JEPPIAAR ENGINEERING COLLEGE

Jeppiaar Nagar, Rajiv Gandhi Salai – 600 119

DEPARTMENT OFMECHANICAL ENGINEERING

QUESTION BANK

V SEMESTER

ME6503 – Design of Machine Elements

Regulation – 2013

JEPPIAAR ENGINEERING COLLEGE

Vision of Institution

To build Jeppiaar Engineering College as an institution of academic excellence in technological and management education to become a world class university.

Mission of Institution

- To excel in teaching and learning, research and innovation by promoting the principles of scientific analysis and creative thinking.
- To participate in the production, development and dissemination of knowledge and interact with national and international communities.
- To equip students with values, ethics and life skills needed to enrich their lives and enable them to meaningfully contribute to the progress of society.
- To prepare students for higher studies and lifelong learning, enrich them with the practical and entrepreneurial skills necessary to excel as future professionals and contribute to Nation's economy.

PO1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations
PO4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

JEPPIAAR ENGINEERING COLLEGE

DEPARTMENT OF MECHANICAL ENGINEERING

Vision of the Department

To create excellent professionals in the field of Mechanical Engineering and to uplift the quality of technical education on par with the International Standards.

Department Mission

1. **To reinforce** the fundamentals of Science and Mathematics to Mechanical Engineering **and critically and relatively investigate co**mplex mechanical systems and processes.
2. To engage in the **production, expansion and practice** of advanced engineering applications through knowledge sharing activities by interacting with global communities and industries.
3. To**equip** students with **engineering ethics, professional roles, corporate social responsibility** and life skills and **apply** them for the betterment of society.
4. **To promote** higher studies and lifelong learning and entrepreneurial skills and **develop** excellent professionals for empowering nation's economy.

PEO's

1. To **enrich** the technical knowledge of design, manufacturing and management of mechanical systems and **develop creative and analytical thinking** in research.
2. To **relate, strengthen and develop** the theoretical knowledge of the Mechanical Engineering by exhibiting various concepts applied through diverse industrial exposures and experts' guidance.
3. **Facilitate** the students to communicate effectively on complex social, professional and engineering activities with strict adherence to ethical principles.
4. **Create awareness for independent and life long learning and develop the ability to keep abreast of modern trends and adopt them for personal technological growth of the nation.**

PSO's

1. To understand the basic concept of various mechanical engineering field such as design, manufacturing, thermal and industrial engineering.
2. To apply the knowledge in advanced mechanical system and processes by using design and analysis techniques.
3. To develop student's professional skills to meet the industry requirements and entrepreneurial skills for improving nation's economy stronger.

ME6503- PRINCIPLES OF MANAGEMENT

COURSE OUTCOMES

C303.1	Explain the design process and stresses due to different loading in machine members.
C303.2	Design shafts, keys and couplings based on strength, rigidity and critical speed.
C303.3	Design various joints for structures under different loading conditions and discuss the bonded joints.
C303.4	Classify the springs and design springs, flywheels, crank shafts and connecting rods.
C303.5	Classify the bearings, design journal bearings and select rolling contact bearings.

ME6503 DESIGN OF MACHINE ELEMENTS L T P C 3 0 0 3

OBJECTIVES

• To familiarize the various steps involved in the Design Process

•To understand the principles involved in evaluating the shape and dimensions of a component to satisfy functional and strength requirements.

• To learn to use standard practices and standard data

• To learn to use catalogues and standard machine components

(Use of P S G Design Data Book is permitted)

UNIT I STEADY STRESSES AND VARIABLE STRESSES IN MACHINE MEMBERS 10

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.

UNIT II SHAFTS AND COUPLINGS 8

Design of solid and hollow shafts based on strength, rigidity and critical speed – Keys, keyways and splines - Rigid and flexible couplings.

