Evaluation
- Presentation

**5. What are the different types of loads that can act on machine components?**

- Steady load.
- Variable load.
- Shock load
- Impact load.

**6. What are the factors affecting endurance strength?**

Factors affecting endurance strength are

- Load
- Surface finish
- Size
- Temperature
- Impact
- Reliability

**7. What are the types of variable stresses?**

- Completely reversed or cyclic stresses
- Fluctuating stresses
- Repeated stresses

**8. Differentiate between repeated stress and reversed stress?**

Repeated stress refers to a stress varying from zero to a maximum value of same nature. Reversed stress of cyclic stress varies from one value of tension to thesame value of compression.

**9. What are the types of fracture?**

- Ductile fracture
- Brittle fracture

**10. Distinguish between brittle fracture and ductile fracture?**

In brittle fracture, crack growth is up to a small depth of the material. In ductile fracture large amount of plastic deformation is present to a higher depth.

**11. Define stress concentration and stress concentration factor**?

Stress concentration is the increase in local stresses at points of rapid change in cross section or discontinuities.

Stress concentration factor is the ratio of maximum stress at critical section to the nominal stress

**12. Explain size factor in endurance strength?**

Size factor is used to consider the effect of the size on endurance strength. A large size object will have more defects compared to a small one. So,endurance strength is reduced. If *K* is the size factor,

Actual endurance strength = Theoretical endurance limit x *K*

**13. Explain Griffith theory. (Or) State the condition for crack growth?**

A crack can propagate if the energy release rate of crack is greater than crack resistance.

**14. What are the modes of fracture?**

- Mode I (Opening mode) – Displacement is normal to crack surface.
- Mode II (Sliding mode) – Displacement is in the plane of the plate.
- Mode III (Tearing mode) – Out of plane shear.

**15. What are the factors to be considered in the selection of materials for a machine element**?

- Required material properties
- Manufacturing ease
- Material availability
- Cost

**16. What are various theories of failure?**

- Maximum principal stress theory.
- Maximum shear stress theory.
- Maximum principal strain theory.

**17 List out the factors involved in arriving at factor of safety?**

- material properties
- Nature of loads
- Presence of localized stresses
- Mode of failures

**18. Give some methods of reducing stress concentration**?

- Avoiding sharp corners.
- Providing fillets.
- Use of multiple holes instead of single hole
- Undercutting the shoulder parts.

**19. Explain notch sensitivity**?

State the relation between stress concentration factor, fatigue stress concentration factor and notch sensitivity.

Notch sensitivity ($q$) is the degree to which the theoretical effect of stress concentration is actually reached. The relation is, $Kf = 1 + q\,(Kt-1)$

**20. What are the factors that affect notch sensitivity?**

- Material
- Notch radius
- Size of component
- Type of loading

- Grain Structure

**21. What is the use of Goodman & Soderberg diagrams?**

They are used to solve the problems of variable stresses.

**22. Define machinability?**

It is the property of the material, which refers to a relative case with which a material can be cut. It is measured in a number of ways such as comparing thetool life for cutting different material

**23. What is an S-N Curve?**

An S- N curve has fatigue stress on Y axis and number of loading cycles in *X* axis. It is used to find the fatigue stress value corresponding to a givennumber of cycles.

**24. Define Ductility?**

It is the property of the material enabling it to be drawn into wire, with the application of tensile force. It must be both strong and plastic. It is usuallymeasured in terms of percentage elongation and reduction in area. (eg) Ni, Al, Cu

**25. Define fatigue?**

When a material is subjected to repeated stress, it fails at stresses below the yield point stress; such type of failure of the material is called fatigue.

**26. What is curved beam?**

In curved beam the neutral axis does not coincide with the centroidal axis.

**27. Give some example for curved beam?**

- C frame
- crane hook

**28. What is principle stress and principle plane?**

A plane which has no shear stress is called principle plane the corresponding stress is called principle stress.

**29. Write the bending equation?**

M/I = E/R = Fs/Y.

M – Bending moment
I - Moment of intertia
E - Youngs modulus
R - Radius of the shaft
Fs – Shear stress
Y - Distance from neutral axis

**30. Write the torsion equation?**

T/J = CØ/L = Fs/R

T – Torque
J - Polar moment of intertia
C- Rigidity modulus
Ø – Angle of twist
L – Length of the shaft
Fs – Shear stress
R - Radius of the shaft

## PART – B (13 Marks)

## UNIT-I (STEADY STRESSES AND VARIABLE STRESSES IN MACHINE MEMBERS)

**1.** A cast iron pulley transmits 10 kw at 400 rpm. The diameter of the pulley is 1.2 m and it has four straight arms elliptical cross section, in which the major axis twice the minor axis. Determine the dimension of the arms with the allowable bending stress is 15 MPa.

**2.** **(i)** An unknown weight falls through 10 mm on a collar rigidly attached to the lower end of a vertical bar 3 m long and 600 $mm^2$ in section. If the maximum instantaneous extension is 2 mm, what is the corresponding stress and the value of unknown weight?

**(ii)** A rectangular strut is 150mm wide and 120 mm thick. It carries a load of 180 KN at an eccentricity of 10 mm in a plane bisecting the thickness. Finding the maximum and minimum intensities of stress in the section.

**3.** A mild steel bracket is shown in fig (**i**). It is a subjected to a pull of 5000N acting at 45º to the horizontal axis. The bracket has a rectangular section whose depth is twice the thickness. Find the cross sectional dimensions of the bracket if the permissible stress in the material is 50N/$mm^2$.

**4.** A C-clamp as shown in fig(**ii**), carries a load P = 25 KN. The cross section of the of the clamp at X-X is rectangular having width equal to twice thickness. Assuming that the clamp is made of steel casting with an allowable stress of 100 MPa, find its dimensions. Also determine the stresses at sections Y-Y and Z-Z.

**5.** Determine the maximum and minimum normal stresses and maximum shear stresses at the crank shaft bearing in fig. **(iii).**

**6.** A shaft, as shown in fig (**iv**), is subjected to a bending load of 3 KN, pure torque of 1000 Nm and an axial pulling force of 15 KN. Calculate the stresses at A and B.

**7.** A bolt is subjected to a tensile load of 25KN and a shear load of 10KN. Determine the diameter of the bolt according to **(a)** Maximum principal stress theory **(b)** Maximum principal strain theory **(c)**Maximum shear stress theory. Assume factor of safety 2.5, Yield point stress in simple tension 300N/$mm^2$, Poisson's ratio is 0.25.

**8.** The load on a bolt consists of an axial pull of 10 KN together with a transverse shear force of 5 KN. Find the diameter of bolt required according to (i) Maximum principal stress theory; (ii) Maximum shear stress theory; (iii) Maximum principal strain theory, (iv) Maximum strain energy theory; and (v) Maximum distortion energy theory.

**9.** A mild steel shaft of 50 mm diameter is subjected to a bending moment of 2000 Nm and a torque T. If the yield point of the steel in tension is 200 MPa, find the maximum value of the torque without causing yielding of the shaft according to (i) the maximum principal stress; (ii) The maximum shear stress, and (iii) the maximum distortion strain energy theory of yielding.

**10.** The dimensions of an overhang crank are given in fig (**v**). The force P acting at the crank pin is 1 KN. The crank is made of steel 30C8 and factor of safety is 2. Using maximum shear stress theory of failture, determine the diameter‘d’ at the section XX.

**11.** A crane hook has a section, which for the purpose of analysis is considered trapezoidal as shown in fig **(vi)**. It is made of plain carbon steel with an yield strength of 380 MPa in tension. Determine the load capacity of the hook, for a factor of safety of 3.

**12.** A C-clamp is subjected to a maximum load of W, as shown in fig (**vii**). If the maximum tensile stress in the clamp is limited to 140 MPa, Find the value of load W.

**13.** A transmission shaft made of C45 steel is subjected to fluctuation torque varying from -100Nm to +500Nm. Also, a fluctuation bending moment acts on the shaft, which varies from +500Nm to -500Nm. Let the stress concentration factor be 2. The shaft is machine, for a factor of safety of 1.5. Determine the require diameter of the shaft.

**14.** A cantilever rod of circular section is subjected to a cyclic transverse load; varying from -100N to +300N as shown in fig (v**iii**). Determine the diameter d of the rod by (i) Goodman method and (ii) Soderberg method using the following data.

Factor of safety = 2
Theoretical stress concentration factor = 1.4
Notch sensitivity factor = 0.9
Ultimate strength = 550MPa.
Yield strength = 320MPa.
Endurance strength = 275 MPa.
Size correction factor = 0.85
Surface correction factor = 0.9

**15.** Determine the thickness of a 120 mm wide uniform plate for safe continuous operation if the plate is to be subjected to a tensile load that has a maximum value of 250 KN and a minimum value of 100 KN. The properties of the plate material are as follows:
Endurance limit stress = 225 MPa, and Yield point stress = 300 MPa, The factor of safty based on yield point may be taken as 1.5.

**16.** A shaft is subjected to a bending moment varying from -200Nm to 500Nm and twisting moment varying from 50Nm to 175Nm. The material used has $S_u$ =600MPa, $S_e$ = 300MPa, $K_a$ = 0.76, $K_b$ = 0.85, $K_c$ = 0.897, $K_t$ = 1.85 and q = 0.95. Find the diameter of the shaft by Von Mises Hencky theory. Factor of safety is 1.5.

**17.** The cast iron shaft with an ultimate tensile strength of 175 MPa is subject to a torsional load which is completely reversed, the load is to be applied an indefinite number if cycle, the shaft is 50 mm diameter and is joined to a 75 mm diameter shaft with a 12.5 mm radius fillet. The factor of safety is to be 2. What is the maximum torque that can be applied to the shaft? Solve using soderberg's equation.

**18.** The bar of circular cross section is subjected to alternating tensile force 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 a fatigue load. Use Goodman straight line as basis for design

**19.** A pulley is keyed to a shaft midway between two anti-friction bearings. The bending moment at the pulley varies from -170 Nm to 510 Nm. As torsional moment in the shaft varies from 55 Nm to 165 Nm. The frequency of the variation of the loads is the

same as the shaft speed. The shaft is made of cold drawn steel having an ultimate strength of 538 MPa and yield strength of 400 MPa. Determine the required diameter for an infinite life. The stress concentration factor for the keyway in bending and torsion may be taken as 1.6 and 1.3 respectively. Use design factor N=1.5.

**20.** A circular bar of 500 mm length is supported freely at its two ends. Its acted upon by a central concentrated cyclic load having a minimum value of 20 KN and a maximum value of 50 KN. Determine the diameter of the bar by taking a factor of safety of 1.5, Size effect of 0.85, Surface finish factor of 0.9. The material prosperities of bar are given by, Ultimate strength of 650 MPa, Yield strength of 500 MPa and Endurance strength of 350 MPa.

**21.** A hot rolled steel shaft of 40mm diameter is subjected to a torsional moment that varies from 330Nm to -100Nm and an applied bending moment which rises from 440Nm to -220Nm. The material of the shaft has an ultimate strength of $550MN/m^2$ and yield strength of $410MN/m^2$. Find the approximate factor of safety using Soderberg equation allowing endurance limit to be half the ultimate strength and size factor and surface finish factor to be 0.85 and 0.62 respectively.

**22.** A simply supported beam as a concentrated load at the centre which fluctuates from the value of P to 4P. The span of the beam is 500 mm and its cross-section of circular with a diameter of 60 mm. Staking for the beam material an ultimate stress of 700 MPa, a yield stress of 500 MPa, endurance limit of 330 MPa for reversed bending, and factor of safety of 1.3. Calculate the maximum value of P. Take a size factor of 0.85 and surface finish factor of 0.9.

**23.** A cantilever beam made of cold drawn carbon steel of circular cross-section as shown in fig (**ix**), is subjected to a load which varies from –F to 3F. Determine the maximum load that this member can withstand for an indefinite life using the following data.

Factor of safety = 2
Theoretical stress concentration factor = 1.42
Notch sensitivity factor = 0.9
Ultimate strength = 550MPa.
Yield strength = 470MPa.
Endurance strength = 275 MPa.
Size correction factor = 0.85
Surface correction factor = 0.89

**24.** 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 upto 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 finish factor | = 0.90 |
| Notch sensitivity index | = 0.90 |

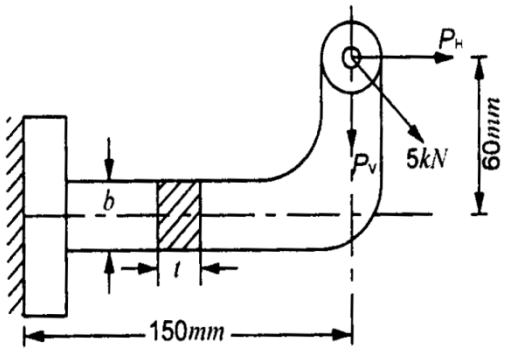



Fig (**i**)

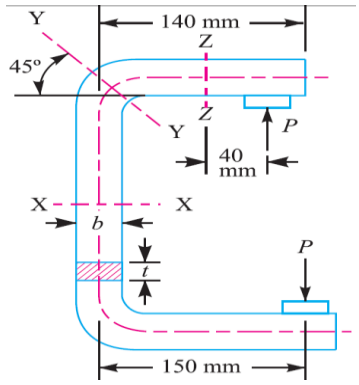



Fig (**ii**)

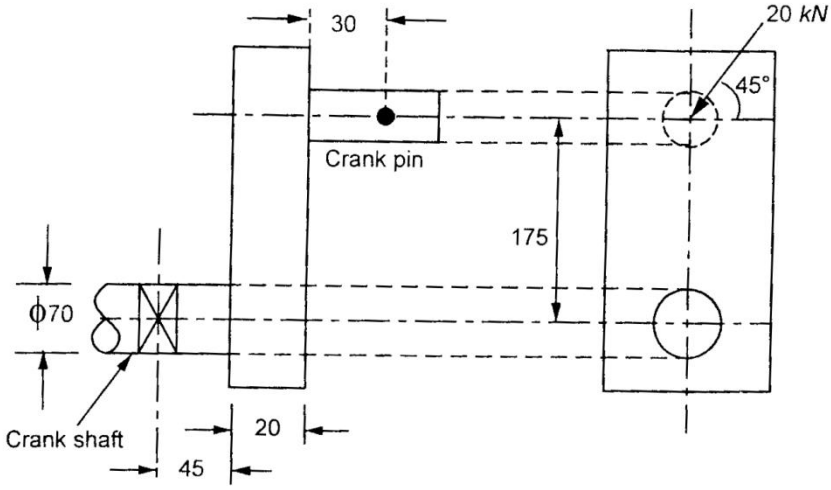



Fig (**iii**)

