

# DHANALAKSHMI SRINIVASAN ENGINEERING COLLEGE



(AUTONOMOUS)  
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## U23MET51/ DESIGN OF MACHINE ELEMENTS

### Syllabus:

<b>UNIT I/ STEADY STRESSES AND VARIABLE STRESSES IN MACHINE MEMBERS</b>	<b>No. Of Periods: 10</b>
Introduction to the design process - factors influencing machine design, selection of materials based on mechanical properties - Preferred numbers, fits and tolerances - Direct, Bending and torsional stress equations - Impact and shock loading - calculation of principle stresses for various load combinations, eccentric loading - curved beams - crane hook and 'C' frame- Factor of safety -theories of failure - Design based on strength and stiffness - stress concentration - Design for variable loading.	
<b>UNIT II/ SHAFTS AND COUPLINGS</b>	<b>No. Of Periods: 8</b>
Design of solid and hollow shafts based on strength, rigidity and critical speed - Keys, keyways and splines - Rigid and flexible couplings	
<b>UNIT III/ TEMPORARY AND PERMANENT JOINTS</b>	<b>No. Of Periods: 9</b>
Threaded fasteners - Bolted joints including eccentric loading, Knuckle joints, Cotter joints - Welded joints, riveted joints for structures - theory of bonded joints.	
<b>UNIT IV/ ENERGY STORING ELEMENTS AND ENGINE COMPONENTS</b>	<b>No. Of Periods: 9</b>
Various types of springs, optimization of helical springs - rubber springs - Flywheels considering stresses in rims and arms for engines and punching machines- Connecting Rods and crank shafts.	
<b>UNIT V/ BEARINGS</b>	<b>No. Of Periods: 9</b>
Sliding contact and rolling contact bearings - Hydrodynamic journal bearings, Sommerfeld Number, Raimondi and Boyd graphs, -- Selection of Rolling Contact bearings.	

### Text Book:

- T1: A Text Book of machine Design, R.S. Khurmi, J.K. Gupta. S.Chand Publication  
T2: Bhandari V, "Design of Machine Elements", 4th Edition, Tata McGraw-Hill Book Co, 2016.  
T3: Joseph Shigley, Charles Mischke, Richard Budynas and Keith Nisbett "Mechanical

**UNIT I-STEADYSTRESSESANDVARIABLESTRESSESINMACHINEMEMBERS**

**PART-A**

**1. How the machine design may have classified?(NOV/DEC 2021)**

**The important factors influencing machine design classification are**

- (i) Strength and stiffness;**
- (ii) Surface finish and tolerance;**
- (iii) Manufacturability;**
- (iv) Working atmosphere;**
- (v) Safety and reliability;**
- (vi) Cost.**

**2. What are the common materials used in mechanical engineering design?(NOV/DEC2015 &2021)**

**The most common materials are**

- (i) Steel based alloys;**
- (ii) Aluminium based alloys;**
- (iii) Nickel based alloys;**
- (iv) Copper based alloys.**

**3. What is stress concentration and stress concentration factor?  
(MAY/JUNE2012) (MAY/JUNE 2016) NOV 18**

**Stress concentration is the increase in local stresses at points of rapid change in cross section or discontinuities. A stress concentration (often called stress raisers) is a location in an object where stress is concentrated.**

An object is stronger when force is evenly distributed over its area, so a reduction in area, e.g., caused by a crack, results in a localized increase in stress.

4. What are the methods used to improve fatigue strength? (NOV/DEC2013, 2014)

(i) Clod working like shot peening, burnishing

(ii) Heat treatments like induction hardening, case hardening, nitriding

(iii) Pre-stressing or auto fretting

5. What is an S-N Curve?(NOV/DEC2016)

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 gives number of cycles.

In high-cycle fatigue situations, materials performance is commonly characterized by an S-N curve, also known as a Wöhler curve.

This is a graph of the magnitude of a cyclic stress (S) against the logarithmic scale of cycles to Failure (N).

6. Differentiate hardness and toughness. (MAY/JUNE2014)

**Hardness:**

It is the ability of material to resist scratching and indentation. Hardness is a measure of how resistant solid matter is to various kinds of permanent shape change when a compressive force is applied.

**Toughness:**

Itisthepropertyofamaterialtoresistfractureduetohighimpactloadslikehammerblows.  
It is

The amount of energy per unit volume that a material can absorb before rupturing.

7. Describe material properties hardness, stiffness and resilience. (NOV/DEC2013) (MAY/JUNE 2016) NOV 18

Hardness is the ability of material to resist scratching and indentation. Hardness is a measure of how resistant solid matter is to various kinds of permanent shape change when a compressive force is applied.

Stiffness is the ability of material to resist deformation under loading. Stiffness is the rigidity of an object — the extent to which it resists deformation in response to an applied force.

Resilience is the ability of material to resist absorb energy and to resist shock and impact load. Proof resilience is defined as the maximum energy that can be absorbed up to the elastic limit, without creating a permanent distortion.

8. State the difference between straight beam and curved beam.(NOV/DEC2012)

Features	straight beam	curved beam
Centroidal axis and neutral	Are coincident	Are not coincident. neutral axis is shifted axis towards the centre of curvature.
Stress developed	Same Throughout section	Differentiates inner and outer radii of the section

9. Where will be the maximum stress developed in a curved beam?

In a symmetrical section (circle, I section with equal flanges) maximum bending stress always occurs at the inner fibre.

If the section is not symmetrical maximum bending stress may occur at either inner or outer fibre.

10. What are the various factors to be considered in deciding the factor of safety?(MAY/JUNE2013)

- (i) Material properties;
- (ii) Nature of load;
- (iii) Presence of localized stresses;
- (iv) Presence of initial stress;
- (v) Mode of failure.

11. Which are the mechanical properties of the metals? List any four mechanical properties. (MAY/JUNE 2012)

The mechanical properties of the metals are those which are associated with the ability of the material to resist mechanical forces and load.

These mechanical properties of the metal include strength, stiffness, elasticity, plasticity, ductility, brittleness, malleability, toughness, resilience, creep and hardness.

12. Give some methods of reducing stress concentration. (MAY/JUNE2013)

- (i) Avoiding sharp corners;

- (ii) Providing fillets;
- (iii) Use of multiple holes instead of single hole;
- (iv) Under cutting the shoulders parts.

13. What is 'Adaptive design'? Where is it used? (NOV/DEC2012), (MAY/JUNE2015)

It is a design process where a new product is developed just by making small changes to the existing product. It is used where no or limited scope is available to go for an entirely new design. In most cases, the designer's work is concerned with adaptation of existing designs. This type of design needs no special knowledge or skill and can be attempted by designers of ordinary technical training. The designer only makes minor alternation or modification in the existing designs of the product.

14. What are the unilateral and bilateral tolerances?

A unilateral tolerance is tolerance in which variation is permitted only in one direction from the specified direction.

eg  $1800+0.000/-0.060$

A bilateral tolerance is tolerance in which variation is permitted in both directions from the specified direction.

eg  $1800+0.060/-0.060$

15. What are various theories of failure?(NOV/DEC2015)

Maximum principal stress theory. Maximum shear stress theory.

Maximum principal strain theory Maximum strain energy theory

16. Define factor of safety.

Factor of safety (FOS) is defined as the ratio between the maximum stress and working stress.

It is also known as (and used interchangeably with) safety factor (SF), is a term describing the load carrying capacity of a system beyond the expected or actual loads.

Essentially, the factor of safety is how much stronger the system is than it usually needs to be for an intended load.