UNIT III TEMPORARY AND PERMANENT JOINTS 9

Threaded fastners - Bolted joints including eccentric loading, Knuckle joints, Cotter joints – Welded joints, riveted joints for structures - theory of bonded joints.

UNIT IV ENERGY STORING ELEMENTS AND ENGINE COMPONENTS9

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.

UNIT V BEARINGS 9

Sliding contact and rolling contact bearings - Hydrodynamic journal bearings, Sommerfeld Number, Raimondi and Boyd graphs, -- Selection of Rolling Contact bearings.

TOTAL: 45 PERIODS

OUTCOMES:

Upon completion of this course, the students can able to successfully design machine components

TEXT BOOK:

1. BhandariV,"Design of Machine Elements",3rd Edition, Tata McGraw-Hill Book Co, 2010.

2. Joseph Shigley, Charles Mischke, Richard Budynas and Keith Nisbett "Mechanical Engineering Design", 8th Edition, Tata McGraw-Hill, 2008.

REFERENCES:

1. Sundararajamoorthy T. V. Shanmugam .N, "Machine Design", Anuradha Publications, Chennai, 2003.

2. Robert C. Juvinall and Kurt M. Marshek,"Fundamentals of Machine Design",4 Edition, Wiley, 2005.

3. Alfred Hall, Halowenko, A and Laughlin, H., "Machine Design", Tata McGraw-Hill BookCo.(Schaum's Outline), 2010

4. Bernard Hamrock, Steven Schmid,Bo Jacobson, "Fundamentals of Machine Elements",2 Edition, Tata McGraw-Hill Book Co., 2006.

5. Orthwein W, "Machine Component Design", Jaico Publishing Co, 2003.

6. AnselUgural, "Mechanical Design – An Integral Approach", 1st Edition, Tata McGraw-Hill Book Co, 2003.

7. Merhyle F. Spotts, Terry E. Shoup and Lee E. Hornberger, "Design of Machine Elements" 8th Edition, Printice Hall, 2003.

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DEPARTMENT OFMECHANICAL ENGINEERING

QUESTION BANK

Subject : ME6503 – Design of Machine Elements

Year / Sem : III / V

UNIT I STEADY STRESSES AND VARIABLE STRESSES IN MACHINE MEMBERS

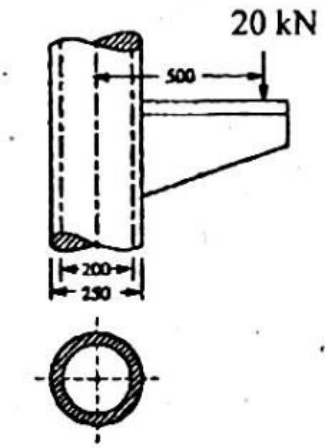
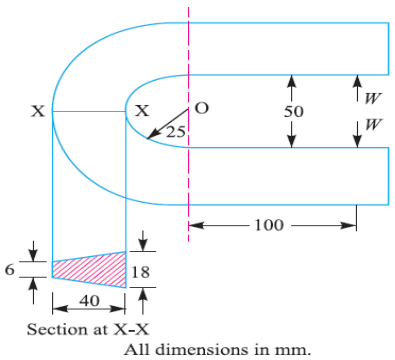
Introduction to the design process - factors influencing machine design, selection of materials based on mechanical properties - Preferred numbers, fits and tolerances – Direct, Bending and torsional stress equations – Impact and shock loading – calculation of principle stresses for various load combinations, 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.