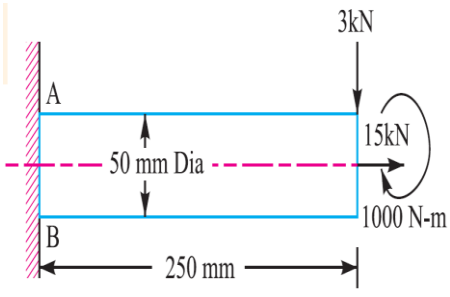



Fig (**iv**)

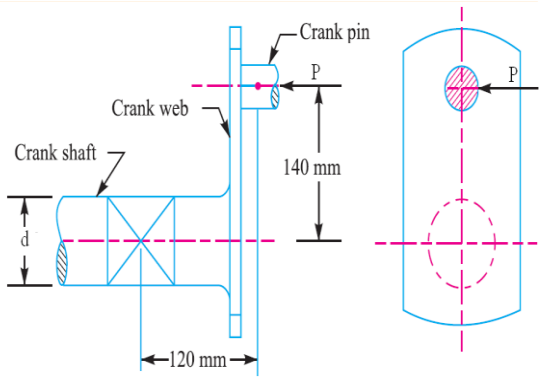
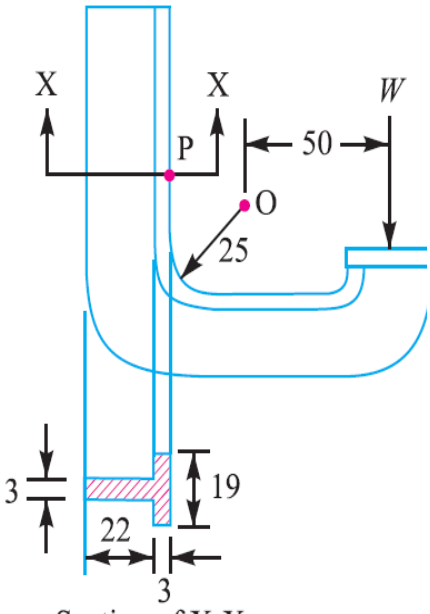


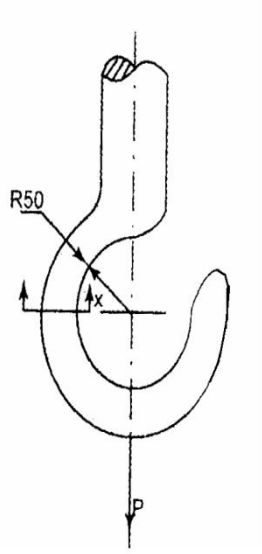

Fig (**v**)




Section of X-X

All dimensions in mm.

Fig (**vii**)



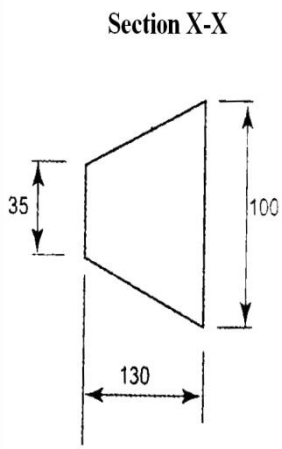
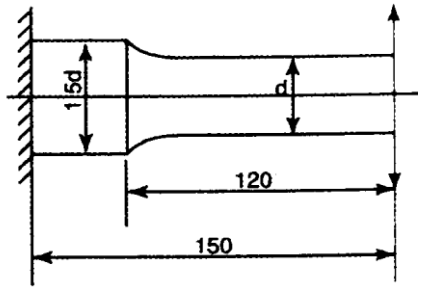
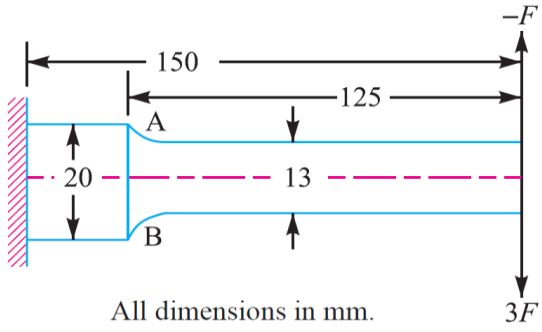




Fig (**vi**)




All dimensions in mm.

# Unit-II
## SHAFTS AND COUPLINGS
## PART-A

**TWO MARK QUESTIONS AND ANSWERS**

**1. Define the term critical speed?**

The speed, at which the shaft runs so that the additional deflection of the shaft from the axis of rotation becomes infinite, is known as critical or whirling speed.

**2. Factor is considered to design a shaft?**

- strength
- Stiffness

**3. What is key?**

A key is device, which is used for connecting two machine parts for preventing relative motion of rotation with respect to each other.

**4. What are the types of keys?**

- Saddle key
- Tangent key
- Sunk key
- Round key and taper pins

**5. What is the main use of woodruff keys?**

A woodruff key is used to transmit small value of torque in automotive and machine tool industries. The keyway in the shaft is milled in a curved shapewhereas the key way in the hub is usually straight.

**6. List the various failures occurred in sunk keys**?

1. Shear failure
2. Crushing failure

**7. What is the function of a coupling between two shafts?**

Couplings are used to connect sections of long transmission shafts and to connect the shaft of a driving machine to the shaft of a driven machine.

**8. Under what circumstances flexible couplings are used?**

They are used to join the abutting ends of shafts when they are not in exact alignment.

They are used to permit an axial misalignment of the shafts without underabsorption of the power, which the shafts are transmitting.

**9. What are the purposes in machinery for which couplings are used?**

1. To provide the connection of shafts of units those are manufactured separately such as motor and generator and to provide fordisconnection for repairs or alterations.
2. To provide misalignment of the shafts or to introduce mechanical flexibility.
3. To reduce the transmission of shock from one shaft to another.
4. To introduce protection against over load.

**10 What are the main functions of the knuckle joints?**

It is used to transmit axial load from one machine element to other

**11. What is the material used for flange or flange coupling?**

Cast iron.

**12. List all the shaft materials?**

Different grades of plain carbon steels, 40 Ni 3, 30 Ni 4 Cr 1, 40 Cr 3 Mo 1 V 20, 40 Cr 1

**13. How are sunk keys designed?**

Sunk keys are designed to fit in a sunk keyway whose bed is parallel to the axis of the shaft.

**14. List the various failures occurred in sunk keys?**

Shear failure, crushing failure.

**15. Where are flexible couplings used?**

Vehicle, stationary machinery, automotivedrives Machine tools.

**16. What are the types of rigidity?**

Torsional rigidity, Lateral rigidity.

## PART – B (13 Marks)

## UNIT-II (SHAFTS AND COUPLINGS)

1. Design and make a neat dimensional sketch of a muff coupling which is used to connect two steel shafts transmitting 40 KW at 350 rpm. The material of the shaft and key is plain carbon steel for which allowable shear and crushing stress may be taken as 40 MPa and 80 MPa respectively. The material of the muff is cast iron for which the allowable shear stress assumed as 15 MPa.
2. Design a muff coupling to connect two steel shafts transmitting 25 KW power at 360 rpm. The shafts and key are made of plain carbon steel 30C8. The sleeve is made of grey cast iron FG 200. The factor of safety of the shaft and key is 4. For the sleeve, the factor of safty is 6 based on the ultimate strength.
3. Design a rigid muff coupling. The power transmitted 30 KW at 360 rpm. Factor of safety is 6. Use C45 for the shaft assumed other data if required.
4. Design a rigid muff coupling. Use C.I for the muff. The power transmitted is 25 KW at 300 r/pm $S_{ut}$=200MPa, F.S=6, use 30C8 steel for the shaft. Consider $S_y$=330 MPa and F.S=4.
5. A rigid type coupling is used to connect two shaft transmit 15KW at 200rpm.The shaft, key and bolts are made of C45 steel and the coupling is of C.I. Design the coupling.
6. Design and draw a cast iron flange coupling for a mild steel shaft transmitting 90KW at 250rpm. The allowable shear stress in the shaft is 40MPa and the angle of twist is not to exceed $1^0$ in a length of 20mm diameters. The allowable shear stress in the coupling bolt is 30MPa.
7. Design a cast iron protective type flange coupling to transmit 15KW at 900rpm from an electric motor to a compressor. The service factor may be assumed as 1.35.The following permissible stress may be used: Shear stress for the shaft, bolt and key material=40MPa Crushing stress for bolt and key=80Mpa Shear stress for cast iron=8Mpa.
8. Two 35 mm shafts are connected by a flange coupling. The flanges are fitted with 6 bolts on 25 mm bolt circle. The shafts transmit a torque of 800 N-m at 350 rpm. For the safe stresses mentioned below, calculate (i) diameter of bolts (ii) thickness of flanges (iii) key dimensions (iv) hub length and (v) power transmitted. Safe stress

for shaft material for 63MPa,safe stress for bolt material 56MPa, safe stress for cast iron 10MPa and safe stress for key material 46MPa.

**9.** Design and sketch protective type C.I flange coupling to transmit 10KW at 250rpm. The permissible shear stress for key, shaft, and bolt as $50N/mm^2$.Take crushing stress of key as $90N/mm^2$and shear stress for C.I as $14N/mm^2$.Assume maximum torque is 30% higher than mean torque.

**10.** Design bushed pin type flexible coupling for the following power to be transmitted 40 KW, shaft speed 1000 rpm. Select the material and determine the dimension.

**11.** A knuckle joint is to transmit a force of 140KN.Allowable stresses in tension, shear and compression are $75N/mm^2$, $65N/mm^2$and $140N/mm^2$respectively. Design the joint.

**12.** Design a shaft to transmit power from an electrical motor a lathe head stock through a pulley by means of belt drive. The pulley weighs 200N and is located 300mm from the centre of the bearing. The dia of pulley is 200mm and the maximum power transmitted is 1KW at 120rpm. The angle of lap of the belt is 180deg and co-efficient of friction b/w the belt and the pulley is 0.3. The shock arid fatigue factors for bending and twisting are 1.5 and 2 respectively. The allowable shear stress in shaft may be taken as 35MPa.

**13.** A shaft is supported on bearings A and B, 800 mm between centres. A $20^0$ straight tooth spur gear having 600mm pitch diameter, is located 200 mm to the right of left hand 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 $180^0$ angle of wrap. The pulley also serves as a flywheel and weighs 2000N. The maximum belt tension is 3000 N and the tension ratio is 3:1. Determine the maximum bending movement and the necessary shaft diameter if the allowable shear stress of the material is 40 MPa.

**14.** A shaft is supported by two bearings placed I m apart. A 600 mm diameter pulley is mounted at a distance of 300 mm to the right of left hand bearing and this drives a pulley directly below it with the help of belt having maximum tension of 2.25 KN. Another pulley 400 mm diameter is placed 200 mm to the left of right hand bearing and is driven with help of electric motor and belt which is placed horizontally to the right. The angle of contact for both pulleys is $180^0$ and =0.24.Determine the suitable diameter for a solid shaft, allowing working stress of 63 MPa and 42 Mpa in shear for the material shaft. Assume the torque one pulley is equal to that other pulley.

**15.** A mild steel shaft transmits 20 KW at 200 rpm. It carries a central load of 900 N and is simply supported between the bearing 2.5 m apart.Determine the size of the shaft and allowable shear stress is 42 MPa and the maximum tensile or compressive stress is not to exceed 56 MPa. What size of the shaft will be required, if it is subjecte to gradually applied loads?

**16.** A line shaft rotating at 200rpm is to transmit 20KW power. the allowable shear stress for the shaft material is 42N/mm2.If the shaft carries a central load of 900N and is simply supported between bearing 3meters apart determine the diameter of the shaft. The maximum tensile or compressive stress is not to exceed $56N/mm^2$.

**17. (i)** A shaft to transmit 50KW at 1200rpm.It is also subjected to a bending moment of 275NNm.Allowable shear stress is 60N/mm2.The shaft is not to twist more than $2^0$ in a length of 2m.G=80XI$0^3$N/$mm^2$.Design a shaft.

**(ii)** A factory line shaft is 4.5m long and is to transmit 75KW at 200rpm.The allowable stress in shear is 45MPa and maximum allowable twist is $1^0$ in a length of 20mm diameter. Determine the required shaft diameter.

**18.** A mild steel shaft transmits 20 KW at 200 rpm. It carries a central load of 900 N and is simply supported between the bearing 2.5 m apart. Determine the size of the shaft and allowable shear stress is 42 MPa and the maximum tensile or compressive stress is not to exceed 56 MPa. What size of the shaft will be required, if it is subjecte to gradually applied loads?

**19. (i)**A 45mm diameter shaft is made of steel with yield strength of 400 MPa. A parallel key of size 14 mm wide and 9 mm thick made of steel with 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.

**(ii)** Find the diameter of a solid steel shaft to transmit 20kw at 200 r/min. The ultimate shear strength 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 plae of solid shaft, find the inside and outside diameter when the ratio of inside to outside diameters is 0.5.

**20.** A hollow steel shaft is to transmit 20 kw at 300 rpm. The loading is such that the maximum bending moment is 1000N-m, the maximum torsional moment is 500 N-m and axial compressive load is 15 KN. The shaft is supported on rigid bearings 1.5 m apart; the maximum permissible shear stress on the shaft is 40 MPa. The inside diameter is 0.8 times the outside diameter. The load is cyclic in nature and applied with shocks. The values of the shock factors are $K_t$=1.5 and $K_m$=1.6.

# UNIT-III

# TEMPORARY AND PERMENANT JOINTS

## PART-A

**TWO MARK QUESTIONS AND ANSWERS**

**1. How is a bolt designated?**

A bolt is designated by a letter M followed by nominal diameter and pitch in mm.