17. Define limits and fits.(MAY/JUNE2015)

There are two extreme permissible sizes for a dimension of the part. The largest permissible size for a dimension of the part is called upper or high or maximum limit, whereas the smallest size of the part is known as lower or minimum limit.

Fits refers to the relative tightness or looseness between two mating parts. Engineering fits are generally used as part of geometric dimensioning and tolerancing when a part or assembly is designed.

18. Define optimization. What are the various methods of optimization in available?

Optimization is the process of maximizing a desired quantity or minimizing the unwanted one.

Methods

- (i) Optimization by evolution
- (ii) Optimization by institution
- (iii) Optimization by trial and error
- (iv) Optimization by numerical algorithm

19. What are the factors that affect notch sensitivity?

- (i) Material
- (ii) Notch radius
- (iii) Size of components
- (iv) Type of loading
- (v) Grain structure

20. Explain notch sensitivity.

Notch sensitivity ( $q$ ) is the degree to which the theoretical effect of stress concentration is actually reached.

The notch sensitivity of a material is a measure of how sensitive a material is to notches or geometric discontinuities. The relation is

$$K_f = 1 + (q(K_t - 1))$$

21. What are preferred numbers? APR18 Data book 7.19

**22. Brief about Soderberg and Goodman lines. APR18 Data book 7.3**

**UNIT II SHAFTS AND COUPLINGS**

**1. Define the term critical speed. (Nov2016) MAY2018**

**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.**

**Critical Speed is the RPM at which the driveshaft is computer projected to bend or whip. Exceeding Critical Speed can produce vibrations that can result in driveshaft failure. The vibrations can also cause damage to the differential gears and bearings. The transmission extension housing, along with the torque converter and planetary gears can also be destroyed. When you take a small piece of steel and bend it repeatedly, the stress will eventually break the steel. The same effect occurs on your complete driveline when no attention is paid to Critical Speed.**

**2. What is meant by woodruff keys? (Nov 2013)**

**A Wood ruff 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 shape whereas the key in the hub is usually straight.**

**The main advantages of a woodruff key are as follows :**

- 1. It accommodates itself to any taper in the hub or boss of the mating piece.**
- 2. It is useful on tapering shaft ends. Its extra depth in the shaft prevents any tendency to turn over in its keyway.**

**The disadvantages are :**

- 1. The depth of the keyway weakens the shaft.**
- 2. It cannot be used as a feather.**

**3 Name any three of the Rigid and Flexible couplings? (Nov2016, May2014) OR Differentiate Rigid and Flexible couplings. (May 2013, 2016)**

- 1. To provide for the connection of shafts of units that are manufactured separately such as a motor and generator and to provide for disconnection for repairs or alternations.**

2. To provide for misalignment of the shafts or to introduce mechanical flexibility.
3. To reduce the transmission of shock loads from one shaft to another.
4. To introduce protection against overloads.
5. It should have no projecting parts.

Shaft couplings are divided into two main groups as follows:

1.

**Rigid coupling.** It is used to connect two shafts which are perfectly aligned. Following types of rigid coupling are important from the subject point of view :

- (a) Sleeve or muff coupling.
- (b) Clamp or split-muff or compression coupling, and
- (c) Flange coupling.

2. **Flexible coupling.** It is used to connect two shafts having both lateral and angular misalignments. Following types of flexible coupling are important from the subject point of view:

- (a) Bushed pin type coupling,
- (b) Universal coupling, and
- (c) Oldham coupling.

4 Under what circumstance flexible couplings are used?(Nov2012)NOV 18

- (i) They are used to join the abutting ends of shafts when they are not in exact alignment.
- (ii) They are used to permit an axial misalignment of the shafts without under absorption of the power, which the shafts are transmitting.

A good shaft coupling should have the following requirements :

1. It should be easy to connect or disconnect.
2. It should transmit the full power from one shaft to the other shaft without losses.
3. It should hold the shafts in perfect alignment.
4. It should reduce the transmission of shock loads from one shaft to another shaft.
5. It should have no projecting parts.

**5 Discuss forces on keys.(Nov 2014)**

**A key is device, which is used for connecting two machine parts for preventing relative motion of rotation with respect to each other. A key is a piece of mildsteel inserted between the shaft and hub or boss of the pulley to connect these together in order to prevent relative motion between them. It is always inserted parallel to the axis of the shaft.**

**(i)Shear force; (ii)Bearing force; (iii)Tensile force**

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

**Keys are used as temporary fastenings and are subjected to considerable crushing and shearing stresses. A keyway is a slot or recess in a shaft and hub of the pulley to accommodate a key.**

**(i)Saddle key; (ii)Tangent key;**

**(iii) Sunk key;**

**(iv) Round key and**

**(v) Taper pins**

**7. What is meant by equivalent bending moment.(May 2012)**

**•**

**The bending moment of a beam is defined as the algebraic sum of all the moments about the neutral axis of any cross-section of a beam.**

**• A beam only supports the load by bending.**

**• A bending moment is simply the bend that occurs in a beam due to a moment.**

**• When a shaft is subjected to combined bending and torsional loading, the design is usually**

**Based on the maximum shear stress theory since the shafts are usually made of ductile materials**

**8. What are the types of stresses acting on a shaft?(May 2014)NOV 18**

**(i) Shear due to torsion;**

**(ii) Stress due to bending;**

**(iii) Axial stress if an axial load acts**

**The bending equation.  $M/I = E/R = F_s/Y$ . M -Bending moment**

**I - Moment of inertia E -Youngs modulus**

**R-Radius of the shaft  $F_s$  – Shear stress**

**Y-Distance from neutral axis**

**9. A shaft of 70mm long is subjected to shear stress of 40MPa and has an angle of twist equal to**

**0.017radian.Determine the diameter of the shaft. Take  $G=80\text{MPa}$ .(Nov 2013)**

**Given data**

**Shear stress,  $\tau=40\text{MPa}$  Length.  $l=70\text{mm}$**

**Angle of twist,  $\theta=0.017\text{rad}$   $G=80\text{Mpa}$**

**Diameter of the shaft,  $d = 2 \times \tau \times l / G\theta$**

$$= 2 \times 40 \times 70 / 80 \times 10^3 \times 0.017$$

$$d=44.11\text{mm}$$

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

**Given data**

**Power transmitted shaft A,  $P_A=80\text{W}$**

**Power transmitted by shaft B,  $P_B=P_A \times (d_B/d_A)^3$**

$$=80 \times (1/2)^3$$

$$=10 \text{ KW}$$

**11. Why a hollow shaft has greater strength and stiffness than solid shaft of equal weight? (Nov 2012) MAY 2018**

**A shaft is a rotating machine element which is used to transmit power from one place to another. The power is delivered to the shaft by some tangential force and the resultant torque (or twisting moment) set up within the shaft permits the power to be transferred to various machines linked up to the shaft.**

**☒ Stresses are maximum at the outer surface of a shaft.**

**☒ A hollow shaft has almost all the material concentrated at the outer circumferences.**

**☒ So it has better strength and stiffness for equal weight**

**12. State the reasons for which the couplings are located near the bearings?(May 2017)**

(i) To provide the connection of shafts of units those are manufactured separately such as motor and generator and to provide for disconnection for repairs or alterations.

(ii) To provide misalignment of the shafts or to introduce mechanical flexibility.

(iii) To reduce the transmission of shock from one shaft to another.

(iv) To introduce protection against overload.

13. Where are the flexible couplings used?

(i) Vehicle;

(ii) Stationary machinery;

(iii) Automotive drives;

(iv) Machine tools.

14. Sketch the cross section of a splined shaft.(May 2012).

Splines are ridges or teeth on a drive shaft that mesh with grooves in a mating piece and transfer torque to it, maintaining the angular correspondence between them.