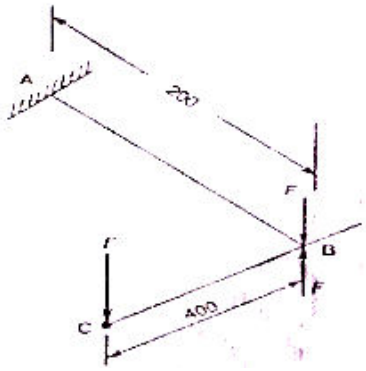
PART-A

CO Mapping : C304.1

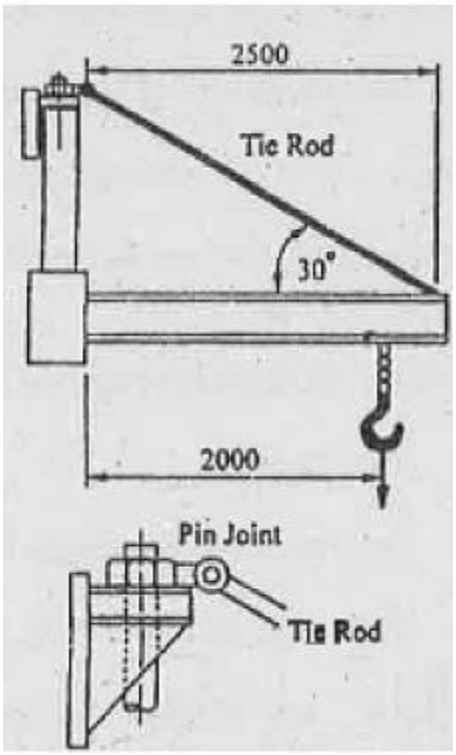
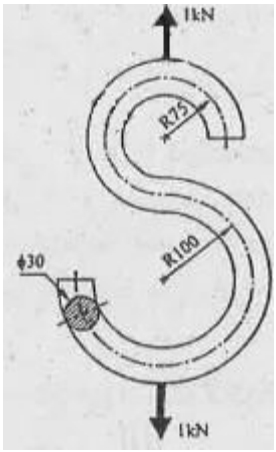
Q.No.	Questions	BT Level	Competence	PO
1	Define design. What are the various phases of design process? How the machine design may be classified?	**BTL-1 BTL-2**	Remembering Understanding	**PO1**
2	What is Adaptive design? Where is it used? Give examples.	**BTL-1**	Remembering	**PO1**
3	What do you mean by Optimum design? What are the various optimization methods available?	**BTL-1**	Remembering	**PO1**
4	What are the factors that govern selection of materials while designing a machine component?	**BTL-1**	Remembering	**PO1,PO6, PO7**
5	What are the common materials used in mechanical engineering design?	**BTL-1**	Remembering	**PO1**
6	Describe material properties hardness, stiffness and resilience.	**BTL-1**	Remembering	**PO1**
7	Define modulus of resilience and proof resilience.	**BTL-1**	Remembering	**PO1**
8	Differentiate hardness and toughness.	**BTL-2**	Understanding	**PO1**
9	Define factor of safety.	**BTL-1**	Remembering	**PO1**