**2. What factors influence the amount of initial tension?**

i. External load
ii. Material used
iii. Bolt diameter

**3. What is bolt of uniform strength?**

A bolt of uniform strength has equal strength at the thread and shank portion.

**4. What are the ways to produce bolts of uniform strength?**

- Reducing shank diameter equal to root diameter.
- Drilling axial hole

**5. What stresses act on screw fastenings?**

- Initial stresses due to screwing up
- Stresses due to external forces
- Combined stresses.

**6. What are the different applications of screwed fasteners?**

The different applications of screwed fasteners are readily connecting & disconnecting machine parts with outdamage

- b. The parts can be rigidly connected
- c. Used for transmitting power

**7. What are the advantages of screwed fasteners?**

The advantages of screwed fasteners are

- They are highly reliable in operation
- They are convenient to assemble & disassemble
- A wide range of screws can be used for various operating conditions
- They are relatively cheap to produce.

**8. Define pitch?**

Pitch is defined as the distance from appoint on one thread to the corresponding on the adjacent thread in the same axis plane.

**9. Define lead**?

Lead is defined as the distance, which a screw thread advances axially in one rotation of the nut.

**10. What are the different types of metric thread?**

1. BSW (British standard Whit worth)
2. BSE (British standard End

**11. Define welding**?

Welding can be defined as a process of joining two similar or dissimilar metals with or without application of pressure along with or without addition offiller material.

**12. What are the types of welded joints?**

- Butt joint
- Lap joint

- T – jointi
- Corner joint
- Edge joint.

**13. What are the two types of stresses are induced in eccentric loading of loaded joint?**

1. Direct shear stress.
2. Bending or torsional shear stress.

**14. Define butt and lap joint?**

Butt joint**:** The joint is made by welding the ends or edges of two plates.

Lap joint**:** The two plates are overlapping each other for a certain distance. Then welded. Such welding is called fillet weld.

**15 When will the edge preparation need?**

If the two plates to be welded have more than 6mm thickness, the edge preparation should be carried out.

**16 What are the two types of fillet weld?**

- Longitudinal or parallel fillet weld
- Transverse fillet weld

**17 State the two types of eccentric welded connections?**

- Welded connections subjected to moment in a plane of the weld.
- Welded connections subjected to moment in a plane normal to the plane of the weld.

**18 What are the practical applications of welded joints?**

It has employed in manufacturing of machine frames, automobile bodies, aircraft, and structural works.

**19. Define Pitch, Lead.**

Pitch is the axial distance from a point on one thread to corresponding point on next thread.

Lead is the distance the screw moves in one turn.

**20. What are the advantages of preloading?**

It stops leakages. It improves fatigue strength.

**21. What factors influence the amount of initial tension?**

External load, material used, Bolt diameter.

**22. What is bolt of uniform strength?**

A bolt of uniform strength has equal strength at the thread and shank portion.

**23. Why are welded joints preferred over riveted joints?**

Material is saved in welding joints and hence the machine element will be light if weldedjoints are used instead of riveted joints. Leak proof joints can be easily obtained by welded jointscompared riveted joints.

**24. How is Welding classified?**

- Forge welding,
- Electric resistance welding
- Fusion welding
- Gas welding

**25. State the types of forces involved while designing.**

- Tension
- Compressive forces.

**26. Types of Cotter joints?**

- Socket and spigot cotter joint
- Sleeve and cotter joint
- Gib and cotter joint

## PART – B (13 Marks)

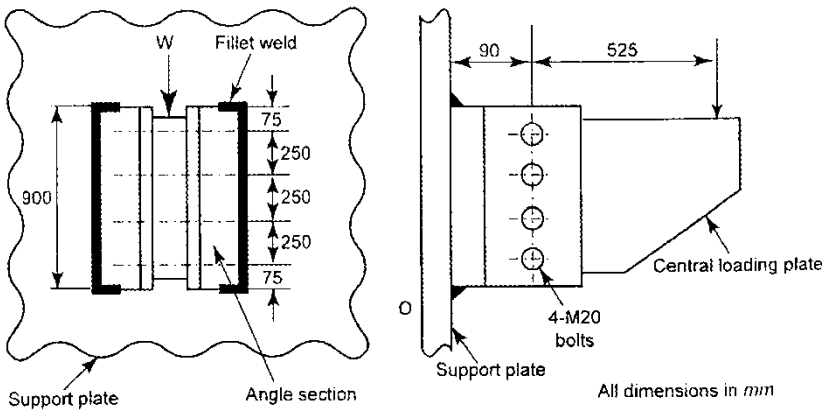
## UNIT-III (TEMPORARY AND PERMENANT JOINTS)

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 $\sigma_y$ = 300MPa for bolt material.
2. A steam engine of effective diameter 300 mm is subjected to a steam pressure of 1.5 N/mm2. The cylinder head is connected by 8 bolts having yield point 330 MPa and endurance limit at 240 MPa. The bolts are tightened with an initial preload of 1.5 times the steam load. A soft copper gasket is used to make the joint leak-proof. Assuming a factor of safety 2, find the size of bolt required. The stiffness factor for copper gasket may be taken as 0.5.
3. A plate bracket used to support a machine is assembled using steel angle sections welded to a support plate and a central loading plate, as shown in fig (**i**). the central loading plate is connected using four M20 bolts, with the arrangement shown. If the factor of safety of 1.6 is required, determine: The maximum load 'W' that can be supported by the bracket upon the bolted connection. Assume that for the bolt material, yield stress in shear 160MPa.
4. A fabricated steel bracket forms the support for as machine hoisting system as shown in fig (**ii**) and Consists of two bolted connections. Using a safety factor of 1.6. Determine:
    i. The maximum value of the normal operating service load 'W' based on the M16 bolted connection
    ii. The required bolt diameter for the base plate connection, For bolts: $\tau_y$ = 128N/mm$^2$
5. A right steel bracket subjected to a vertical force of 10 kN is shown in fig (**iii**) it is fastened to a vertical stanchion by means of four identical bolts. Determine the size of the bolts by maximum shear stress theory. The maximum permissible shear stress in any bolt is limited to 50N/mm$^2$.
6. Determine the size of the bolts and the thickness of the arm for the bracket as shown in Fig (**iv**), if it carries a load of 40 kN at an angle of 60° to the vertical. The material of the bracket and the bolts is same for which the safe stresses can be assumed as 70, 50 and 105 MPa in tension, shear and compression respectively.
7. A rectangular beam is to be welded to a plate. The maximum load of 14 kN is applied repetitiously. Determine the size of weld required for10,000,000 cycles. Assume the shear load is distributed uniformly over the entire weld. Refer fig (**v**) shown below.
8. A 50mm diameter solid shaft is welded to flat plate as shown in fig (**vi**). if the size of the weld is 15mm, Find the maximum and shear stress in the weld.
9. A shaft of rectangular cross section is welded to a support by means of fillet welds as shown in fig (**vii**). Determine the size of the weld, if the permissible shear stress in the weld is limited to 75N/mm$^2$.

10. A plate 75mm wide and 12.5mm thick is joined with another plate by a single transverse weld and a double parallel fillet weld as shown fig (**viii**). The maximum tensile and shear stresses are 70mPa and 56MPa respectively. Find the length of each parallel fillet weld, if the joint is subjected to both static and fatigue loading. Stress concentration factor for transverse weld is 1.5 and for parallel fillet weld is 2.7.
11. A weldedjoint as shown in fig (**ix**) 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 200 × 150 × 10 mm angle is to be welded to a steel plate by fillet welds as shown in Fig(**x**). If the angle is subjected to a static load of 200 kN, find the length of weld at the top and bottom. The allowable shear stress for static loading may be taken as 75 MPa.
13. Find the maximum shear stress induced in the weld of 6 mm size when a channel, as shown in Fig(**xi**), is welded to a plate and loaded with 20 kN force at a distance of 200 mm.
14. The bracket, as shown in Fig (**xii**), is designed to carry a dead weight of P = 15 kN. What sizes of the fillet welds are required at the top and bottom of the bracket? Assume the forces act through the points A and B. The welds are produced by shielded arc welding process with a permissible strength of 150 MPa.
15. 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 : $\sigma t$ = 120 MPa; $\tau$ = 100 MPa; $\sigma c$ = 150 MPa Find the efficiency of joint, taking the strength of the rivet in double shear as twice than that of single shear.
16. 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 fficiency of the joint. Take the working stresses in tension and shearing as 80 MPa and 60 MPa  espectively.
17. A steam boiler is to be designed for a working pressure of 2.5 N/mm2 with its inside diameter 1.6 m. Give the design calculations for the longitudinal and circumferential joints for the following working stresses for steel plates and rivets : In tension = 75 MPa ; In shear = 60 MPa; In crushing = 125 MPa. Draw the joints to a suitable scale.
18. Two lengths of mild steel tie rod having width 200 mm and thickness 12.5 mm are to be connected by means of a butt joint with double cover plates. Design the joint if the permissible stresses are 80 MPa in tension, 65 MPa in shear and 160 MPa in crushing. Make a sketch of the joint.

19.design and draw a cotter joint to support a load varing from 30 KN in compression to 30 KN in tension.the material used is carbon steel for which the following allowable stresses may be used. The load is applied statically.

Tensile stress=compressive stress=50 Mpa; shear stress=35 MPa; and crushing stress=90MPa.




**Fig(i)**

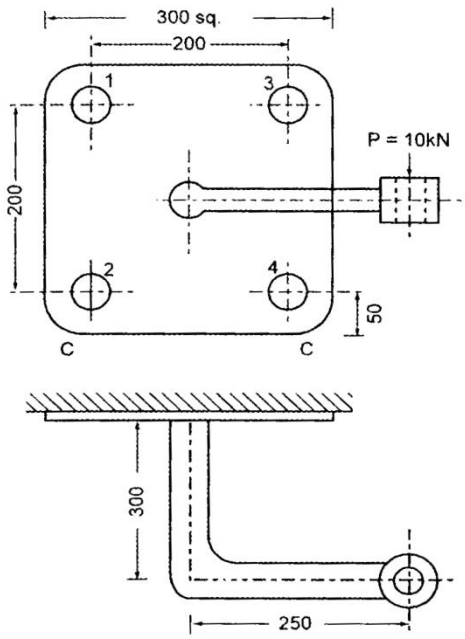



Fig (**iii**)

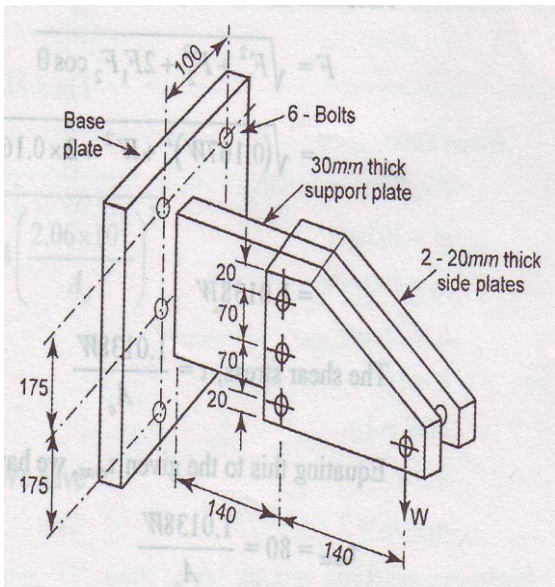
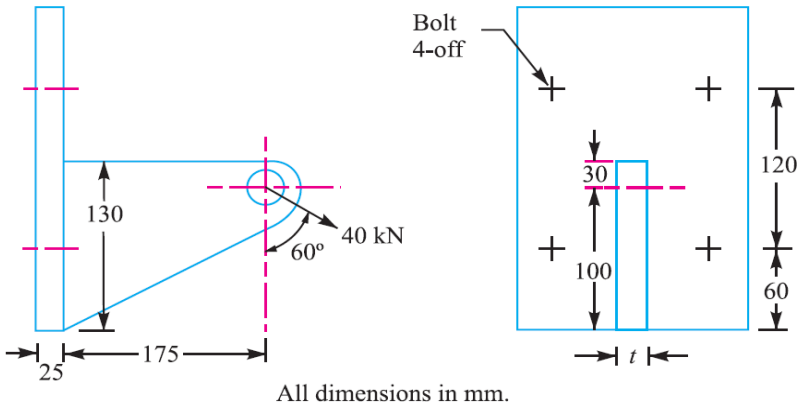



Fig (**ii**)




All dimensions in mm.