15. Write down the Dunkerley's equation for the critical speed of the shaft.

When a shaft carries  $n$  pulleys of gears, the critical speed of the shaft may be found by Dunkerley's equation.

$$\frac{1}{\omega^2} = \frac{1}{\omega_1^2} + \frac{1}{\omega_2^2} + \dots + \frac{1}{\omega_n^2}$$

$$\frac{1}{\omega^2} = \frac{1}{\omega_1^2} + \frac{1}{\omega_2^2} + \dots + \frac{1}{\omega_n^2}$$

$$\frac{1}{\omega^2} = \frac{1}{\omega_1^2} + \frac{1}{\omega_2^2} + \dots + \frac{1}{\omega_n^2}$$

Where  $\omega_1, \omega_2, \omega_3, \dots, \omega_n$  are the critical speeds of the shaft when each mass is considered.

16. What is the effect of keyways cut into the shaft?(May 2016)

(i) To avoid wear;

(ii) To transmit power efficiently;

(iii) Cost low

17. What is the difference between spindle and axle?( April 2015)

☐ A shaft is a rotating member that is used to transfer power.

☐ There may or may not be normal loads applied to it.

☒ Whereas an axle is a rotating member that doesnot transfer power but only handles normal loads.

☒ Now spindle is a rotating member that transfers power but doesnot support any driven member/normal load.

18. How the length and diameter of a shaft affects its critical speed? (April 2015)

- (a) Stiffness of the shaft and its support
- (b) Total mass of shaft and attached parts
- (c) Unbalance of the mass with respect to the axis of rotation
- (d) The amount of damping in the system

19. What is meant by design of a shaft based on rigidity? (Nov 2015)

- (a) Shafts subjected to twisting moment or torque only,
- (b) Shafts subjected to bending moment only,
- (c) Shafts subjected to combined twisting and bending moments, and
- (d) Shafts subjected to axial loads in addition to combined torsional and bending loads.

20. What are the possible modes of failure of the pin (bolt) in a flexible coupling?(Nov 2015)

Bushed pin flexible couplings Muff couplings.

Flexible couplings are usually used to transmit torque from one shaft to another when the two shafts are slightly misaligned. They can accommodate varying degrees of misalignment up to  $3^\circ$  and some parallel misalignment. In addition, they can also be used for vibration damping or noise reduction. In rotating shaft applications a flexible coupling can protect the driving and driven shaft components (such as bearings) from the harmful effects of conditions such as misaligned shafts, vibration, shock loads, and thermal expansion of the shafts or other components.

### UNITIII      TEMPORARY AND PERMANENTJOINTS

1. What stresses act on screw fastening? (MAY/JUNE 2016)

- (i) Initial stresses due to screwing up;
- (ii) Stresses due to external forces;
- (iii) Combined stresses.

The power screws (also known as translation screws) are used to convert rotary motion into translatory motion. For example, in the case of the lead screw of lathe, the rotary motion is available but the tool has to be advanced in the direction of the cut against the cutting resistance of the material. The power screws with multiple threads such as double, triple etc. are employed when it is desired to secure a large lead with fine threads or high efficiency. Such type of threads are usually found in high speed actuators.

2. What are the different applications of screwed fasteners?(NOV/DEC 2016)

i For readily connecting and disconnecting machine parts without damage

ii The parts can be rigidly connected

iii Used for transmitting power.

iv. They are highly reliable in operation

v. They are convenient to assemble & disassemble

vi. A wide range of screws can be used for various operating conditions

vii. They are relatively cheap to produce.

3. What are the two types of fillet weld? (MAY/JUNE2016)

(i) Longitudinal or parallel fillet weld;

(ii) Transverse fillet weld

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

4. State the two types of eccentric welded connections. (NOV/DEC2013)(NOV/DEC 2016)

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 of filler material.

(i) Welded connections subjected to moment in a plane of the weld.

(ii) Welded connections subjected to moment in a plane normal to the plane of the weld.

1. Direct shear stress.

2. Bending or torsional shear stress.

5. Define efficiency of rivet joint

**Efficiency of rivet joint is defined as the ratio of strength of the joint in the weakest mode to strength of the unpunched plates.**

$$\eta = \frac{\text{Strength of rivet joint}}{\text{Strength of unpunched plates}}$$

$$\eta = \frac{P}{P_0}$$

**Blind rivets are used almost universally in the construction of plywood road cases.**

**Common but more exotic uses of rivets are to reinforce jeans and to produce the distinctive sound of a sizzle cymbal.**

**6. What are the different types of cotter joint?(MAY/JUNE2014)**

**A cotter is a flat wedge-shaped piece of steel which is used to connect rigidly two rods which transmit motion in the axial direction (tensile or compressive forces) without rotation.**

**Applications:**

- 1. Joint between the piston rod and and the cross head of the steam engine**
- 2. Joint between the slide spindle and the fork of the valve mechanism**
- 3. Joint between the piston rod and the tail**
- 4. Connecting two halves of flywheel**
- 5. Foundation Bolt**

**(i) Socket and spigot cotter joint**

**Elements: Socket, spigot, cotter**

**(ii) Sleeve and cotter joint**

**Elements: Sleeve, enlarged rod (2nos),Cotter(2nos)**

**(iii) Gib and cotter joint**

**Elements: Gib, cotter.**

**7. Define term of self-locking of power screws. (NOV/DEC 2012) NOV 18**

**If the friction angle is greater than helix angle of the power screw, the torque applied to lower the load will be positive, indicating that an effort is applied to lower the load.**

**This type of screw is known as self-locking screw.**

- Advantage: Parts which have been joined by threaded fasteners can be disassembled and reassembled when they must be serviced or replaced.**

- **Disadvantage: Threaded fasteners unintentionally back off when the assembly is in use, and the consequences are usually inconvenient, costly and may present serious legal implications for product warranties.**

**8. How is bolt designated? Give example.**

**Bolted joints are one of the most common elements in construction and machine design. They consist of fasteners that capture and join other parts, and are secured with the mating of screw threads.**

**There are two main types of bolted joint designs: tension joints and shear joints.**

**In the tension joint, the bolt and clamped components of the joint are designed to transfer an applied tension load through the joint by way of the clamped components by the design of a proper balance of joint and bolt stiffness. The second type of bolted joint transfers the applied load in shear of the bolt shank and relies on the shear strength of the bolt.**

**M30X2.5 M d X P**

**M- Major diameter of bolt**

**D- Nominal diameter in mm, P- Pitch in mm**

**9. What are the disadvantages of welding?(NOV/DEC2014, 2017)**

- ☒ **It has poor vibration damping characteristics**
- ☒ **Welding results in a thermal distortion of the parts.**
- ☒ **There by including residual stresses.**
- ☒ **Since there is an uneven heating and cooling during fabrication, therefore the members may get distorted or additional stresses may develop.**
- ☒ **It requires a highly skilled labour and supervision.**
- ☒ **Since no provision is kept for expansion and contraction in possibility of cracks developing in it.**
- ☒ **The inspection of welding work is more difficult than riveting work.**

**10. Why are welded joints preferred over riveted joints?(MAY/JUNE2013)NOV 18**

- ☒ **The welded structures are usually lighter than riveted structures. This is due to the reason, that in welding, gussets or other connecting components are not used.**
- ☒ **The welded joints provide maximum efficiency (maybe 100%) which is not possible in case of Riveted joints.**
- ☒ **Alterations and additions can be easily made in the existing structures.**

- ☐ As the welded structure is smooth in appearance, therefore it looks pleasing.
- ☐ In welded connections, the tension members are not weakened as in the case of riveted joints.
- ☐ A welded joint has a great strength. Often a welded joint has the strength of the parent metal itself.