10	List the important factors that influence the magnitude of factor of safety.	**BTL-1**	Remembering	**PO4,PO6, PO7,PO8**
11	What are the different types of loads that can act on machine components?	**BTL-1**	Remembering	**PO1**
12	What is an impact load? Give examples.	**BTL-1**	Remembering	**PO1**
13	What are the modes of fracture? Explain Griffith theory. (Or) State the condition for crack growth.	**BTL-1**	Remembering	**PO1**
14	What are the types of fracture? Distinguish them.	**BTL-1**	Remembering	**PO1**
15	What are the various theories of failure?	**BTL-1**	Remembering	**PO1**
16	What is the use of Goodman &Soderberg diagrams? Write Soderberg equation for machine component subjected to (a) combination of mean and variable torques (b) combination of mean and variable bending moments.	**BTL-1**	Remembering	**PO1**
17	Which theory of failure is suitable for the design of brittle materials?	**BTL-1**	Remembering	**PO1**
18	What is curved beam? Give some example for curved beam.	**BTL-1**	Remembering	**PO1**
19	State the difference between straight beams and curved beams.	**BTL-1**	Remembering	**PO1**
20	Why nonsymmetrical I and T sections are preferred in design of curved beams?	**BTL-1**	Remembering	**PO1**
21	Define principal plane and principal stresses?	**BTL-1**	Remembering	**PO1**
22	Why normal stress theory is not suitable for ductile materials?	**BTL-1**	Remembering	**PO1**
23	Define stress concentration and stress concentration factor.	**BTL-1**	Remembering	**PO1**
24	State the various methods of finding stresses concentration factors.	**BTL-1**	Remembering	**PO1**
25	Give some methods of reducing stress concentration.	**BTL-1**	Remembering	**PO1**
26	Explain notch sensitivity. State the relation between stress concentration factor, fatigue stress concentration factor and notch sensitivity.	**BTL-1**	Remembering	**PO1**
27	What are the factors that affect notch sensitivity?	**BTL-1**	Remembering	**PO1**
28	What are the types of variable stresses?	**BTL-1**	Remembering	**PO1**
29	Differentiate between repeated stress and reversed stress.	**BTL-2**	Understanding	**PO1**
30	Explain size factor in endurance strength.	**BTL-2**	Understanding	**PO1**
31	Define fatigue. What are the methods used to improve fatigue strength?	**BTL-1**	Remembering	**PO1**
32	What is an S-N curve? What is low and high cycle fatigue?	**BTL-1**	Remembering	**PO1,PO2**
PART-B & PART-C				
Q.No.	**Questions**	**BT Level**	**Competence**	**PO**

1	A Circular bar of 500 mm length is supported freely at it 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 1.5, size effect of 0.85, surface finish factor of 0.9. The material properties of bar as given by: ultimate strength of 650 MPa, yield strength of 500 MPa and endurance strength of 350 MPa.	**BTL-5**	Evaluating	**PO1,PO2, PO3**
2	A hollow circular column of external diameter 250 mm and internal diameter 200 mm carries a projecting bracket on which a load of 20 kN rests, as shown in Fig. The centre of the load from the centre of the column is 500 mm. Find the stresses at the sides of the column. All dimensions in mm. 	**BTL-5**	Evaluating	**PO1**
3	(i) Theframeofapunchpressisshowninfigure below.Findthestressesattheinnerand outersurfaceat section X-X ofthe frame, ifW=5000 N.  **ii)** What is factor of safety? List the factors to be considered while deciding the factor of safety.	**BTL-5** **BTL-2**	Evaluating Understanding	**PO1, PO4,PO6, PO7,PO8**
4	(i) What are the factors influencing machine design? Explain it.	**BTL-1BTL-2**	Remembering Understanding	**PO1**

	(ii)Write short notes on the following: (a) Interchangeability (b) Tolerance (c) Allowance.			
5	An unknown weights fall through 10 mm 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 2 mm. What is the corresponding stress and the value of the weight? Take E = 200 kN/mm^2.	**BTL-5**	Evaluating	**PO1**
6	A mass of 50 kg drops through 25 mm at the center of a 250 mm long simply supported beam. The beam has a square cross section. It is made of steel 30C8 (Syt = 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.	**BTL-5**	Evaluating	**PO1,PO2, PO3**
7	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 σ_u= 650 N/mm^2, σ_y= 480 N/mm^2, Size factor B = 0.85 and surface finish factor C = 0.5.	**BTL-5**	Evaluating	**PO1,PO2, PO3**
8	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 30Mn2 steel having a allowable shear strength equal to 100 N/mm^2. Determine the diameter of the shaft. 	**BTL-5**	Evaluating	**PO1,PO2, PO3**
9	Theloadonaboltconsistsofadirect loadof25kNtogetherwithashear loadof 15kN.Considering the following theories of failure, determinethediameterof bolt requiredif the material of the bolt is C15 having 200 N/mm^2 yield strength. Accordingto 1. Maximumprincipal (normal)stresstheory;2.Maximumshear stresstheory;3.Maximum principalstraintheory;4.Maximumstrainenergy theoryand5.Maximumdistortion energy(von mises) theory.	**BTL-5**	Evaluating	**PO1,PO2, PO3**