**Fig(iv)**

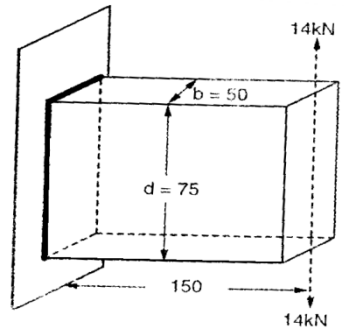



Fig (**v**)

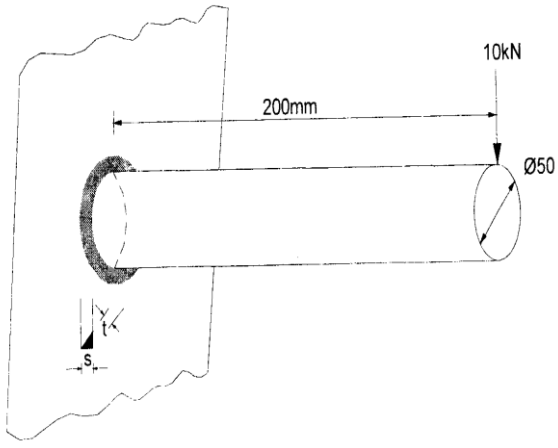
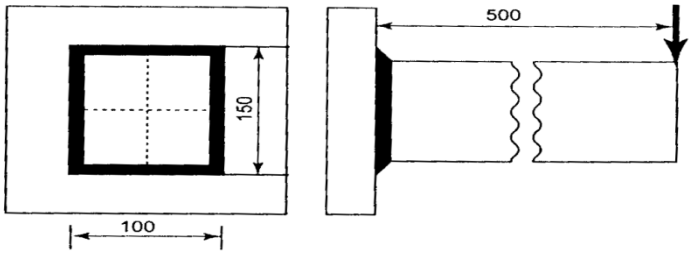
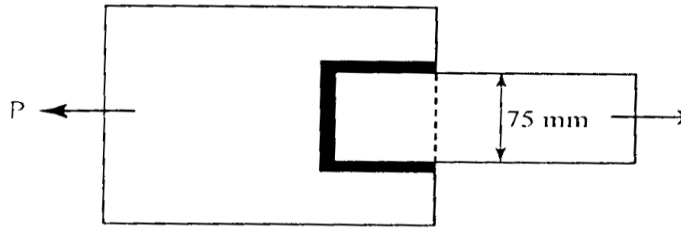



Fig (**vi**)




**fig(viii)**




**Fig(vii)**

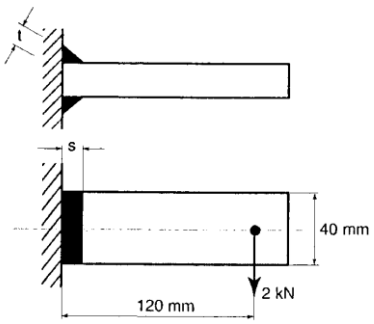



Fig (**ix**)

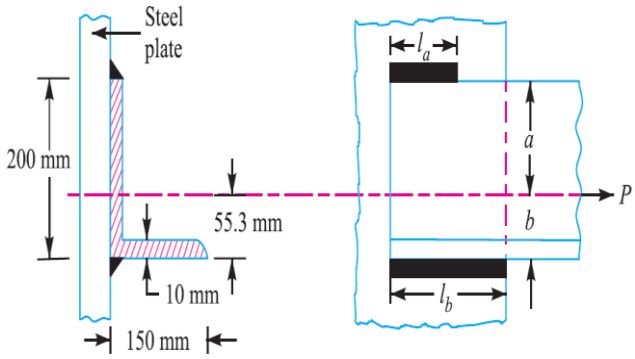
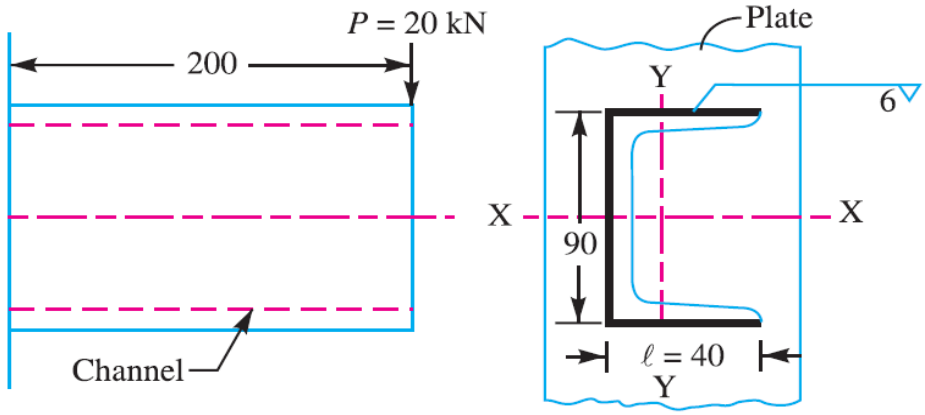
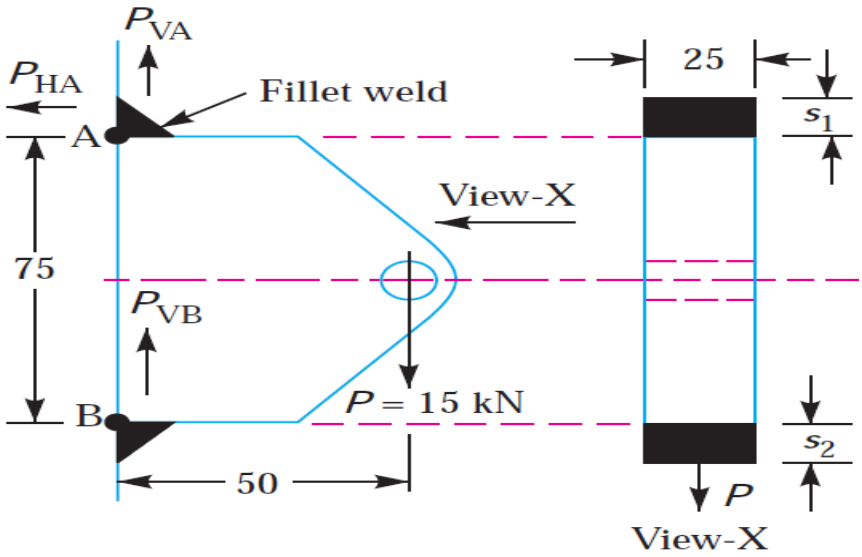



Fig (**x**)




All dimensions in mm.

Fig (**xi**)




All dimensions in mm.

**Fig(xii)**

# UNI-IV

# ENERGY STORING ELEMENTS

## PART-A

**TWO MARK QUESTIONS AND ANSWERS**

**1. What is a spring?**

A spring is an elastic member, which deflects, or distorts under the action of load and regains its original shape after the load is removed.

**2. State any two functions of springs?**

- To measure forces in spring balance, meters and engine indicators.
- To store energy.

**3. What are the various types of springs?**

- Helical springs
- Spiral springs
- Leaf springs
- Disc spring or Belleville springs

**4. Classify the helical springs?**

- Close – coiled or tension helical spring.
- Open –coiled or compression helical spring.

**5. Define: Leaf springs?**

A leaf spring consists of flat bars of varying lengths clamped together andsupported at both ends, thus acting as a simply supported beam.

**6. Define: Belleville Springs?**

They are made in the form of a cone disc to carry a high compressive force. In order to improve their load carrying capacity, they may be stacked uptogether. The major stresses are tensile and compressive.

**7. What is spring index (C)?**

The ratio of mean or pitch diameter to the diameter of wire for the spring is called the spring index.

**8. What is pitch?**

The axial distance between adjacent coils in uncompressed state.

**9. What is solid length?**

The length of a spring under the maximum compression is called its solid length. It is the product of total number of coils and the diameter of wire.

$$Ls = nt \times d$$

Where, nt = total number of coils.

**10. What are the requirements of spring while designing?**

- Spring must carry the service load without the stress exceeding the safe value.
- The spring rate must be satisfactory for the given application.

**11 What are the end conditions of spring?**

- Plain end.
- Plain and ground end
- Squared end
- Squared and ground end.

**12. What is buckling of springs?**

The helical compression spring behaves like a column and buckles at acomparative small load when the length of the spring is more than 4 times themean coil diameter.

**13. What is surge in springs?**

The material is subjected to higher stresses, which may cause early fatigue failure. This effect is called as spring surge.

**14. What is a laminated leaf spring?**

In order to increase, the load carrying capacity, number of flat plates are placed and below the other.

**15. What semi – elliptical leaf springs?**

The spring consists of number of leaves, which are held together by Uclips.
The long leaf fastened to the supported is called master leaf. Remaining leaves are called as graduated leaves.

**16. What is nipping of laminated leaf spring?**

Prestressing of leaf springs is obtained by a difference of radii of curvature known as nipping.

**17. What are the various application of springs?**

The springs are used in various applications, they are

- Used to absorb energy or shocks (e.g. shock absorbers, buffers, e.t.c.)
- To apply forces as in brakes clutches, spring-loaded valves, e.t.c.
- To measure forces as in spring balances and engine indicators
- To store energy as in watches

**18. Define free length**?

Free length of the spring is the length of the spring when it is free or unloaded condition. It is equal to the solid length plus the maximum deflection orcompression plus clash allowance.

Lf = solid length + Ymax + 0.15 Ymax

**19. Define spring index?**

Spring index (C) is defined as the ratio of the mean diameter of the coil to the diameter of the wire.

C =D/d

**20. Define spring rate (stiffness)?**

The spring stiffness or spring constant is defined as the load required per unit deflection of the spring.

K= W/y

Where W-load y-deflection

**21. Define pitch?**

Pitch of the spring is defined as the axial distance between the adjacent coils in uncompressed state. Mathematically

Pitch=free length n-1

**22. What are the points to be taken into consideration while selecting the pitch of thespring?**

The points taken into consideration of selecting the pitch of the springs are

- The pitch of the coil should be such that if the spring is accidentally compressed the stress does not increase the yield point stress in torsion.
- The spring should not be close up before the maximum service load is reached.

**23. Define active turns?**

Active turns of the spring are defined as the number of turns, which impart spring action while loaded. As load increases the no of active coils decreases.

**24. Define inactive turns?**

Inactive turns of the spring is defined as the number of turns which does not contribute to the spring action while loaded. As load increases number of inactivecoils increases from 0.5 to 1 turn.

**25. What are the different kinds of end connections for compression helical springs?**

The different kinds of end connection for compression helical springs are

- Plain ends
- Ground ends
- Squared ends
- Ground & square ends

**26. Write about the eccentric loading of springs?**

If the load acting on the spring does not coincide with the axis of the spring, then spring is said to be have eccentric load. In eccentric loading the safeload of the spring decreases and the stiffness of the spring is also affected.

**27. Explain about surge in springs?**

When one end of the spring is resting on a rigid support and the other end is loaded suddenly, all the coils of spring does not deflect equally, becausesome time is required for the propagation of stress along the wire.

Thus a wave ofcompression propagates to the fixed end from where it is reflected back to thedeflected end this wave passes through the spring indefinitely. If the time intervalbetween the load application and that of the wave to propagate are equal, thenresonance will occur. This will result in very high stresses and cause failure. Thisphenomenon is called surge.

**28. What are the methods used for eliminating surge in springs?**

The methods used for eliminating surge are

- By using dampers on the center coil so that the wave propagation dies out
- By using springs having high natural frequency.

**29. What are the disadvantages of using helical spring of non-circular wires?**

- The quality of the spring is not good
- The shape of the wire does not remain constant while forming the helix. It reduces the energy absorbing capacity of the spring.
- The stress distribution is not favorable as in circular wires. But this effect is negligible where loading is of static nature.

**30 Why concentric springs are used?**

- To get greater spring force within a given space
- To insure the operation of a mechanism in the event of failure of one of the spring

**31. What is the advantage of leaf spring over helical spring?**

The advantage of leaf spring over helical spring is that the end of the spring may be guided along a definite path as it deflects to act a structural member in addition to energy absorbing device.

**32. Write notes on the master leaf & graduated leaf?**

The longest leaf of the spring is known as main leaf or master leaf has its ends in the form of an eye through which bolts are passed to secure the spring.

The leaf of the spring other than master leaf is called the graduated leaves.

**33. What is meant by nip in leaf springs?**

By giving greater radius of curvature to the full length leaves than the graduated leaves, before the leaves are assembled to form a spring thus a gap or clearance will be left between the leaves. This initial gap is called nip.

**34. What is the application of leaf spring?**

The leaf springs are used in automobiles as shock absorbers for giving suspension to the automobile and it gives support to the structure.

**35. Define flat spiral spring?**

A flat spiral spring is a long thin strip of elastic material wound like a spiral. These springs are frequently used in watch springs, gramophones, e.t.c

**36. What are the differences between helical torsion spring and tension helical springs?**

Helical torsion springs are wound similar to that of tension springs but the ends are shaped to transmit torque. The primary stress in helical torsion spring is bending stress whereas in tension springs the stresses are torsional shear stresses.

**37. Define helical springs?**

The helical springs are made up of a wire coiled in the form of a helix and is primarily intended for compressive or tensile load.

**38. What are the different types of helical springs?**

The different types of helical springs are

- Open coil helical spring
- Closed coil helical spring

**39. Define surging in springs?**

If the load applied is of fluctuating type, which results in a very large deflection, it causes spring failure. This phenomenon is called surging.

## PART – B (13 Marks)

### UNIT-IV ENERGY STORING ELEMENTS

Design a spring for spring loaded safety valve for the following condition :

Operating pressure = 1.2 MPa

Diameter of the valve seat = 110 mm

Design shear stress for the spring = 380 MPa.

G = shear modulus = 84 GPa.

The spring is to be kept in the casing of 130 mm inner diameter and 400 mm long. The spring should be at maximum lift of 6 mm when the pressure is 1.275 MPa. (16)

Design a leaf spring for a truck to following specifications.

Maximum load on springs = 160 kN

Number of springs = 4; spring material = chromium vanadium steel

Permissible tensile stress = 600 MPa

Maximum number of leaves = 10

Span of the spring = 1300 mm

Permissible deflection = 90 mm

E for the material = 210 GPa.

Derive the deflection equation for helical spring. (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/mm$^2$. (10)

A rimmed flywheel made of grey cast iron (mass density = 7100 kg/m$^3$) is used on a punching press running at a mean speed of 200 r.p.m. The punching operation consists of one quarter revolution during which the flywheel is required to supply 3000 N.m of energy. The coefficient of speed fluctuations is limited to 0.2. The rim, which contributes 90% of the required moment of inertia, has a mean radius of 0.5 m due to space limitations. The cross-section of the rim is square. Determine its dimensions.

A multi cylinder engine is to run at a constant load at a speed of 500 rpm on drawing the crank effort diagram to seeks of 1 cm = 2500 Nm and 1 cm = 600, the area above and below the mean torque line were measured and found to be in order +1.60, –1.72, +1.68, –1.91, +1.97 and –1.62. If the speed is to be kept with in limits of ± 1% of the mean speed, design the suitable type of flywheel.

The intercepted areas between the output torque curve and the mean resistance line of a turning moment diagram for a multicylinder engine, taken in order from one end are as follows :

–35, +410, –285, +325, –335, +260, –365, +285, –260 mm$^2$. The diagram has been drawn to a scale of 1 mm = 70 N-m and 1 mm = 4.5°. The engine speed is 900 rpm and the fluctuation in speed is not to exceed 2% of the mean speed.

Find the mass and cross-section of the flywheel rim having 650 mm mean diameter. The density of the material of the flywheel may be taken as 7200 kg/m$^3$. The rim is rectangular with the width 2 times the thickness. Neglect effect of arms, etc. (16)

A punching press pierces 30 holes per minute in a plate using 12 kN-m of energy per hole during each revolution. Each piercing takes 35% of the time needed to make one revolution. The punch receives power through a gear reduction unit which in turn is fed by a motor driven belt pulley 750 mm diameter and turning at 240 rpm. Find the power of the electric motor if overall efficiency of ~~the trans~~mission ~~unit~~ is 80%. Design a cast iron flywheel to be used with the punching machine for a coefficient of fluctuation of speed is 0.05, if the space considerations limits the maximum diameter to 1.3 m.