**11. Name the possible modes of failure of riveted joint?(MAY/JUNE 2015)**

A rivet is a permanent mechanical fastener. Before being installed, a rivet consists of a smooth cylindrical shaft with a head on one end. The end opposite to the head is called the tail. On installation the rivet is placed in a punched or drilled hole, and the tail is upset, or bucked (i.e., deformed), so that it expands to about 1.5 times the original shaft diameter, holding the rivet in place.

- (i) Crushing of rivet
- (ii) Shearing of rivet
- (iii) Tearing of the plate at the edge
- (iv) Tearing of the plate between rivets.

**12. What is Gib?(NOV/DEC2013)**

- Gib is an element made of mild steel with thickness equal to the cotter.
- It is wedge shaped piece of rectangular cross section with two rectangular projections.
- One side of gib is tapered and the other straight.
- The tapered side of the gib bears against the taper side of the cotter such that outer edges of the cotter and gib as a unit are parallel.

**13. State advantages of threaded joints.**

Threaded joints are detachable joints of two or more component parts either directly connected with each other or by standardized fasteners, i.e. bolts, nuts and screws.

- (i) High clamping;
- (ii) Simple design;
- (iii) Easy manufacturing

The advantages of the screwed joints are as follows:

1: Screwed joints are highly relabeling service.

2: screwed joints are easy to assemble and disassemble.

3: A wide range of screwed joints is available to be adopted under various working conditions  
4: Screws are relatively cheap.

5: Due to standardization, cheap manufacturing processes can be adopted. 6: Screws can be used to transmit power such as lead screw.

15. Why are the ACME threads preferred over square thread for power screw?  
(NOV/DEC 2014)

☐ ACME stands for Association of Consulting Municipal Engineers.

☐ ACME threads are easier to machine and are stronger than the square thread.

☐

ACME threads are thicker and wider and they operate better in environments with dirt and debris.

16. Determine the safe tensile load for a bolt of M20, assuming a safe tensile stress of 40 MPa? (MAY/JUNE 2012)

For M20 bolt the nominal diameter  $d_p = 18.376$  mm and the effective diameter is 16.933 mm.

Safe tensile load = Permissible stress  $\times$  Cross sectional area of bottom of the thread

$$= 40 \times \left[ \frac{\pi}{4} (d_p^2 - d_r^2) \right]$$

$$= 4 \times 2$$

$$= 9786.759 \text{ N}$$

17. What are the ways to produce bolts of uniform strength? (MAY/JUNE 2015)

(i) Reducing shank diameter equal to root diameter

(ii) Drilling axial hole

18. What are the advantages of screwed fasteners?

(i) They are highly reliable in operation

(ii) They are convenient to assemble & disassemble

(iii) A wide range of screws can be used for various operating conditions

(iv) They are relatively cheap to produce.

18. What are the types of welded joints?

**A welding joint is a point or edge where two or more pieces of metal or plastic are joined together. They are formed by welding two or more workpieces (metal or plastic) according to a particular geometry. Five types of joints referred to by the American Welding Society:**

**Butt joint Lap joint T - joint**

**Corner joint Edge joint**

**19. List down the different ways by which a riveted joint may fail.(MAY/JUNE2012)(NOV/DEC 2012)**

- (i) Crushing of rivets;**
- (ii) Shear of rivets;**
- (iii) Tearing of the plate at the edge;**
- (iv) Tearing of the plate between rivets.**

#### **UNITIV ENERGYSTORINGELEMENTSANDENGINECOMPONENTS**

**1. State any two functions of springs.(NOV2016)NOV 18**

- (i) To measure forces in spring balance, meters and engine indicators.**
- (ii) To store energy**
- (iii) To apply forces and to control the motions as in brakes and clutches.**
- (iv) To control the motion by maintaining contact between two elements as in cam and followers.**

**2. What are the various types of springs?(MAY2012)**

**Helical springs Spiral springs Leaf springs**

**Disc spring or Belleville springs**

**3. What is surge in springs?(MAY2018)**

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

**When the time interval between the load applications is equal to the time required for travelling the wave, the resonance will occur.**

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

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

5. What is spring index?(MAY2013)

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

$$C = \frac{D}{d}$$

$$C = \frac{D}{d}$$

6. Define spring rate(stiffness)(MAY2016)

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

$$k = \frac{P}{y}$$

7. Why concentric springs are used? Or State the purpose of concentric spring.(APR2015)

(i) To get greater spring force within a given space.

(ii) To insure the operation of a mechanism in the event of failure of one of the springs.

8. 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.

9. How does the function of flywheel differ from that of governor?(NOV 2012,2016, MAY2018)

A governor regulates the mean speed of an engine when there are variations in the mean loads. It automatically controls the supply of working fluid to engine with the varying load condition and keeps the mean speed within the limits. It does not control the speed variation caused by the varying load. A flywheel does not maintain constant speed.

10. Define coefficient of fluctuation of energy in a flywheel.(MAY2014,2016, NOV2014) NOV 18

The difference between maximum and minimum energy during the cycle is called fluctuation of energy

It is denoted by  $K_e$ .

$$K_e = \frac{\Delta E}{E}$$

11. State any two important applications of leaf spring?

The leaf springs are commonly used in automobile like as structural members and energy absorbing devices.

It also carry

- lateral loads
- brake torque
- driving torque

12. Define co-efficient of fluctuation of speed in a flywheel..(MAY 2016, NOV 2014)

It is the ratio of the maximum change of speed to mean speed of the flywheel. It is denoted by  $K_s$ .

For Machine tools = 0.025 For Geared drives 0.02

For Electrical generators = 0.003 to 0.006

13. Write the formula for natural frequency of spring.(NOV 2012)

$$f_{res} = \frac{d}{9D^2 n_t} \sqrt{\frac{G}{\rho}}$$

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

- (i) The quality of the spring is not good
- (ii) The stress distribution is not favorable as in circular wires.

But this effect is negligible where loading is of static nature

15. What are the stresses induced in flywheel arms?

- Tensile stress due to centrifugal force.
- Bending stress due to Torque.
- Stress due to belt tension.
- Specify the types of flywheel.

1. Solid piece flywheel.

a. Web type b. Rim and hub type.

2. Split wheel

a. Rim and hub type only

17. What is the advantage of leaf spring over helical spring?

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

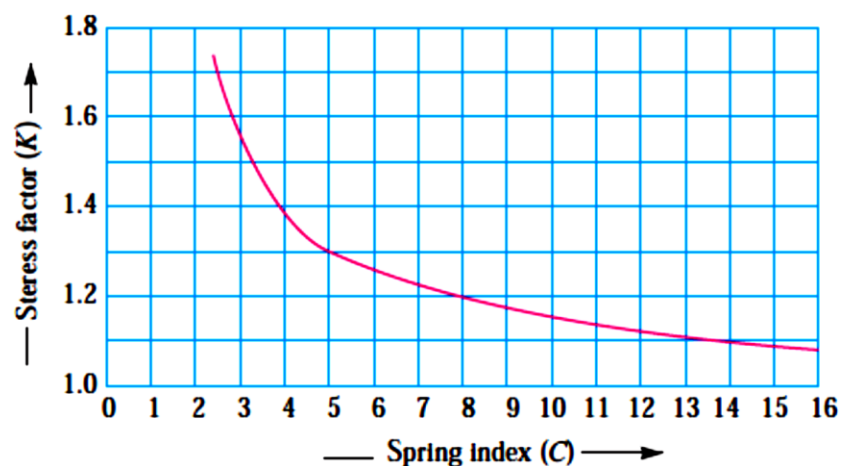
18. What are the different kinds of end connections for compression helical springs?