	Assume F.O.S = 2.			
10	A solid circular shaft of diameter 45 mm is loaded by bending moment 650 Nm, torque 900 Nm and axial tensile force of 30 kN. The shaft material is ductile with yield strength of 280 MPa. Determine the factor of safety according to Maximum principle stress, Tresca and Von misses theories of failure.	**BTL-5**	Evaluating	**PO1,PO3, PO5**
11	A cantilever rod of length 120 mm with circular section is subjected to a cyclic transverse load; varying from -100 N and 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	**BTL-5**	Evaluating	**PO1,PO2, PO3**
12	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 relation ii) Modified Goodman relation and iii) Soderberg relation. Take yield strength = 0.55 Ultimate strength; Endurance strength = 0.5 Ultimate strength; and factor of safety = 2.	**BTL-5**	Evaluating	**PO1**
13	A wall crane with a pin – joint tie rod is as shown in Fig. The crane hook is to take a maximum load 35kN, when the load is at a distance of 2 m from the wall. The tie rod and pin are made of steel FeG 250 (Syt = 250 N/mm2) and the factor of safety is 5. Calculate the diameter of the tie rod and the pin.	**BTL-5**	Evaluating	**PO1,PO2, PO3**

				
14	A link shaped in the form of a letter S is made up of 30 mm diameter bar, as shown in fig. Determine the maximum tensile stress and maximum shear stress in the link. 	**BTL-5**	Evaluating	**PO1,PO4**

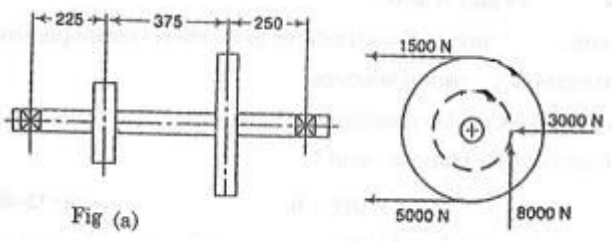
UNIT II SHAFTS AND COUPLINGS				
Design of solid and hollow shafts based on strength, rigidity and critical speed – Keys, keyways and splines - Rigid and flexible couplings.				
PART-A				
CO Mapping : C304.2				
Q.	**Questions**	**BT**	**Competence**	**PO**

No.		Level		
1	What is a shaft? Differentiate between shaft, axle and spindle.	**BTL-1** **BTL-2**	Remembering Understanding	**PO1**
2	What are the materials used for shafts?	**BTL-1**	Remembering	**PO1**
3	What are the types of shaft?	**BTL-1**	Remembering	**PO1**
4	On what basis shafts are designed?	**BTL-1**	Remembering	**PO1**
5	What are the types of rigidity?	**BTL-1**	Remembering	**PO1**
6	What is meant by design of a shaft based on rigidity?	**BTL-1**	Remembering	**PO1**
7	Why is maximum shear stress theory used for shaft?	**BTL-1**	Remembering	**PO1**
8	What is the significance of slenderness ratio in shaft design?	**BTL-1**	Remembering	**PO1,PO2**
9	Why rotating shafts are generally made with circular cross section?	**BTL-1**	Remembering	**PO1**
10	Define the term critical speed of a shaft.	**BTL-1**	Remembering	**PO1,PO2**
11	What do you mean by stiffness and rigidity with reference to shafts?	**BTL-1**	Remembering	**PO1**
12	Why a hollow shaft has greater strength and stiffness than solid shaft of equal weight?	**BTL-1**	Remembering	**PO1**
13	State any two reasons for preferring hollow shafts over solid shafts.	**BTL-1**	Remembering	**PO1**
14	Define equivalent torsional moment of a shaft.	**BTL-1**	Remembering	**PO1**
15	A shaft of 750 mm long is subjected to shear stress of 40 MPa and has an angle of twist 0.017 radian. Determine the diameter of the shaft. Take G = 0.8x105 MPa.	**BTL-5**	Evaluating	**PO1**
16	What is column factor?	**BTL-1**	Remembering	**PO1**
17	Suitable couplings for (i) Shafts with parallel misalignment (ii) Shafts with angular misalignment of 10^{o} (iii) shafts in perfect alignment.	**BTL-2**	Understanding	**PO1**
18	What is shock factor and what does it indicate?	**BTL-1**	Remembering	**PO1,PO6**
19	What is a key? What types of stress are developed in the key?	**BTL-1**	Remembering	**PO1**
20	What are the types of key?	**BTL-2**	Understanding	**PO1**
21	What is the effect of keyway cut into shaft?	**BTL-1**	Remembering	**PO1**
22	List the different types of sunk keys and draw any one.	**BTL-2**	Understanding	**PO1**
23	What is the main use of woodruff keys?	**BTL-1**	Remembering	**PO1**
24	Differentiate between keys and splines.	**BTL-2**	Understanding	**PO1**
25	What is coupling?	**BTL-1**	Remembering	**PO1**