Allowable shear stress in the shaft mateial = 48 MPa

Allowable tensile stress for cast iron = 5 MPa

Density of cast iron = 7200 Kg/m$^3$. (16)

A single cylinder double acting steam engine delivers 187.5 kW at 100 rpm. The maximum fluctuation of energy per revolution is 15%. The speed variation is limited to 1% either way from the mean. The mean diameter of the rim is 2.4 m. Design a cast iron flywheel for the engine.

7. A locomotive spring has an overall length of 1.1m and sustained a load of 75kN at itscenter. The spring has 3 full length leaves and 15 graduated leaves with a central band of100mm wide. All leaves are to be stresses to 420N/mm^2. When fully loaded the ratio of thespring depth to width is to be approximately 2.Take E=2.1*10^5N/mm^2.
(i) Determine width and thickness of the leaves.
(ii) Determine the initial space that should be provided between the full length
and graduated leaves before the band load is applied.
(iii) what load is exerted on the band after the spring is assembled.

8.A punching m/c makes 24 strokes per minute and is capable of punching 30 mm dia holes in 20mm. thick plates having an ultimate shear strength of 350 $N/mm^2$ , the punching operation take place during 1/10 th of a revolution of the crank shaft.
(i)determine the power required for the driving motor , assuming a mechanical efficiency of 75%.
(ii)find suitable dimensions for rim section.the permissible coefficient of speed fluctuation is 0.4: the flywheel revolves at 9 times the speed of the crankshaft. Assume cast iron for flywheel. Assume suitable permissible stresses.Assume suitablepermissible coefficient of speed fluctuation is 0.4.

# Unit-V
## BEARINGS
## PART-A

**TWO MARK QUESTIONS AND ANSWERS**

**1. What is bearing?**

Bearing is a stationery machine element which supports a rotating shafts or axles and confines its motion.

**2. Classify the types of bearings**?

i. Depending upon the type of load coming upon the shaft:

- Radial bearing
- Thrust bearings.

ii. Depending upon the nature of contact:

- Sliding contact
- Rolling contact bearings or Antifriction bearings.

Closed coil helical spring Open coil helical spring

The spring wires are coiled very closely, each turn is nearly at rightangles to the axis of helix

The wires are coiled such that there is a gap between the two consecutiveturns.

Helix angle is less than 10o Helix angle is large (>10o)

**3. What are the required properties of bearing materials?**

Bearing material should have the following properties.

- High compressive strength
- Low coefficient of friction
- High thermal conductivity
- High resistance to corrosion
- Sufficient fatigue strength
- It should be soft with a low modulus of elasticity
- Bearing materials should not get weld easily to the journal material.

**4. What is a journal bearing?**

A journal bearing is a sliding contact bearing which gives lateral support to the rotating shaft.

**5. What are the types of journal bearings depending upon the nature of contact?**

- Full journal bearing
- Partial bearing
- Fitted bearing.

**6. What are the types of journal bearing depending upon the nature of lubrication?**

- Thick film type
- Thin film type
- Hydrostatic bearings
- Hydrodynamic bearing.

**7. What is known as self – acting bearing?**

The pressure is created within the system due to rotation of the shaft, this type of bearing is known as self – acting bearing.

**8. What is flywheel?**

Flywheel is a machine elements used to minimize the fluctuation of speedin a engine.

**9. What is the function of flywheel?**

A flywheel used in machine serves as a reservoir which stores energy during the period when the supply of energy is more than the requirement andreleases it dulling the period when the requirement of energy is more than thesupply.

**10. Define the term 'fluctuation of speed' and 'fluctuation of energy'?**

The ratio of maximum fluctuation of speed to the mean speed is called co efficient of fluctuation of speed.

The ratio of fluctuation of energy to the mean energy is called coefficient of fluctuation of energy.

**11. State the type of stresses induced in a rim flywheel?**

- Tensile stress due to centrifugal force
- Tensile bending stress caused by the restraint of the arms and
- The shrinkage stresses due to unequal rate of cooling of casting.

**12. What are the stresses induced in flywheel arms?**

- Tensile stress due to centrifugal force.
- Bending stress due to torque.
- Stress due to belt tension.

**13. How does the function of flywheel differ from that of governor?**

A governor regulates the mean speed of an engine when there are variations in the mean loads. It automatically controls the supply of working fluidto engine with the varying load condition & keeps the mean speed with containlimits. It does not control the speed variation caused by the varying load. Aflywheel does not maintain constant speed.

**14. State any two types of flywheel.**

- Disc type,
- Web type.

**15. Define antifriction bearings.**

Instead of sliding, the contact between the bearing elements is rolling.

**16. State the components of rolling contact bearings.**

Outer race, Inner race, Rolling element, and Retaining cage or separator.

**17. What are the types of thrust ball bearings?**

One directional flat race, One directional grooved race, Two directional grooved race.

**18. Classify the roller bearings.**

Cylindrical roller bearings, Taper roller bearing, Needle roller bearing.

**19. What is load rating?**

The load carrying capacity of a rolling element bearing is called load rating.

**20. Explain the term Dynamic load carrying capacities of rolling contact bearing.**

Dynamic load rating is defined as the radial load in radial bearings(or thrust load in thrust

bearings) that can be carried for a minimum life of one million revolutions

**21. Define thrust bearing?**

When the load acting on the bearing is axial, then the type of bearing is called thrust bearing.

**22. What is the load to be considered for designing a ball bearing?**

- State load
- Dynamic load

## UNIT V- BEARINGS

### PART-B (13 Marks)

Design a journal bearing for a centrifugal pump from the following data :

Load on the journal = 20 kN, 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/mm$^2$ Calculate mass of the lubricating oil required for artificial cooling, if rise of temperature of oil be limited 10°C. Heat dissipation coefficient = 1232 W/m$^2$/ °C.

A bearing for an axial flow compressor is to carry a radial load of 2500 N and thrust of 1500 N. The service imposes light shock and the bearing will be in use for 40 hours/week for 5 years. The speed of the shaft is 1000 rpm. Select suitable ball bearing for the purpose and give the required tolerances on the shaft and the housing. Diameter of the shaft is 50 mm. (16)

Following data is given for a 360° hydrodynamic bearing.

Journal diameter = 100 mm, Radial clearance = 0.12 mm, Radial load = 50 kN, Bearing length = 100 mm, Journal speed = 1440 rpm and viscosity of lubricant = 16 CP. Calculate

(i) Minimum film thickness

(ii) Co–efficient of friction and

(iii) Power lost in friction.

Following data is given for a 360° hydrodynamic bearing :

| | |
|---|---|
| Journal diameter | = 100 mm |
| Bearing length | = 100 mm |
| Radial load | = 50 kN |
| Journal speed | = 1440 r.p.m. |
| Radial clearance | = 0.12 mm |
| Viscosity of the lubricant | = 16 cP |

Calculate : (i) minimum film thickness (ii) coefficient of friction and (iii) Power lost in friction.

4. What do you understand by viscosity index?
The following data is given for a hydrostatic thrust bearing: thrust load is 5000 N, shaft speed is720 rpm, and shaft diameter is 500mm, recess diameter 300 mm, film thickness is 0.15mm,viscosity of lubricant is 160 SUS, specific gravity is 0.86, calculate (1) supply pressure (2) flowrequirement in lt/min (3) power loss in pumping (4) frictional power loss.

5. Design a journal bearing for a centrifugal pump from the following data: Load on the journal =20000 N; Speed of the journal =900 rpm; type of oil is SAE 10, which the absolute viscosity at 55°C=0.017kg/m-s; Ambient temp of oil =15.5°C; A Maximum bearing for the pump =1.5N/mm$^2$.

6. Select a roller contact bearing for the spindle of a drilling machine with journal dia of 60mm carrying an axial load of 9000N at an

angular speed of 30 rad/sec. bearing life may be taken as 10,000hrs. And also calculate the rated life of the bearing.

7. The cover of a cylindrical pressure vessel made of C.I is.the inner dia of cylindrical is 500mm and the internal pressure is limited to 2 Mpa .the cover is fixed to the cylinder by means of 16 bolts with a nominal dia of 20 mm .each bolt is initially tightened with a preload of 20 KN.the bolts are made of steel FeF 250 ($\partial_{yt}$=250N/mm$^2$). Assume E for steel =207 KN/mm$^2$; E for cast iron=100 KN/mm$^2$; E for zinc =90KN/mm$^2$; determine the factor of safety for bolts considering the effect of the gasket.

8. A connecting rod is required to be is designed for a high speed, four stroke I.C engine. The following data are available. Diameter of piston =80mm; mass of reciprocating parts =1.6kg; stroke length =125mm; length of connecting rod =300mm; rpm =2200(when developing 50KW); compression ratio =6.8:1(approx) probe maximum explosion pressure =3.5 N/mm$^2$.

9.A connecting rod of a petrol engine is to be designed for the following data; piston dia 80mm: stroke 120mm;weight of the reciprocating parts =15N; length of connecting rod =240mm; max speed 2800 rpm; explosion pressure corresponding to 10$^o$of crank angle is 3Mpa; FOS 6. IF THE connecting rod is to be made of 40 cr steel, find the dimensions of the I- section connecting r

Reg. No. : | | | | | | | | | | | | |

**Question Paper Code : 53310**

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2019.

Fourth/Fifth/Sixth Semester

Mechanical Engineering

ME 6503 – DESIGN OF MACHINE ELEMENTS

(Common to Mechanical Engineering (Sandwich), Automobile Engineering, Industrial Engineering, Mechatronics and Automobile Engineering, Mechanical Engineering)

(Regulation 2013)

(Also common to PTME 6503 – Design of Machine Elements for B.E Part Time – Fourth Semester – Mechanical Engineering – Regulation 2014)

Time : Three hours Maximum : 100 marks

Use of Approved Design Data book is permitted.

Any required design data can be suitably assumed.

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. List any two factors that influence the process of machine design.
2. Brief Saint venant's theory of failure.
3. Compare rigid coupling and Flexible coupling.
4. What is meant by critical speed?
5. Under what circumstances riveted joints are preferred over welded joints.
6. List out the advantages of threaded joints.
7. Determine the combined stiffness of two springs connected in parallel and series.
8. What are the various forces acting on a connecting rod?
9. Differentiate sliding contact bearing and rolling contact bearing.
10. Define life of a bearing.

PART B — (5 × 13 = 65 marks)

11. (a) A hollow shaft is required to transmit 500 KW at 100 rpm. The maximum torque being 20% greater than the mean. The shear stress is not to exceed 65 MPa and twist in a length of 2 metres not to exceed 1.2 degrees. Find the external and internal diameter of the shaft, if the ratio of internal to external diameter is 3/8. Take modulus of rigidity as 84 GPa. (13)

Or

(b) A 40 mm diameter shaft is made from carbon steel having ultimate tensile strength of 600 MPa. It is subjected to a torque which fluctuates between 1500 Nm to –900 Nm. Using Soderberg method, calculate the factor of safety. Assume suitable values for any other data needed. (13)

12. (a) Design a clamp coupling to transmit 40kW at 150 rpm. The allowable shear stress for the shaft and key is 50 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. (13)

Or

(b) A Steel solid shaft transmitting 15 KW at 200 rpm is supported on two bearings 750 mm apart and has two gears keyed to it. The pinion having 30 teeth of 5 mm module is located 100mm to the left of the right hand bearing and delivers power horizontally to the right. The gear having 100 teeth of 5 mm module is located 150 mm to the right of the left hand bearing and receives power in a vertical direction from below. Using an allowable stress of 54 MPa in shear, determine the diameter of the shaft. (13)

13. (a) Design a knuckle joint to transmit 100 KN. The design stresses may be taken as 70 MPa in tension, 65 MPa in shear and 120 MPa in compression. (13)

Or

(b) Find the efficiency of a double riveted lap joint of 6 mm plates with 20 mm diameter rivets having a pitch of 55 mm. Assume Permissible tensile stress in plate is 120 MPa, Permissible shearing stress is 90 MPa and Permissible crushing stress is 180 MPa. (13)

14. (a) Determine the dimensions of cross section of the connecting rod for a diesel engine with the following data

Cylinder bore = 100 mm, Length of connecting rod = 350 mm

Maximum gas pressure = 4 MPa and factor of safety= 2 (13)

Or

(b) 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 a design shear stress of 680 MPa and modulus of rigidity of 80 KN/mm$^2$. Determine the spring rate and initial shear stress in the wire. (13)

15. (a) A ball bearing is operating on a work cycle consisting of three parts- a radial load of 3000 N at 1440 rpm for one quarter cycle, a radial load of 5000 N at 720 rpm for one half cycle and radial load of 2500 N at 1440 rpm for the remaining cycle. The expected life of the bearing is 10,000 hr. calculate the dynamic load carrying capacity of the bearing.

Or

(b) Following data is given for a 360° hydrodynamic bearing.

Radial load = 3.2 KN

Journal speed = 1490 rpm

l/d ratio = 1

Unit bearing pressure = 1.3 MPa

Radial clearance = 0.05 mm

viscosity of oil = 25 centipoise

Assume that the total heat generated in the bearing is carried by the total oil flow in the bearing, calculate the journal diameter, power lost in friction and the temperature rise. (13)

PART C — (1 × 15 = 15 marks)

16. (a) A Single row deep groove ball bearing is subjected to a radial force of 8 KN and a thrust force of 3 KN. The values of $X$ and $Y$ factors are 0.56 and 1.5 respectively. The shaft rotates at 1200 rpm. The diameter of the shaft is 75 mm and Bearing No. 6315 (C = 112000 N) is selected for this application. Estimate

(i) Life of the bearing with 90% reliability

(ii) Reliability for 20000 hr. life. (15)

Or

(b) Design a cotter joint to support a load varying from 30 KN in compression to 30 KN in tension. The material used is carbon steel for which the following allowable stresses may be used. The load is applied statically.