Plain ends; Ground ends; Square ends;

Ground and square ends.

19.

Sketch the stresses induced in the cross-section of a helical spring, considering Wahl's effect. (MAY 2015, 2017)



## UNIT V BEARINGS

1. Classify the bearings. (MAY 2014)

- Based on nature of contact between bearing surfaces.

a. Sliding contact bearing.

b. Rolling contact (or) Antifriction bearing.

- Based on load applied.

a. Radial bearing (Circumferentially loaded)

b. Thrust bearing (Axially loaded)

2. What is a journal bearing? (MAY 2014) NOV 2017

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

Naturally, a bearing will be required to offer minimum frictional resistance to moving part so as to result in minimum loss of power.

In order to reduce frictional resistance, a layer of fluid may be provided.

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

(i) Thick film type

(ii) Thin film type

(iii) Hydrostatic bearings

(v) Hydrodynamic bearing

4. Define anti-friction bearing. (APRIL 2017), (NOV 2013) NOV 18

The contact between the bearing elements is rolling; this type has very small friction.

Reliability of Anti-friction bearing:

☒ It is a given range of operating conditions

☒ It is a specific environmental condition

☒ It is a prescribed economic survival time

5. Explain the term dynamic load carrying capacities of rolling contact bearing.

Dynamic load rating is defined as the radial load in radial bearing which can be carried for a minimum life of one million revolutions.

The dynamic load rating is based on the assumption that the inner race is rotating while the outer race is stationary.

The dynamic load rating is usually provided by the bearing manufacturer.

6. List any four advantages of rolling contact bearing over sliding contact bearing. (MAY 2016)

(i) Starting friction is low.

(ii) Lubrication is simple.

(iii) It requires less axial space and more diameter space.

7. Differentiate Rolling contact bearing and Sliding contact bearing.

Rolling contact bearing	Sliding contact bearing	Starting friction is low
		Starting friction is High

Wear is low    Wear is high

**Heavier loads and higher speeds are permissible  
are permissible**

**Medium loads and lower speeds**

**8. What are the various types of radial ball bearing? (NOV 2016) (MAY 2012)**

- (i) Single row deep groove**
- (ii) Filling notch bearing**
- (iii) Angular contact bearing**
- (iv) Double row bearing**
- (v) Self-aligning bearing**

**9. Define static capacity of bearing. (NOV 2014)**

**It is defined as load acting on a non-rotating bearing under which permanent deformation is 0.0001 times the ball or roller bearing.**

**The static load rating is based on the assumption that the inner race is idling while the outer race is stationary.**

**10. Define the reliability of a bearing. (NOV-2016)**

**Reliability can be defined as the probability that a system or product will successfully operate for:**

- a given range of operating conditions**
- a specific environmental condition**
- a prescribed economic survival time**

**The probability will have a value between 0 and 1.**

**11. What is the application of thrust bearing? NOV 2017**

**Thrust bearings are used to support axial load on the rotating elements.**

**(i) IC engines**

**(ii) Flour mills**

**(iii) Marine**

**12. What is Sommerfeld number? (APRIL 2015)**

It is very important and useful non-dimensional number in hydrodynamic lubrication analysis because it contains many of the parameters ( $D$ ,  $C$ ,  $Z$ ,  $p$ ) specified by the designer.

13. What is the advantage of Teflon which is used for bearings?

It has a low coefficient of friction;

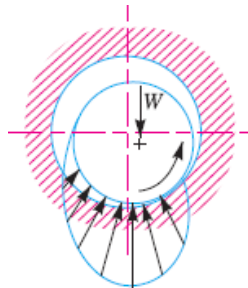
It can be used at high temperature. It can be used as chemically inert.

14. Define hydrodynamic lubrication. (MAY 2016)

The fluid film pressure is generated only by the rotation of the journal.

The position of the journal gets adjusted in such a manner that a force supporting the journal load is produced due to film pressure.

15. Plot the friction induced in various bearings based on the shaft speed. (APRIL 2017)



16. Explain the term Dynamic load carrying capacities of rolling contact bearing. (NOV-12)

Dynamic load rating is defined as the radial load in radial bearings that can be carried for a minimum life of one million revolutions.

The dynamic load rating is based on the assumption that the inner race is rotating while the outer race is stationary.

The dynamic load rating is usually provided by the bearing manufacturer.

17.

What are the types of journal bearings depending upon the nature of contact? (NOV 2016)

(i) Full journal bearing

(ii) Partial bearing

(iii) Fitted bearing

18. What is known as self-aligning bearing? (APRIL 2015)

The pressure is created within the system due to rotation of the shaft; this type of bearing is known as self-aligning bearing.

19. What are the bearing materials? NOV 18

Aluminium Alloy, Copper alloy, Babbit,

Cast iron steel, Silver

20.

In hydrodynamic bearing, what are factors which influence the formation of wedge fluid film? (NOV-2014) MAY 2018

(i) The contact surfaces must meet at a slight angle to allow the formation of the lubrication wedge.

(ii) The fluid must be disturbing itself completely within the bearing clearance area.

#### Unit I PART-B

1. 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<sup>2</sup> in section. If the maximum instantaneous extension is known to be 2 mm, what is the corresponding stress and the value of unknown weight? Take  $E = 200 \text{ KN/mm}^2$ . (NOV/DEC 2014) (16)
2. 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 metres not to exceed 1.4 degrees. Find the external diameter of the shaft, if the internal diameter to the external diameter is 3/8. Take modulus of rigidity as 84 GPa. (MAY/JUNE 2013) (16)
3. The frame of a punch press is shown in Fig. Find the stresses at the inner and outer surface at section X-X of the frame, if  $W = 5000 \text{ N}$ . (MAY/JUNE 2014, APR 18)

4. A C-clamp is subjected to a maximum load of  $W$ , as shown in Fig. If the maximum tensile stress in the clamp is limited to 140 MPa, find the value of load  $W$ . (NOV/DEC 2012) (16)
5. A Cantilever of span 20 mm and 50 mm diameter carries a vertical downward load of 3 kN at free end along with a torque of 1000 N-m and an axial pulling force of 15 kN as shown in Fig. Calculate the maximum normal stress at the top and bottom face of the fixed end (MAY/JUNE 2016) (16)
6. 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  
 1. Maximum principal stress theory;  
 2. Maximum shear stress theory; 3. Maximum principal strain theory;  
 4. Maximum strain energy theory; and 5. Maximum distortion energy theory. (NOV/DEC 2015) (16)
7. A machine component is subjected to a flexural stress which fluctuates between  $+300 \text{ MN/m}^2$  and  $-150 \text{ MN/m}^2$ . 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. (MAY/JUNE 2013) (16)
8. A circular bar of 500 mm length is supported freely at its two ends. It is 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 bar by taking a factor of safety of 1.5, size effect of 0.85, surface finish factor of 0.9. The material properties of bar are given by: ultimate strength of 650 MPa, yield strength of 500 MPa and endurance strength of 350 MPa. (NOV/DEC 2016) (16)
9. 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.  
 (NOV/DEC 2015) (16)

Factor of safety	= 1.5
Theoretical stress concentration factor	= 1.4
Notch sensitivity index	= 0.90
Ultimate strength	= 550 MPa

Yield strength	=320 MPa
Endurancelimit	=275 MPa
Sizeeffectfactor	= 0.85
Surfaceeffectfactor	= 0.90