26	What are the purposes in machinery for which couplings are used?	**BTL-1**	Remembering	**PO1**
27	State the reasons for which the couplings are located near the bearings.	**BTL-1**	Remembering	**PO1**
28	Under what circumstances flexible couplings are used?	**BTL-1**	Remembering	**PO1**
29	Where are flexible couplings used?	**BTL-1**	Remembering	**PO1**
30	What are the possible modes of failure of the pin (bolt) in a flexible coupling?	**BTL-1**	Remembering	**PO1**
31	What is the advantage of gear coupling?	**BTL-1**	Remembering	**PO1**
32	What is a flange coupling? What are the different types of flange coupling?	**BTL-1**	Remembering	**PO1**
33	What is the difference between rigid and flexible coupling?	**BTL-2**	Understanding	**PO1**
34	Differentiate between a cotter joint and a knuckle joint.	**BTL-2**	Understanding	**PO1**

PART-B & PART-C

Q. No.	Questions	BT Level	Competence	PO
1	In an axial flow rotary compressor, the shaft is subjected to maximum twisting moment and maximum bending moment of 1500 Nm and 300 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.	**BTL-5**	Evaluating	**PO1,PO2, PO3,PO6**
2	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 rpm. The maximum axial propeller thrust is 500 kN and the shaft weighs 70 kN. Determine (i) The maximum shear stress developed in the shaft and (ii) The angular twist between the bearings.	**BTL-5**	Evaluating	**PO1**
3	Ahollow shaft is required to transmit 600 kW at 110 rpm, 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 internal diameter to the external diameter is 3/8. Take modulus of rigidity as 84 GPa.	**BTL-5**	Evaluating	**PO1,PO2, PO3**

4	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 side for each pulley is 2.5:1. The yield strength of the shaft material σ_y = 380 MPa and factor of safety is 3. Estimate the suitable diameter of the shaft.	**BTL-5**	Evaluating	**PO1,PO2, PO3**
5	A shaft is supported by two bearings placed 1100 mm apart. A pulley of diameter 620 mm is keyed at 400 mm to the right of the left hand bearing and this drives a pulley directly below it with a maximum tension of 2.75 kN. Another pulley of diameter 400 mm is placed 200 mm to the left of the right hand bearing and is driven with a motor placed horizontally to the right. The angle of contact of the pulleys is 180^o and the coefficient of friction between the belt and the pulleys is 0.3. Find the diameter of the shaft. Assume K_b = 3, K_t= 2.5, S_{yt} = 190 MPa, S_{Ut} = 300 MPa.	**BTL-5**	Evaluating	**PO1,PO2, PO3**
6	A 600 mm diameter driven by a horizontal belt transmits power through a solid shaft to a 262 mm diameter pinion which drives a mating 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 (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 (a)	**BTL-5**	Evaluating	**PO1,PO2, PO3**
7	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	**BTL-6**	Creating	**PO1,PO2, PO3**