Tensile and compressive stresses = 50 MPa

Shear stress = 35 Mpa

Crushing stress = 90 MPa. (15)

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# Question Paper Code : 41403

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2018

Fourth/Fifth/Sixth Semester

Mechanical Engineering

ME 6503 – DESIGN OF MACHINE ELEMENTS

(Common to Mechanical Engineering (Sandwich)/Automobile Engineering/ Industrial Engineering/Mechanical and Automation Engineering/Mechatronics Engineering)

(Regulations 2013)

Time : Three Hours | Maximum : 100 Marks

Answer ALL questions.

PART – A **(10×2=20 Marks)**

1. What are preferred numbers ?
2. Brief about Soderberg and Goodman lines.
3. Write the advantages that hollow shafts offer as compared to solid shafts.
4. Write Rayleigh-Ritz equation to determine the critical speed of shaft subjected to point loads.
5. List out the advantages of the V-threads.
6. What is Caulking and Fullering process in riveted joints ? Why is it used ?
7. Define surge in Springs.
8. State functions of flywheel.
9. What are essential condition for wedge film formation in Hydro dynamic bearing ?
10. Define load factor and explain its significance in related to bearing selection.

PART – B (5×13=65 Marks)

11. a) A wall bracket with rectangular cross section is shown in figure 11 (a). The depth of the cross section is twice that of the width. The force P acting on the bracket at 60° to the vertical is 5 KN. The material of the bracket is Grey Cast iron FG 200 and the factor of safety is 3.5. Determine the dimensions of the cross sections of the bracket. Assume maximum normal stress theory of failure. (13)

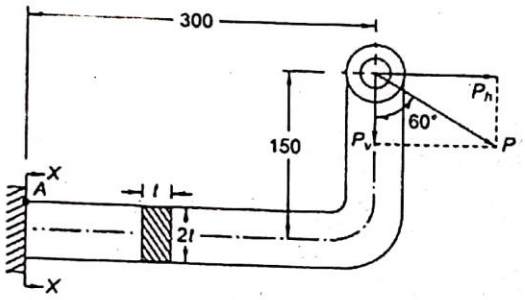


Fig. 11 (a)

(OR)

b) The C-Frame of a 100 KN capacity press is shown in figure 11 b (i), 11 b (ii). The material of the frame is FG 200. Assuming the factor of safety as 3, determine the dimensions of the frame. (13)

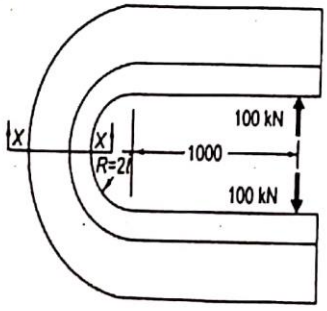


Fig. 11. b (i)

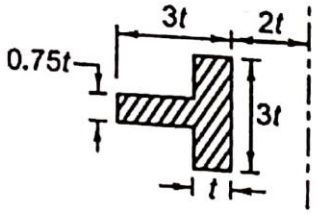


Fig. 11. b (ii)

12. a) A rigid coupling is used to transmit 50 kW power at 300 rpm. There are six bolts the outer diameter of the flanges is 220 mm, while the recess diameter is 150 mm. The coefficient of friction between the flanges is 0.15 mm. The bolts are made of steel 45C8 ($S_{yt}$ = 380 N/mm$^2$) and the factor of safety is 3. Determine the diameter of the bolts. Assume that the bolts are fitted in large clearance holes. (13)

(OR)

b) A transmission shaft supporting a helical gear B and an overhang bevel gear D is shown in figure 12. b. The shaft is mounted on two bearings A and C. The pitch circle diameter of the helical gear is 450 mm and the diameter of the bevel gear at the forces is 450 mm. Power is transmitted from the helical gear to the bevel gear. The gears are keyed to the shaft. The material of the shaft is steel 45C8 ($S_{ut}$ = 600 and $S_{yt}$ = 380 N/mm$^2$). The factors $k_b$ and $k_t$ of ASME code are 2.0 and 1.5 respectively. Determine the shaft diameter using the ASME code. **(13)**

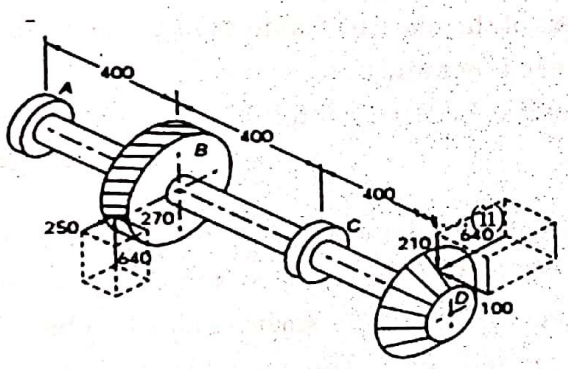


Fig. 12. (b)

13. a) The structural connection shown in figure 13. a. i) is subjected to an eccentric force P of 10 kN with an eccentricity of 500 mm from the CG of the bolts. The centre distance between bolts 1 and 2 is 200 mm, and the centre distance between bolts 1 and 3 is 150 mm. All the bolts are identical. The bolts are made from plain carbon steel 30C8 ($S_{yt}$ = 400 N/mm$^2$) and the factor of safety is 2.5. Determine the size of the bolts. **(13)**

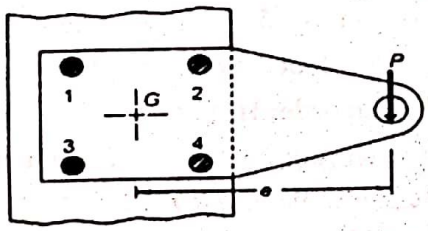


Fig. 13. a (i)

(OR)

b) A cylindrical steam pressure vessel of 1 m inside diameter is subjected to an internal pressure of 2.5 MPa. Design a double-riveted, double-strap longitudinal butt joint for the vessel. The straps are of equal width. The pitch of the rivets in the outer row should be twice of the pitch in the inner row. A zig-zag pattern is used for rivets in inner and outer rows. The efficiency of the riveted joint should be at least 70%. The permissible tensile strength for the steel plate of pressure vessel is 80 N/mm$^2$. The permissible shear stress for the rivet material is 60 N/mm$^2$. Assume that the rivets in double shear are 1.875 times stronger than in single shear and the joint do not fail by crushing. Calculate i) thickness of the plate ii) diameter of the rivets iii) pitch of the rivets iv) distance between inner and outer rows of the rivets v) margin vi) thickness of the straps vii) efficiency of the joint. Make neat sketch showing all the calculated dimensions. **(7×1.5= 10.5+2.5)**

14. a) A helical compression spring made of circular wire, is subjected to an axial force, which varies from 2.5 kN to 3.5 kN. Over this range of force, the deflection of the spring should be approximately 5 mm. The spring index can be taken as 5. The spring has square and ground ends. The spring is made of patented and cold-drawn steel wire and ultimate tensile strength of 1050 N/mm$^2$ and modulus of rigidity of 81370 N/mm$^2$. The permissible shear stress for the spring wire should be taken as 50% of the ultimate tensile strength. Design the spring and calculate i) Wire diameter ii) mean coil diameter iii) number of active coils iv) total number of coils v) solid length of spring vi) free length of spring vii) required spring rate viii) actual spring rate. **(8×1.5= 12+1)**

(OR)

b) The turning moment diagram of a multi-cylinder engine is drawn with a scale of (1 mm = 1°) on the abscissa and (1 mm = 250 N-m) on the ordinate. The intercepted areas between the torque developed by the engine and the mean resisting torque of the machines, taken in order from one end are –350, +800, –600, + 900, –550, +450 and –650 mm$^2$. The engine is running at a mean speed of 750 rpm and the coefficient of speed fluctuation is limited to 0.02. A rimmed flywheel made of grey cast iron FG 200 (density = 7100 kg/m$^3$) is provided. The spokes, hub and shaft are assumed to contribute 10% of the required moment of inertia. The rim has rectangular cross-section and the ratio of width to thickness is 1.5. Determine the dimensions of the rim. **(13)**

15. a) A shaft transmitting 50 kW at 1255 rpm from the gear $G_1$ to the gear $G_2$ and mounted on two single-row deep groove ball bearings $B_1$ and $B_2$ as shown. The gear tooth forces are $P_{t1}$ = 15915 N, $P_{r1}$ = 5793 N, $P_{t2}$ = 9549 N and $P_{r2}$ = 3476 N. The diameter of the shaft at bearings $B_1$ and $B_2$ is 75 mm. The load factor is 1.4 and the expected life for 90% of the bearings is 10000 h. Select suitable ball bearings. Refer figure 15 (a). **(13)**

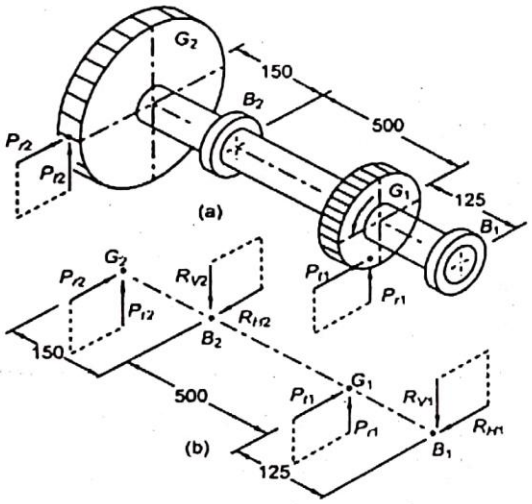


Fig. 15. (a)

(OR)

b) The following data is given for a full hydrodynamic bearing used for electric motor radial load = 1200 N; journal speed = 1440 rpm; journal diameter = 50 mm static load on the bearing = 350 N. The values of surface roughness of the journal and the bearing are 2 and 1 micron respectively. The minimum oil film thickness should be five times the sum of surface roughness of the journal and the bearings. Determine i) length of the bearing ii) radial clearance iii) minimum oil film thickness iv) viscosity of lubricant v) flow of lubricant select a suitable oil for this application assuming the operating temperature as 65°C. **(2+2+2+4+3)**

PART – C (1×15=15 Marks)

16. a) Determine the stress at point A and B split ring shown in fig. 16 (a). if a compressive force = 20 kN is applied point 'C'. (15)

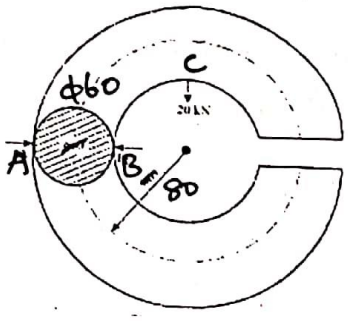


Fig. 16 (a)

(OR)

b) Explain why the standard I-Section is chosen for designing of connecting rod over other cross section without sacrificing the fundamentals and write the design equation for connecting rod based on crippling load. (15)

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# Question Paper Code : 50872

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2017
Fourth/Fifth/Sixth Semester
Mechanical Engineering
ME 6503 – DESIGN OF MACHINE ELEMENTS
(Common to Mechanical Engineering (Sandwich)/Automobile Engineering/ Industrial Engineering/Mechanical and Automation Engineering/Mechatronics Engineering)
(Regulations 2013)

Time : Three Hours | Maximum : 100 Marks

Usage of PSG design data book is permitted.

Answer ALL questions..

PART – A **(10×2=20 Marks)**

1. What is shock factor and what does it indicate ?
2. Differentiate hardness and toughness.
3. List the different types of sunk keys and draw any one.
4. Differentiate rigid and flexible couplings.
5. State the disadvantages of welded joints.
6. What is known as proof load in bolts ?
7. While designing helical springs, K is introduced in the shear stress equation, why ?
8. List the advantages of hydrostatic bearings.
9. Brief why fly wheels are used in punching machines.
10. What type of bearings can take axial load ?

PART – B **(5×13=65 Marks)**

11. a) Design a journal bearing for a 49.9 mm dia journal. It is ground and hardened and is rotating at 1500 rpm in a bearing of diameter and length 50 mm. The inlet temperature of oil 65°C. Determine a) maximum radial load that the journal can carry b) power loss.

(OR)

b) A deep groove ball bearing No. 6308 selected for a particular application, carries a radial load of 2900 N and a thrust load of 1800 N ; both being steady. The inner race of the bearing rotates at 900 r.p.m. The bearing is required to have a minimum life of 9000 hours. Check whether the bearing selected can serve the purpose.

12. a) A bolt is subjected to a direct load of 25 kN and shear load of 15 kN. Considering following theories of failure, determine a suitable size of the bolt if the material of the bolt is C15 having 200 N/mm$^2$ yield strength. Assume F.O.S. as 2 and also give your comments.
   i) Maximum normal stress theory
   ii) Maximum shear stress theory
   iii) Von misses theory.

(OR)

b) A mass of 50 kg drops through 25 mm at the centre of a 250 mm long simply supported beam. The beam has a square cross section. It is made of steel 30C8 ($S_{yt}$ = 400 N/mm$^2$) and the factor of safety is 2. The modulus of elasticity is 207000 N/mm$^2$. Determine the dimension of the cross section of the beam.

13. a) A 600 mm diameter pulley driven by a horizontal belt transmits power through a solid shaft to a 262 mm diameter pinion which drives a matting gear. The pulley weighs 1200 N to provide some flywheel effect. The arrangement of elements, the belt tensions and components of the gear reactions on the pinion are as indicated in Figure 13(a). Determine the necessary shaft diameter using a suitable value for commercial shafting and shock fatigue factors of $K_b$ = 2 and $K_t$ = 15.

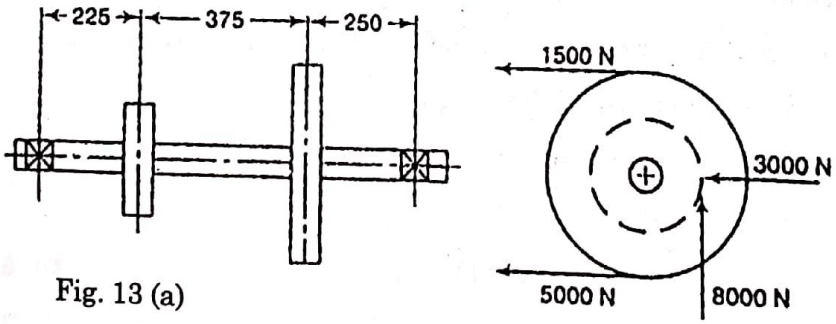


Fig. 13 (a)

(OR)

b) A shaft made of AISI 1030 cold drawn steel ($\sigma_u = 520$ MPa and $\sigma_y = 440$ MPa) transmits 50 kW at 900 rpm through a gear. Select an appropriate square key for the gear.