10. 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. (NOV/DEC 2015)

(16)

Factor of safety	= 1.5
Theoretical stress concentration factor	= 1.4
Notch sensitivity index	= 0.90
Ultimate strength	=550 MPa
Yield strength	=320 MPa
Endurancelimit	=275 MPa
Sizeeffectfactor	= 0.85
Surfaceeffectfactor	= 0.90

11. A steel cantilever is 200 mm long. It is subjected to an axial load which varies from 150 N (compression) to 450 N (tension) and also a transverse load at its free end which varies from 80 N up to 120 N down. The cantilever is of circular cross-section. It is of diameter  $2d$  for the first 50 mm and of diameter  $d$  for the remaining length. Determine its diameter taking a factor of safety of 2. Assume the following values : (MAY/JUNE 2016) (16)

Yield stress	= 330 MPa
Endurancelimit 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
Sizeeffectfactor	=0.85
Surfaceeffectfactor	=0.90
Notch sensitivity index	=0.90 Similar model Refer DMEQ & A problem

12. A hot rolled steel shaft is subjected to a torsional moment that varies from 330 N-m clockwise to 110 N-m counterclockwise and an applied

bending moment at a critical section varies from 440 N-m to - 220 N-m. The shaft is of uniform cross-section and no keyway is present at the critical section. Determine the required shaft diameter. The material has an ultimate strength of 550 MN/m<sup>2</sup> and yield strength of 410 MN/m<sup>2</sup>. Take the endurance limit as half the ultimate strength, factor of safety of 2, size factor of 0.85 and a surface finish factor of 0.62. (NOV/DEC 2013) NOV 18 (16)

*Refertext book pageno: 1.205 Q.no: 25*

13. A pulley is keyed to a shaft midway between two bearings. The shaft is made of cold drawn steel for which the ultimate strength is 550 MPa and the yield strength is 400 MPa. The bending moment at the pulley varies from -150 N-m to +400 N-m and the torque on the shaft varies from - 50 N-m to + 150 N-m. Obtain the diameter of the shaft for an indefinite life. The stress concentration factors for the keyway at the pulley in bending and in torsion are 1.6 and 1.3 respectively. Take the following values: (MAY/JUNE 2012), (NOV/DEC 2012) (16)

Factor of safety	= 1.5
Load correction factors	= 1.0 in bending, and 0.6 in torsion
Size effect factor	= 0.85
Surface effect factor	= 0.88

*Refertext book pageno: 1.194 Q.no: 19*

**Unit II PART-B**

1. Design a muff coupling to connect two shafts transmitting 40 kW at 120 r.p.m. The permissible shear and crushing stress for the shaft and key material (mild steel) are 30 MPa and 80 MPa respectively. The material of muff is cast iron with permissible shear stress of 15 MPa. Assume that the maximum torque transmitted is 25 per cent greater than the mean torque. (May 2107) (Nov 2016) (May 2102) (16)
2. 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: (a) The allowable shear and crushing stress for shaft and key material is 40 MPa and 80 MPa respectively. (b) The allowable shear stress for cast iron is 15 MPa. (c) The allowable bearing pressure for rubber bush is 0.8 N/mm<sup>2</sup>. (d) The material of the pin is same as that of shaft and key. Draw neat sketch of the coupling. (Nov 2015)(Nov 2102)(16)

3. It is required to design a bushed-pin type flexible coupling to connect the output shaft of an electric motor to the shaft of a centrifugal pump. The motor delivers 20 KW power at 720 rpm. The starting torque of motor can be assumed to be 150% of the rated torque. Design the coupling and specify the dimensions of its components. (May 2103) (16)

*Similar type of problem no:2*

4. Design a rigid flange coupling to transmit a torque of 250 N-m between two coaxial shafts. The shaft is made of alloy steel, flanges out of cast iron and bolts out of steel. Four bolts are used to couple the flanges. The shafts are keyed to the flange hub. The permissible stresses are given below:

Shear stress on shaft = 100 MPa

Bearing or crushing stress on shaft = 250 MPa Shear stress on

keys = 100 MPa

Bearing stress on keys = 250 MPa

Shearing stress on cast iron = 200 MPa Shear stress on

bolts = 100 MPa

After designing the various elements, make a neat sketch of the assembly indicating the important dimensions. The stresses developed in the various members may be checked if thumb rules are used for fixing the dimensions. (Nov 2013) NOV 18(16)

5. Design and draw a cast iron flange coupling for a mild steel shaft transmitting 90 kW at 2500

r.p.m. The allowable shear stress in the shaft is 40 MPa and the angle of twist is not to exceed 1° in a length of 20 diameters. The allowable shear stress in the coupling bolts is 30 MPa. (Nov 2014) (16)

6. Design a bushed-pin type flexible coupling for connecting a motor shaft to a pump shaft for the following service conditions: Power to be transmitted = 40 kW ; speed of the motor shaft = 1000

r.p.m. ; diameter of the motor shaft = 50 mm ; diameter of the pump shaft = 45 mm. The bearing pressure in the rubber bush and allowable stress in the pins are to be limited to 0.45 N/mm<sup>2</sup> and 25 MPa respectively. (16)

*Similar model DME Q&A Problem no:2*

7. Design and draw a protective type of cast iron flange coupling for a steel shaft transmitting 15 kW at 200 r.p.m. and having an allowable shear stress of 40 MPa. The working stress in the bolts should not exceed 30 MPa. Assume that the same material is used for shaft and key and that the crushing stress is twice the value of its shear stress. The maximum torque is 25% greater than the full load torque. The shear stress for cast iron is 14 MPa. (May 2016) (16)

8. Determine the dimensions of flange coupling that connects a motor and a pump shaft. The power to be transmitted is 2 kW at a shaft speed of 900 rpm. Select suitable materials for the parts of the coupling and list the dimensions. (May 2014) (16)

*Similar model DME Q&A Problem no:2*

9. A hollow shaft of 0.5 m outside diameter and 0.3 m inside diameter is used to drive a propeller of a marine vessel. The shaft is mounted on bearings 6 metre apart and it transmits 5600 kW at 150 r.p.m. The maximum axial propeller thrust is 500 kN and the shaft weighs 70 kN. Determine : 1. The maximum shear stress developed in the shaft, and 2. The angular twist between the bearings. (Nov 2016) (16)

10. A solid steel shaft is supported on two bearings 1.8 m apart and rotates at 250 r.p.m. A 20° involute gear D, 300 mm diameter is keyed to the shaft at a distance of 150 mm to the left of the right hand bearing. Two pulleys B and C are located on the shaft at distances of 600 mm and 1350 mm respectively to the right of the left hand bearing. The diameters of the pulleys B and C are 750 mm and 600 mm respectively. 30 kW is supplied to the gear, out of which 18.75 kW is taken off at the pulley C and 11.25 kW from pulley B. The drive from B is vertically downward while from C the drive is downward at an angle of 60° to the horizontal. In both cases the belt tension ratio is 2 and the angle of lap is 180°. The combined fatigue and shock factors for torsion and bending may be taken as 1.5 and 2 respectively. Design a suitable shaft taking working stress to be 42 MPa in shear and 84 MPa in tension. (May 2016) (16)

11. A steel solid shaft transmitting 15 kW at 200 r.p.m. 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 100 mm 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. (May 2014) (16)