	pressure in the rubber bush = 0.3MPa.			
8	In an axial flow rotary compressor, the shaft is subjected to maximum twisting moment and maximum bending moment of 1500 Nm and 300 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.	**BTL-5**	Evaluating	**PO1,PO2, PO3,PO6**
9	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 (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.	**BTL-6 BTL-5**	Evaluating Creating	**PO1,PO2, PO3,PO6**
10	It is required to design square key for fixing a gear on a shaft of 30 mm diameter. The shaft is transmitting 20 kW power at 600 rpm to the gear. The key is made of steel 50C4 (Syt = 460 N/mm^2) and the factor of safety is 4. For key material, the yield strength in compression can be assumed to be equal to the yield strength in tension. Determine the dimensions of the key.	**BTL-5**	Evaluating	**PO1,PO2, PO3**
11	Design a rectangular key for the following application: A shaft 65 mm diameter transmits power at maximum shear stress of 67 MPa. The shear stress in the key should not exceed 75% of the stress developed in the shaft. The key should be at least 2.5 times strong in crushing compared to shear failure of the key.	**BTL-6**	Creating	**PO1,PO2, PO3,PO6**
12	A shaft made of AISI 1030 cold drawn steel (σ_u= 520MPa and σ_y= 440 MPa) transmits 50 kW at 900 rpm through a gear. Select an appropriate square key for the gear.	**BTL-5**	Evaluating	**PO1,PO2, PO3**
13	A rigid coupling is used to transmit 60kW at 350 rpm. There are six bolts. The outer diameter of the flanges is 250 mm, while the recess diameter is 175 mm. The coefficient of friction between the flanges is 0.15. 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.	**BTL-5**	Evaluating	**PO1,PO2, PO3,PO6**
14	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	**BTL-6**	Creating	**PO1,PO2, PO3**

	1^{o}in a length of 20 meters. The allowable shear stress in the coupling bolt is 30 MPa. Take G = 84 kN/mm^2.			

UNIT III TEMPORARY AND PERMANENT JOINTS

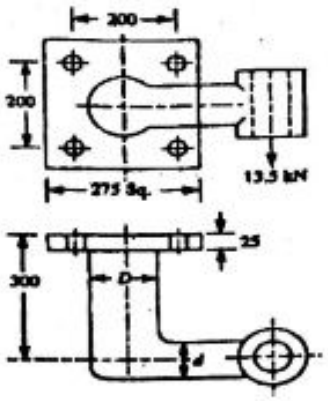
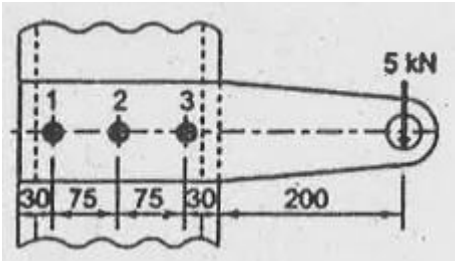
Threaded fastners - Bolted joints including eccentric loading, Knuckle joints, Cotter joints – Welded joints, riveted joints for structures - theory of bonded joints.