14. a) An ISA 200 × 100 × 100 angle is welded to a steel plate by means of fillet welds as shown in Fig 14 (a). The angle is subjected to a static force of 150 kN and permissible shear stress for the weld is 70 N/mm$^2$. Determine the lengths of the weld at the top and bottom.

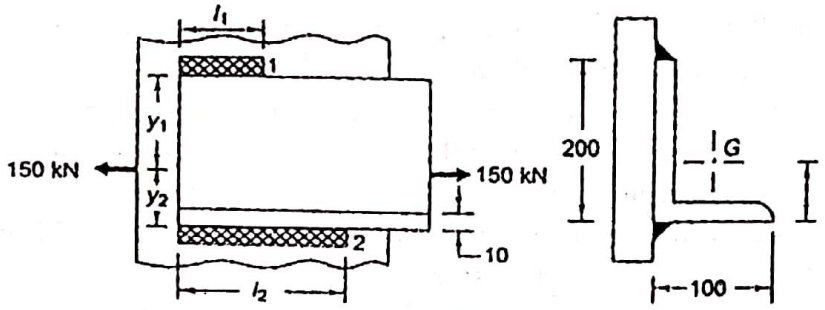


Fig. 14 (a)

(OR)

b) Fig. 14(b) shows a bracket fixed on a steel column by means of 3 bolts of same size. If the permissible tensile and shear stress are limited to 75 N/mm$^2$ and 55 N/mm$^2$ respectively. Find the size of bolts.

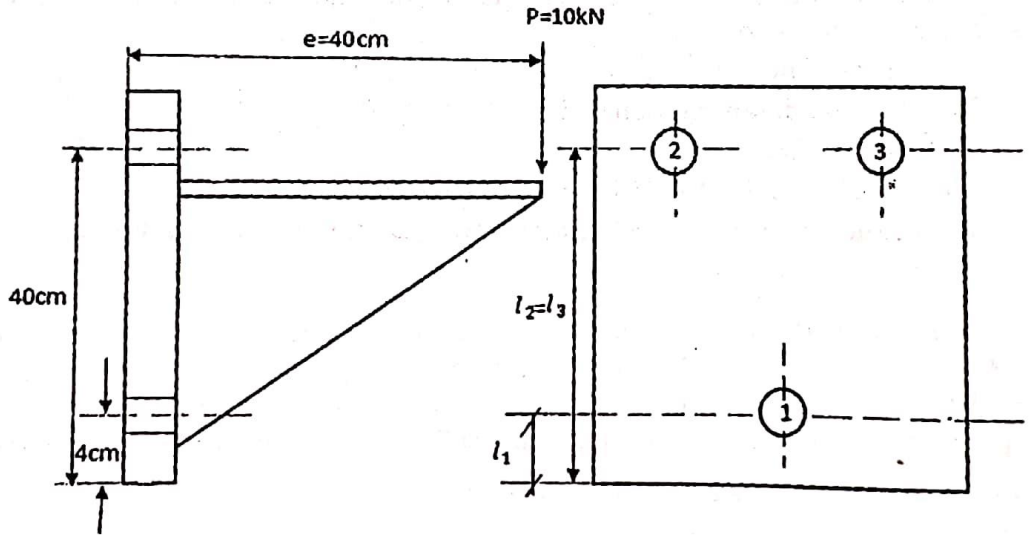


Fig. 14 (b)

15. a) A spring loaded safety valve for a boiler is required to blow off at a pressure of 0.8 MPa. The diamater of valve seat is 90 mm and maximum lift of valve is 10 mm. Design a suitable spring for the valve assuming the spring index as 7. Provide an initial compression of 30 mm. Take allowable shear stress as 420 MPa.

(OR)

b) A punching machine makes 25 working stokes per minute and is capable of punching 25 mm diameter holes in 18 mm thick steel plates having an ultimate shear strength of 3000 kg/cm$^2$. The punching operation takes place during 1/10$^{th}$ of a revolution of the crank shaft. Estimate the horse power needed for the driving motor, assuming a mechanical efficiency of 95 %. Determine suitable dimensions for the rim cross section of the flywheel, which is to revolve at 9 times the speed of crankshaft. The permissible fluctuation of speed is 0.1. The flywheel is to be made of cast iron having a working stress (tensile) of 60 kg/cm$^2$ and weighing 7.25 gm/cu. cm. The diameter of the flywheel must not exceed 149 cm owing to space restrictions. The hub and spokes may be assumed to provide 5% of the rotational inertia of the wheel. Check for the centrifugal stress induced in the rim.

PART – C **(1×15=15 Marks)**

16. a) 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.

(OR)

b) It is required to design a knuckle joint to connect two circular rods subjected to an axial tensile force of 50 kN. The rods are co-axial and a small amount of angular movement between their axes is permissible. Design the joint and specify the dimensions of its components. Select suitable materials for the parts.

Assume rod materials as 30C8 and FOS = 5.

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**Question Paper Code : 51856**

**B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2016**

**Fifth Semester**

**Mechanical Engineering**

**ME 2303/ME 53/10122 ME 504 – DESIGN OF MACHINE ELEMENTS / MACHINE DESIGN**

**(Common to Fifth Semester, Automobile Engineering and Mechanical and Automation Engineering, Fourth Semester – Manufacturing Engineering, Industrial Engineering and Management and Industrial Engineering)**

**(Regulations 2008/2010)**

**(Common to PTME 2303 – Design of Machine Elements for B.E. (Part-Time) Fourth Semester – Mechanical Engineering – Regulations – 2009)**

**Time : Three Hours** **Maximum : 100 Marks**

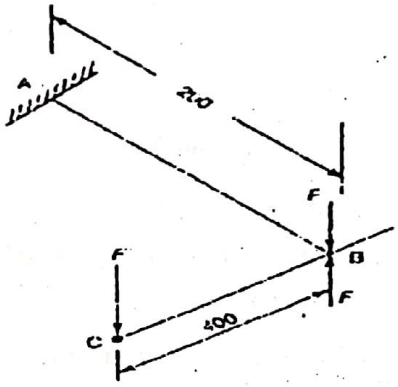
**Use of approved data book permitted**
**Answer ALL questions.**

**PART – A (10 × 2 = 20 Marks)**

1. Define limits and fits.
2. What is an adaptive design ?
3. Why a hollow shaft has greater strength and stiffness than solid shaft of equal weight ?
4. Under what circumstances flexible couplings are used ?
5. State the two types of eccentric welded connections.
6. What is a gib ? Why is it provided in a cotter joint ?
7. What is stiffness of spring ?
8. What is nipping of leaf spring ?
9. What is meant by journal bearing ?
10. What do you mean by life of an individual bearing ?

## PART – B (5 × 16 = 80 Marks)

11. (a) The shaft of an overhang crank is subjected to a force F of 2 kN as shown in fig. below. The shaft is made of 30 $Mn^2$ steel having a allowable shear strength equal to 100 $N/mm^2$. Determine the diameter of the shaft. **(16)**




**OR**

(b) Design a muff coupling to connect two steel shafts transmitting 25 kW power at 360 rpm. The shafts and key are made of plain carbon steel 30 C8 ($S_{yt}$ = $S_{yc}$ = 400 $N/mm^2$). The sleeve is made of grey cast iron FG 200 ($S_{ut}$ = 200 $N/mm^2$). The factor of safety for the shafts and key is 4. For the sleeve, the factor of safety is 6 based on ultimate strength. **(16)**

12. (a) A horizontal nickel steel shaft rests on two bearings, A at the left and B at the right end and carries two gears C and D located at distances of 250 mm and 400 mm respectively from the centre line of the left and right bearings. The pitch diameter of the gear C is 600 mm and that of gear D is 200 mm. The distance between the centre line of the bearings is 2400 mm. The shaft transmits 20 kW at 120 rpm. The power is delivered to the shaft at gear C and is taken out at gear D in such a manner that the tooth pressure $F_{tc}$ of the gear C and $F_{tD}$ of the gear D act vertically downwards.

Find the diameter of the shaft, if the working stress is 100 MPa in tension and 56 MPa in shear. The gear C and D weighs 950 N and 350 N respectively. The combined shock and fatigue factors for bending and torsion may be taken as 1.5 and 1.2 respectively. **(16)**

**OR**

(b) Design a bushed-pin type of flexible coupling to connect a pump shaft to a motor shaft transmitting 32 kW at 960 r.p.m. The overall torque is 20 percent more than mean torque. The material properties are as follows :

(i) The allowable shear and crushing stress for shaft and key material is 40 MPa and 80 MPa respectively

(ii) The allowable shear stress for cast iron is 15 MPa;

(iii) The allowable bearing pressure for rubber bush is 0.8 $N/mm^2$

(iv) The material of the pin is same as that of shaft and key.

Draw neat sketch of the coupling. **(16)**

13. (a) A rectangular steel plate 100 mm wide is welded to a vertical plate to form a cantilever with an overlap of 50 mm and an overhang of 150 mm. It carries a vertical downward load of 60 kN at free end. Fillet weld is done three sides of the plate for a permissible stress of 140 $N/mm^2$. Determine the size of the weld. **(16)**

**OR**

(b) A knuckle joint is to transmit a force of 140 kN. Allowable stresses in tension, shear and compression are 75 $N/mm^2$, 65 $N/mm^2$ and 140 $N/mm^2$ respectively. Design the joint. **(16)**

14. (a) A helical compression spring made of oil tempered carbon steel is subjected to a load which varies from 400 N to 1000 N. The spring index is 6 and the design factor of safely is 1.25. If the yield stress in shear is 770 MPa and endurance stress in shear is 350 MPa, find: (i) Size of the spring wire, (ii) Diameter of the spring, (iii) Number of turns of the spring, and (iv) Free length of the spring. The compression of the spring at the maximum load is 30 mm. The modulus of rigidity for the spring material may be taken as 80 $kN/mm^2$. **(16)**

**OR**

(b) A single cylinder double acting steam engine delivers 185 kW at 100 r.p.m. The maximum fluctuation of energy per revolution is 15 percent of the energy developed per revolution. The speed variation is limited to 1 percent either way from the mean. The mean diameters of the rim are 2.4 m. Design and draw two views of the flywheel. **(16)**

15. (a) Design a journal bearing for 12 MW, 1000 rpm steam turbine, which is supported by two bearings. Take the atmospheric temperature as 16 °C and operating temperature of oil as 60 °C assume viscosity of oil as 23 $Ns/m^2$. **(16)**

**OR**

(b) Select a suitable deep groove ball bearing for supporting a radial load of 10 kN and an axial load of 3 kN for a life of 4000 hours at 800 rpm. Select from series 63. Calculate the expected life of the selected bearing. **(16)**

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Reg. No. : | | | | | | | | | | | | |

**Question Paper Code : 27372**

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2015.

Fifth Semester

Mechanical Engineering

ME 6503 — DESIGN OF MACHINE ELEMENTS

(Regulations 2013)

(Common to B.E. Automobile Engineering, Mechanical and Automation Engineering, Industrial Engineering and Mechatronics Engineering)

Time : Three hours Maximum : 100 marks

Note: Use of Approved Design Data Book is permitted.
Any required design data can be suitably assumed

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Which theory of failure is suitable for the design of brittle materials?

2. What are the common materials used in mechanical engineering design?

3. What is meant by design of a shaft based on rigidity?

4. What are the possible modes of failure of the pin (bolt) in a flexible coupling?

5. What is the total shear in a double strap butt joint with equal length of straps?

6. What is the bending stress induced in the weld when a circular rod of diameter d, welded to a rigid plate by a circular fillet weld of size 't', which is subjected to a bending moment M?

7. What is the purpose of the flywheel?

8. What type of spring is used to maintain an effective contact between a cam and a reciprocating roller or flat faced follower?

9. What is meant by square journal bearing?

10. Give an example for anti-friction bearing.

PART B — (5 × 16 = 80 marks)

11. (a) A bolt is subjected to an axial pull of 10 kN and a transverse shear force of 5 kN. The yield strength of the bolt material is 300 MPa. Considering a factor of safety of 2.5. Determine the diameter of the bolt, using (i) maximum normal stress theory, (ii) maximum shear stress theory, and (iii) maximum principal strain theory. Take Poisson's ratio as 0.25. (16)

Or

(b) A cantilever rod of length 120 mm with circular section is subjected to a cyclic transverse load; varying from -100 N to 300 N at its free end. Determine the diameter 'd' of the rod, by (i) Goodman method and (ii) Soderberg method using the following data.

Factor of safety = 2; Theoretical stress concentration factor = 1.4; Notch sensitivity factor = 0.9; Ultimate strength = 550 MPa; Yield strength = 320 MPa; Endurance limit = 275 MPa; Size correction factor = 0.85; Surface correction factor = 0.9. (16)

12. (a) The shaft of length 1 m carrying two pulleys 1 and 2 at its left and right ends respectively and it is supported on two bearings A and B which are located 0.25 m from the left end and the same 0.25 m from the right end respectively. The shaft transmits 7.5 kW power at 360 rpm from pulley 1 to pulley 2. The diameters of pulley 1 and 2 are 250 and 500 mm respectively. The masses of pulley 1 and 2 are 10 kg and 30 kg respectively. The belt tension act vertically downward and ratio of belt tensions on tight side to slack sid for each pulley is 2.5:1. The yield strength of the shaft material $\sigma_y$ = 380 MPa and factor of safety is 3.