### Unit III PART-B

1. Design a knuckle joint to transmit 150 kN. The design stresses may be taken as 75 MPa in tension, 60 MPa in shear and 150 MPa in compression. (MAY 2012) (NOV/DEC 2015) NOV 18 (16)
2. For supporting the travelling crane in a workshop, the brackets are fixed on steel columns as shown in Fig. The maximum load that comes on the bracket is 12 kN acting vertically at a distance of 400 mm from the face of the column. The vertical face of the bracket is secured to a column by four bolts, in two rows (two in each row) at a distance of 50 mm from the lower edge of the bracket. Determine the size of the bolts if the permissible value of the tensile stress for the bolt material is 84 MPa. Also find the cross-section of the arm of the bracket which is rectangular. (NOV/DEC 2013) (16)
3. Steam engine of effective diameter 300 mm is subjected to a steam pressure of 1.5 N/mm<sup>2</sup>. 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. (NOV/DEC 2015) (MAY/JUNE 2016) NOV 18 (16)
4. Fig. shows a solid forged bracket to carry a vertical load of 13.5 kN applied through the centre of hole. The square flange is secured to the flat side of a vertical stanchion through four bolts. Calculate suitable diameter D and d for the arms of the bracket, if the permissible stresses are 110 MPa in tension and 65 MPa in shear. Estimate also the tensile load on each top bolt and the maximum shearing force on each bolt. (NOV/DEC 2016) (16)
5. 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. (MAY/JUNE 2012) (16)
6. Find the maximum shear stress induced in the weld of 6 mm size when a channel, as shown in Fig, is welded to a plate and loaded with 20 kN force at a distance of 200 mm. (NOV/DEC 2013)
7. A rectangular steel plate is welded as a cantilever to a vertical column and supports a single concentrated load P, as shown in Fig. 10.30. Determine the weld size if shear stress in the same is not to exceed 140 MPa. (NOV/DEC 2012) (MAY/JUNE 2015) (MAY/JUNE 2016) (16)

8. Design a double riveted butt joint with two cover plates for the longitudinal seam of a boiler shell 1.5 m diameter subjected to a steam pressure of  $0.95 \text{ N/mm}^2$ . Assume joint efficiency as 75%, allowable tensile stress in the plate 90 MPa; compressive stress 140 MPa; and shear stress in the rivet 56 MPa. (NOV/DEC 2016) (16)
9. A cast iron cylinder head is fastened to a cylinder of 500 mm bore with 8 stud bolts. The maximum pressure inside the cylinder is 2 MPa. The stiffness of part is thrice the stiffness of the bolt. What should be the initial tightening load so that the joint is leak proof at maximum pressure? Also choose a suitable bolt for the above application. What is an eccentric loaded welded joint? Discuss the procedure for designing such a joint. (May 2014) (16)
10. A steel bolt of M16X2 is 300 mm long carries an impact load of 5000 Nm. If the threads stop adjacent to the nut and  $E = 2.1 \times 10^5 \text{ N/mm}^2$ . (i) Find the stress in the root area; (ii) Find the stress if the shank area is reduced to root area. (Nov 2014) (16)
11. A  $200 \times 150 \times 10 \text{ mm}$  angle is to be welded to a steel plate by fillet welds as shown in Fig. 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. (Apr 2014) (16)
12. Design and draw 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 stress = compressive stress = 50 MPa; shear stress = 35 MPa and crushing stress = 90 MPa. (MAY/JUNE 2013) (16)
14. A bracket is welded to the vertical column by means of two fillet welds as shown in fig. Determine the size of the welds, if the permissible shear stress is limited to  $70 \text{ N/mm}^2$ . (May-17) (16)

#### UNIT IV PART-B

1. Design a helical spring for a spring loaded safety valve (Ramsbottom safety valve) for the following conditions: Diameter of valve seat = 65 mm; Operating pressure =  $0.7 \text{ N/mm}^2$ ; Maximum pressure when the valve blows off freely =  $0.75 \text{ N/mm}^2$ ; Maximum lift of the valve when the pressure rises from 0.7 to  $0.75 \text{ N/mm}^2 = 3.5 \text{ mm}$ ; Maximum allowable stress = 550 MPa; Modulus of rigidity =  $84 \text{ KN/mm}^2$ ; Spring index = 6. Draw a neat sketch of the free spring showing the main dimensions. (May & Nov 2012) (16)
2. A safety valve of 60 mm diameter is to blow off at a pressure of  $1.2 \text{ N/mm}^2$ . It is held on its seat by a close coiled helical spring. The maximum lift of the valve is 10 mm. Design a suitable compression spring of spring index 5 and providing an initial compression of 35 mm. The maximum shear stress in the material of the wire is limited to 500 MPa. The modulus

- ofrigidity for the spring material is  $80 \text{ KN/mm}^2$ . The permissible shear stress for the spring wire should be taken as 30% of the ultimate tensile strength. Design the spring and Calculate: 1. Diameter of the spring wire, 2. Mean coil diameter, 3. Number of active turns, and 4. Pitch of the coil. (may 2013, 2015) *NOV 18* (16)
3. 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 safety is 1.25. If the yield stress in shear is 770 MPa and endurance stress in shear is 350 MPa, find: 1. Size of the spring wire, 2. Diameters of the spring, 3. Number of turns of the spring, and 4. 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  $80 \text{ KN/mm}^2$ .(nov 2013) (16)
4. Design a close coiled helical compression spring for a service load ranging from 2250 N to 2750 N. The axial deflection of the spring for the load range is 6 mm. Assume a spring index of 5. The permissible shear stress intensity is 420 MPa and modulus of rigidity,  $G = 84 \text{ KN/mm}^2$ . Neglect the effect of stress concentration. Draw a fully dimensioned sketch of the spring, showing details of the finish of the end coils. (nov 2014) (16)
5. A railway wagon of mass 20 tonnes is moving with a velocity of 2 m/s. It is brought to rest by two buffers with springs of 300 mm diameter. The maximum deflection of springs is 250 mm. The allowable shear stress in the spring material is 600 MPa. Design the spring for the buffers. 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.(nov 2015) (16)
6. Design a leaf spring for the following specifications: Total load = 140 KN; Number of springs supporting the load = 4; Maximum number of leaves = 10; Span of the spring = 1000 mm; Permissible deflection = 80 mm. Take Young's modulus,  $E = 200 \text{ KN/mm}^2$  and allowable stress in spring material as 600 MPa. (Nov 2016, Apr 2015) (16)
7. Design and draw a cast iron flywheel used for a four stroke I.C engine developing 180 KW at 240 r.p.m. The hoop or centrifugal stress developed in the flywheel is 5.2 MPa, the total fluctuation of speed is to be limited to 3% of the mean speed. The work done during the power stroke is 1/3 more than the average work done during the whole cycle. The maximum torque on the shaft is twice the mean torque. The density of cast iron is