Estimate the suitable diameter of the shaft. (16)

Or

(b) Design a bushed pin type of flexible coupling for connecting a motor and a pump shaft. The following data are provided:

Power transmitted = 20 kW; Speed = 1000 rpm; Diameter of the motor and pump shafts = 50 mm; Allowable bearing pressure in the rubber bush = 0.3 MPa. (16)

13. (a) A steam engine cylinder of 300 mm effective diameter, is subjected to a steam pressure of 1.5 MPa. The cylinder head is connected by means of 8 bolts having yield strength of 30 MPa and endurance limit of 240 MPa. The bolts are tightened with an initial preload of 1.5 times that of steam load. A soft copper gasket is used to make the joint leak proof assuming a fatigue stress concentration factor of 1.4, and factor of safety of 2; determine the size of the bolts required. (16)

Or

(b) Design a knuckle joint to withstand a load of 100 kN. All the parts of the joint are made of the same material with $\sigma_{ut} = \sigma_{uc}$ = 480 MPa, and $\tau_u$ = 360 MPa. Use factor of safety of 6 on ultimate strength. (16)

14. (a) A railway wagon moving at a velocity of 1.5 m/s is brought to rest by bumper consisting of two helical springs arranged in parallel. The mass of the wagon is 1500 kg. The springs are compressed by 150 mm in bringing the wagon to rest. The spring index can be taken as 6. The springs are made of oil-hardened and tempered steel wire with ultimate tensile strength of 1250 MPa and modulus of rigidity of 81.37 GPa. The permissible shear stress for the spring wire can be taken as 50% of the ultimate tensile strength. Design the spring and calculate (i) wire diameter (ii) mean coil diameter (iii) number of active coils (iv) total number of coils (v) solid length (vi) free length and (vii) pitch of the coil. (16)

Or

(b) A 5 kW induction motor, running at 960 rpm operates a riveting machine. The flywheel fitted to it, is of mass 120 kg, with radius of gyration equal to 0.35 m. Each riveting takes 1 second and requires 9 kW. Determine (i) the number of rivets formed per hour and (ii) the reduction in speed of the flywheel, after the riveting operation. (16)

15. (a) 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 the operating temperature of 75°C may be taken as 0.011 kg/m-s. The room temperature is 35°C. Find (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. (16)

Or

(b) Select a single row deep groove ball bearing for a radial load of 4000 N and an axial load of 5000 N, operating at a speed of 1600 rpm for an average life of 5 years at 10 hours per day. Assume uniform and steady load. (16)

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Reg. No. : | | | | | | | | | | | | |

**Question Paper Code : 91654**

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2014.

Fifth Semester

Mechanical Engineering

ME 2303/ME 53/10122 ME 504 — DESIGN OF MACHINE ELEMENTS/ MACHINE DESIGN

(Common to Fifth Semester, Automobile Engineering and Mechanical and Automation Engineering, Fourth Semester – Manufacturing Engineering, Industrial Engineering and Management and Industrial Engineering)

(Regulation 2008/2010)

(Common to PTME 2303/PTME 3214/10122 ME 504 — Design of Machine Elements/ Machine Design for B.E. (Part-Time) Fourth/Fifth Semester Mechanical Engineering – Regulation 2009/2010)

Time : Three hours Maximum : 100 marks

(Approved Data Book as permitted)

Any missing data can suitably be assumed.

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Determine the force required to punch a hole of 20mm diameter in a 5mm thick plate with ultimate shear strength of 250 MPa?

2. List at least two methods to improve the fatigue strength.

3. Shaft A has diameter which is double the diameter of shaft B of same material and transmit 80 kW if both shafts rotate at same speed, what is the power transmitted by shaft B.

4. Discuss forces on keys.

5. Why are ACME treads preferred over square thread for power screw?

6. What are the disadvantages of welding?

7. Define (a) Coefficient of fluctuation of speed (b) Coefficient of fluctuation of energy.

8. Distinguish between close coiled and open coiled springs.

9. In hydrodynamic bearing, what are factors which influence the formation of wedge fluid film?

10. Define static Capacity of Bearing.

PART B — (5 × 16 = 80 marks)

11. (a) An unknown weights falls through 10mm onto a collar which is rigidly attached to the lower end of a vertical bar 3 m long and 600 $mm^2$ cross section. The maximum instantaneous extension is 2mm. What is the corresponding stress and the value of the weight? Take E = 200 $kN/mm^2$.

Or

(b) A shaft of diameter 'd' is subjected to a torque varying between 900 Nm to 1800 Nm. Assuming a factor of safety 2 and a stress concentration factor of 1.2, find the diameter of the shaft. Take $\sigma_u$ = 650 $N/mm^2$, $\sigma_y$ = 480 $N/mm^2$, Size factor B = 0.85 and surface finish factor C = 0.5.

12. (a) In an axial flow rotary compressor, the shaft is subjected to maximum twisting moment and maximum bending moment of 1500 Nm and 3000 Nm respectively. Neglecting the axial load, determine the diameter, if the permissible shear stress is 50 $N/mm^2$. Assume minor shocks. If the shaft is hollow one with K = di/do = 0.4., what will be material saving in hollow shaft which is subjected to same loading and material as a solid shaft.

Or

(b) 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 $kN/mm^2$.

13. (a) A steel bolt of M16x2 is 300mm long carries an impact load of 5000 Nm. If the threads stop adjacent to the Nut and E = 2.1 × $10^5$ MPa

(i) Find the stress in the root area

(ii) Find the stress if the shank area is reduced to root area.

Or

(b) A cylindrical beam of size 60 mm is attached to support by a complete circumferential fillet weld of 6mm. find (i) torque and (ii) bending moment that can be applied if limiting shear stress is 140 MPa.

14. (a) Design a closed coiled helical spring subjected a tensile load of magnitude varying from 2500 N to 3000 N and the axial deflection of spring for this range of load is 6.5 mm. Design the spring, taking the spring index as 6 and safe shear stress for material equal to 465 MPa.

Or

(b) Design a CI flywheel for a four stroke engine developing 150 kW at 200 rpm. Calculate the mean diameter of the flywheel if the hoop stress is not to exceed 4 MPa. Total fluctuation of speed is to be 4% of the mean speed. Work done during the power stroke may be assumed to be 1.5 times the average work done during the cycle. Density of CI is 7200 kg/m$^3$.

15. (a) A 50 mm diameter journal bearing rotates at 1500 rpm, L/D = 1, radial clearance is 0.05 mm, minimum film thickness = 0.01 mm. Calculate the maximum radial load that the journal bearing can carry and still operate under hydrodynamic condition. For this load, calculate power lost in friction and increase in the oil temperature. Assume Hg = $H_d$. Absolute viscosity = 20x10$^3$ Pas, Sp. Gravity of oil 0.8, Sp. Heat of oil 2.1 kJ/kg°C.

Or

(b) Find the rated load of a deep groove ball bearing for the following load cycle.

| S.L. NO. | RADIAL LOAD (N) | AXIAL LOAD (N) | % OF TIME |
|---|---|---|---|
| 1 | 3000 | 1000 | 15 |
| 2 | 3500 | 1000 | 20 |
| 3 | 3500 | 10 | 30 |
| 4 | 500 | 2000 | 35 |

Also find the 90% life of ball bearing if bearing used is 6207 with dynamic capacity 19620 N.

Reg. No. : | | | | | | | | | | | | |

**Question Paper Code : 41040**

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2013.

Fifth Semester

Mechanical Engineering

080120025 — DESIGN OF MACHINE ELEMENTS

(Common to Automobile Engineering)

(Regulation 2008)

Time : Three hours Maximum : 100 marks

Use of approved Design data Book is permitted.

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. What is the effect of stress concentration on ductile materials?

2. Define endurance limit?

3. What are the advantages of hollow shaft over solid shaft?

4. Why is maximum shear stress theory used for shafts?

5. What are the different types of stresses to which a bolt is subjected?

6. How bonded joints are different from welded joints?

7. List the advantages of helical springs.

8. Why levers are usually tapered?

9. Give two applications of hydrostatic bearing.

10. Name the materials used for making fly wheels.

PART B — (5 × 16 = 80 marks)

11. (a) A bolt is subjected to a tensile load of 25 kN and to a shear load of 10 kN. Suggest a suitable size of a bolt according to various theories of failure. Take allowable yield stress is 300 $N/mm^2$. Poisson's ratio is 0.25.

Or

(b) 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 (i) Gerber equation (ii) Goodman equation and iii) Soderberg equation. Take the value of yield strength as 0.55 UTS and endurance strength as 0.50 UTS. Take factor of safety as 2.

12. (a) In an axial flow compressor the shaft is subjected to a maximum torque of 1.5 MN-mm and a maximum bending moment of 0.35 MN-mm. The shear stress is limited to 50 $N/mm^2$. Assuming factor of safety of 1.5 in bending and shock factor in twisting as 2. Design the diameter of shaft.

Or

(b) Design a muff coupling for a shaft which transmits 55 kW at 120 rpm. The permissible shear stress values are for shaft = 60 $N/mm^2$, muff = 10 $N/mm^2$ and key 40 $N/mm^2$ respectively. The permissible bending stress value for key is 100 $N/mm^2$. Also make a sketch of the muff coupling.

13. (a) The cylinder head of a steam engine is subjected to a steam pressure of 0.7 $N/mm^2$. It is held in position by means of 12 bolts. A soft copper gasket is used to make the joint leak–proof. The effective diameter of cylinder is 300 mm. Find the size of the bolts so that the stress in the bolts is not to exceed 100 MPa.

Or

(b) A plate of 200 mm width is welded to a vertical plate by fillet welding on three sides to form a cantilever with an overlap of 150 mm and overhang of 400 mm and a vertical downward load of 35 kN is applied at free end for a weld stress of 75 $N/mm^2$. Determine the size of the weld.

14. (a) Design a closed coiled helical compression spring for a load range varying from 2.25 kN to 2.75 kN and corresponding axial deflection of 6 mm. Spring index is 5. Permissible shear stress is 400 N/mm$^2$ and modulus of rigidity is 80 kN/mm$^2$.

Or

(b) A hand lever for brake is 0.8m long from the centre of gravity of the spindle to the point of application of the pull of 300 N. The effective overhang from the nearest bearing is 100 mm. If the permissible stress in tensile, shear and crushing is not to exceed 66 N/mm$^2$, design the spindle, key and lever. Assume the arm of the lever to be rectangular having width twice of its thickness.

15. (a) A single row deep groove ball bearing operating at 2000 rpm is acted by a 10 kN radial load and 8 kN thrust load. The bearing is subjected to a light shock load and the outer ring is rotating. Determine the rating life of the bearing.

Or

(b) Design a 6 arm rim type C. I flywheel for four stroke engine developing 45 kw at 1400 rpm. Total fluctuation of speed is 2.5% of main speed. Work done during power stroke is 30% more than average work during a cycle.

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Reg. No. : | | | | | | | | | | | | |

**Question Paper Code : 21039**

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2012.

Fifth Semester

Mechanical Engineering

080120025 — DESIGN OF MACHINE ELEMENTS

(Common to Automobile Engineering)

(Regulation 2008)

Time : Three hours Maximum : 100 marks

Use of PSG design data book is permitted.

Assumptions and Assumed data have to be stated clearly.

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What is meant by factor of safety?
2. Define endurance limit.
3. How is the shaft designed when it is subjected to twisting moment only?
4. Why are two universal joints often used when there is angular misalignment between two shafts?
5. Classify the rivet heads according to Indian standard specifications.
6. What are the assumptions made in the design of welded joint?
7. State the application of hand and foot levers.
8. List out the materials commonly used for manufacture of the leaf springs.
9. What is meant by hydrodynamic lubrication?
10. Define coefficient of steadiness.

PART B — (5 × 16 = 80 marks)

11. (a) A hollow shaft is required to transmit 600 kW at 110 r.p.m., the maximum torque being 20% greater than the mean. The shear stress is not to exceed 63 MPa and twist in a length of 3 meters not to exceed 1.4 degrees. Find the external diameter of the shaft, if the ratio internal diameter to the external diameter is 3/8. Take modulus of rigidity as 84 GPa.

Or

(b) A 50 mm diameter shaft is made from carbon steel having ultimate tensile strength of 630 MPa. It is subjected to a torque which fluctuates between 2000 N-m to – 800 N-m. Using Soderberg method, calculate the factor of safety. Assume suitable values for any other data needed.

12. (a) Compare the weight, strength and stiffness of a hollow shaft of the same external diameter as that of the solid shaft. The inside diameter of the hollow shaft being half the external diameter. Both the shafts have the same material and length.

Or

(b) Design a clamp coupling to transmit 30 kW at 100 r.p.m. The allowable 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.

13. (a) Design a lap joint for a mild steel flat tie bar 200 mm × 10 mm thick, using 24 mm diameter rivets. Assume allowable stresses in tension and compression of the plate material as 112 MPa and 200 MPa respectively and shear stress of the rivets as 84 MPa. Show the disposition of the rivets for maximum joint efficiency and determine joint efficiency. Take diameter of rivet hole as 25.5 mm for a 24 mm diameter rivet.

Or

(b) 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.

14. (a) A loaded narrow-gauge car of mass 1800 kg and moving at a velocity of 72 m/min, is brought to rest by a bumper consisting of two helical steel springs of square section. The mean diameter of the coil is six times the side of the square section. In bringing the car to rest, the springs are to be compressed 200 mm. Assuming the allowable shear stress as 365 MPa and spring index of 6, find (i) Maximum load on each spring, (ii) side of the square section of the wire. (iii) mean diameter of the coils, and (iv) number of active coils. Take modulus of rigidity as 80 kN/mm$^2$.

Or

(b) Design a right angled bell crank lever having one arm 500 mm and the other 150 mm long. The load of 5 kN is to be raised acting on a pin at the end of 500 mm arm and the effort is applied at the end of 150 mm arm. The lever consists of steel forgings, turning on a point at the fulcrum. The permissible stresses for the pin and lever are 84 MPa in tension and compression and 70 MPa in shear. The bearing pressure on the pin is not to exceed 10 N/mm$^2$.

15. (a) Design a journal bearing for a centrifugal pump from the following data: Load on the journal = 20000N; Speed of the journal = 900 r.p.m.; Type of oil is SAE 10, for which 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/mm$^2$. 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/m$^2$/°C.

Or

(b) A single cylinder, single acting, four stroke oil engine develops 20 kW at 300 r.p.m. The work done by the gases during expansion stroke is 2.3 times the work done on the gases during the compression and the work done during the suction and exhaust strokes is negligible. The speed is to be maintained with in ± 1%. Determine the mass moment of inertia of the flywheel.

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