7220 Kg/m<sup>3</sup>. (nov 2012) (16)

8. A punching press pierces 35 holes per minute in a plate using 10 KN-m of energy per hole during each revolution. Each piercing takes 40 per cent of the time needed to make one revolution. The punch receives power through a gear reduction unit which in turn is fed by motor driven belt pulley 800 mm diameter and turning at 210 r.p.m. Find the power of the electric motor if overall efficiency of the transmission unit is 80 per cent. Design a cast iron flywheel to be used with the punching machine for a coefficient of steadiness of 5, if the space considerations limit the maximum diameter to 1.3 m. Allowable shear stress in the shaft material = 50 MPa, Allowable tensile stress for cast iron = 4 MPa, Density of cast iron = 7200 Kg / m<sup>3</sup>. (May 2016, 2017) (16)
9. The areas of the turning moment diagram for one revolution of a multi-cylinder engine with reference to the mean turning moment, below and above the line, are - 32, + 408, - 267, + 333, - 310, + 226, - 374, + 260 and - 244 mm<sup>2</sup>. The scale for abscissa and ordinate are: 1 mm = 2.4° and 1 mm = 650 N-m respectively. The mean speed is 300 r.p.m. with a percentage speed fluctuation of ± 1.5%. If the hoop stress in the material of the rim is not to exceed 5.6 MPa, determine the suitable diameter and cross-section for the flywheel, assuming that the width is equal to 4 times the thickness. The density of the material may be taken as 7200 kg / m<sup>3</sup>. Neglect the effect of the boss and arms. (May 2014, Nov 2016) (16)
10. An engine runs at a constant load at a speed of 480 rpm. The crank effort diagram is drawn to a scale 1mm = 200 Nm torque and 1mm = 3.6° crank angle. The areas of the diagram above and below the mean torque line in sq.mm are in the following order: +110, -132, +153, -166, +197, -162. Design the flywheel if the total fluctuation of speed is not to exceed 5 MPa. Assume that the rim breadth is approximately 2.5 times the rim thickness and 90% of the moment of inertia is due to rim. The density of the material of the flywheel is 7250 Kg/m<sup>3</sup>. Make a sketch of the flywheel giving the dimensions of the rim, the mean diameter of the rim and other estimated dimensions of spoke, hub etc. (May 2012) (16)
11. The turning moment diagram of a multi-cylinder engine is drawn with a scale of (1 mm = 1°) on the abscissa and (1mm = 250 Nm) on the ordinate. The intercepted areas between the torque developed by the engine and the mean resisting torque of the machine, taken in order from one end are

-350, +800, +600, +900, -550, +450 and -650 mm<sup>2</sup>. The engine is running at a mean speed of 750 rpm and the coefficient of speed fluctuating is limited to 0.02. A rimmed flywheel made of grey cast iron FG 200 ( $\rho=7100 \text{ Kg/m}^3$ ) is provided. The spokes, hub and shaft are assumed to contribute 10% of the required moment of inertia. The rim has a rectangular cross-section and ratio of width to thickness is 1.5. Determine the dimensions of rim.

12. A closed coiled helical compression spring has plain ends and is to fit over a 20 mm diameter rod. When a compressive force of 100 N is applied to the spring it compresses by 50 mm. If the spring has a preferred wire diameter of 4 mm and the spring material has a maximum allowable shear stress of  $180 \text{ MN/m}^2$  and a modulus of rigidity of  $81 \text{ GN/m}^2$ , determine: (i) The mean coil diameter of the spring; (ii) The diametral clearance between the spring and the rod; (iii) The number of coil in the spring; (iv) The solid length of the spring. (May 2014) (16)

15. A helical compression spring of the exhaust valve mechanism is initially compressed with a preload of 375 N. When the spring is further compressed and the valve is fully opened, the torsional shear stress in the spring wire should not exceed  $42 \text{ MN/m}^2$ . The spring is to be designed for minimum weight. Calculate the wire diameter and the mean coil diameter of the spring. (May 2017) (16)

#### Unit V PART-B

1. Design a journal bearing for a centrifugal pump from the following data: Load on the journal = 20 000 N; Speed of the journal = 900 r.p.m.; Type of oil is SAE 10, for which the absolute viscosity at  $55^\circ\text{C} = 0.017 \text{ kg / m-s}$ ; Ambient temperature of oil =  $15.5^\circ\text{C}$ ; Maximum bearing pressure for the pump =  $1.5 \text{ N / mm}^2$ . Calculate also mass of the lubricating oil required for artificial cooling, if rise of temperature of oil be limited to  $10^\circ\text{C}$ . Heat dissipation coefficient =  $1232 \text{ W/m}^2/^\circ\text{C}$ . (Nov dec 2013) NOV 18 (16)
2. The load on the journal bearing is 150 kN due to turbine shaft of 300 mm diameter running at 1800 r.p.m. Determine the following: i. Length of the bearing if the allowable bearing pressure is  $1.6 \text{ N/mm}^2$ , and ii. Amount of heat to be removed by the lubricant per minute if the bearing temperature is  $60^\circ\text{C}$  and viscosity of the oil at  $60^\circ\text{C}$  is  $0.02 \text{ kg/m-s}$  and the bearing clearance is 0.25mm. (MAY/JUNE 2014) (16)
3. A full journal bearing of 50 mm diameter and 100 mm long has a bearing pressure of  $1.4 \text{ N/mm}^2$ . The speed of the journal is 900 r.p.m. and the ratio

of journal diameter to the diametral 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 :  
 1. The amount of artificial cooling required, and 2. 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. (NOV-2015) (16)

4. Design a journal bearing for a centrifugal pump with the following data: Diameter of the journal=150 mm; Load on bearing = 40 KN; speed of journal=900 rpm. (16)

5. The load on the journal bearing is 150 KN due to turbine of 300 mm diameter running at 1800 rpm determine the following (1) Length of the bearing if the allowable bearing pressure is 1.6 N/mm<sup>2</sup>

(2) Amount of heat to be removed by the lubricant per minute if the bearing temperature is 60°C and viscosity of the oil at 60°C is 0.02 kg/m-s and the bearing clearance is 0.25. (Nov/Dec 2011) (16)

6. 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. Take 300 working days per year. (APRIL/MAY 2017) (MAY 2016) (NOV 2015) NOV 18 (16)

7. 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  $H_g = H_d$ . Absolute viscosity =  $20 \times 10^3$  Pa-s, Sp. Gravity of oil 2.1 KJ/Kg°C. (NOV 2014) (16)

8. Design a journal bearing for 12 MW, 1000 rpm steam turbine, which is supported by two bearings. Take the atmospheric temperatures as 18°C and operating temperature of oil as 60°C. Assume viscosity of oil as 23 centistokes. (NOV 2016) (16)

9. 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 hrs at 800 rpm. Select from series 63. Calculate the expected life of the selected bearing. (NOV 2012) (16)

10. Select a bearing for a 40 mm diameter shaft rotates at 400 rpm. Due to bevel gear mounted on the shaft, the bearing will have to withstand a 5000 N radial load and a 3000 N thrust load. The life of the bearing expected to be at least 1000 hrs. (MAY 2014) (16)

**11. Find the rated load of a deep groove ball bearing for the following load cycle**

<b>SL.NO</b>	<b>RADIAL LOAD</b>	<b>AXIAL LOAD</b>	<b>%OF TIME</b>
<b>1</b>	<b>3000</b>	<b>1000</b>	<b>15</b>
<b>2</b>	<b>3500</b>	<b>1000</b>	<b>20</b>
<b>3</b>	<b>3500</b>	<b>10</b>	<b>30</b>
<b>4</b>	<b>500</b>	<b>2000</b>	<b>35</b>

**Also find the 90% life of ball bearing used is 6207 with dynamic capacity 19620 N.(NOV 2014) (16)**

**12. A ball bearing is rated by manufacture to have an average life of 1000 hrs when carrying a load of 45 KN at 1800 rpm. (i) What is the 90% life expectancy for these bearings? (ii) What is the rated load capacity of this bearing for an average life of 50,000 hrs at 1800 rpm?(NOV 2016) (16)**

**13. A ball bearing for drilling machine spindle is rotating at 3000 rpm. It is subjected to a radial load of 2500 N and an axial thrust of 1500 N. It is to work 50 hours per week for one year. Design a suitable bearing if the diameter of the spindle is 40 mm(MAY 2014) (16)**

**14. A roller bearing is selected to withstand a radial load of 40 KN and life of 1200 hrs at 600 rpm. What load rating would you look for in searching from manufacturer's catalogue if it specifies load at speed 500 rpm and life 3000 hrs. (16)**