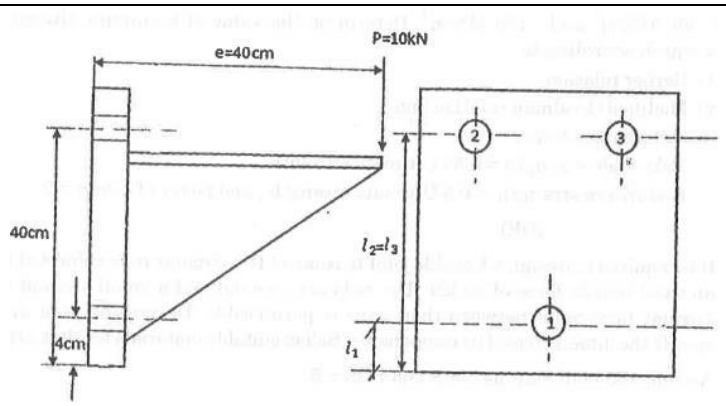
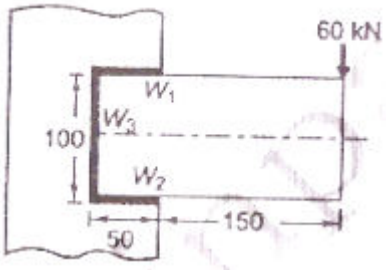
PART-A

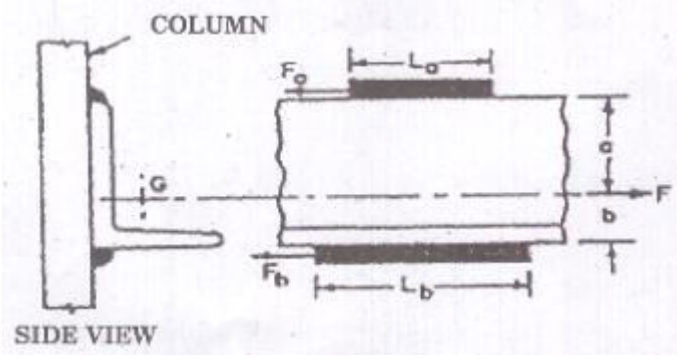
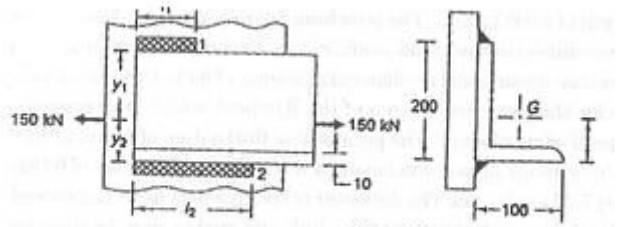
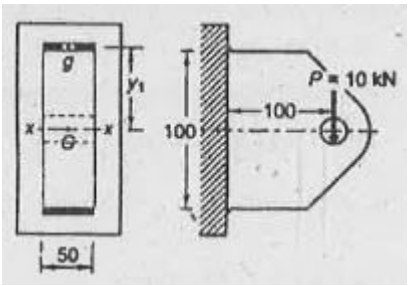
CO Mapping : C304.3

Q. No.	Questions	BT Level	Competence	PO
1	What are stresses that act on screw fastening?	**BTL-1**	Remembering	**PO1**
2	Give some examples for temporary joints and permanent joints?	**BTL-1**	Remembering	**PO1**
3	State there conditions where tap bolts are used.	**BTL-1**	Remembering	**PO1**
4	What do you understand by the single start and double start threads?	**BTL-1**	Remembering	**PO1**
5	Define the term self-locking of power.	**BTL-1**	Remembering	**PO1**
6	What is a stud?	**BTL-1**	Remembering	**PO1**
7	How is a bolt designated? Give example.	**BTL-1**	Remembering	**PO1**
8	Why are ACME threads preferred over square thread for power screw?	**BTL-1**	Remembering	**PO1**
9	What are the essential stresses induced due to screwing up forces?	**BTL-1**	Remembering	**PO1**
10	What is bolt of uniform strength? What are the ways to produce bolts of uniform strength?	**BTL-1**	Remembering	**PO1**
11	State the advantages of threaded joints.	**BTL-1**	Remembering	**PO1**
12	What are the different applications of screwed fasteners?	**BTL-1**	Remembering	**PO1**
13	Determine the safe tensile load for a bolt of M20, Assume a safe tensile stress of 40 Mpa?	**BTL-5**	Evaluating	**PO1**
14	What is known as proof load in bolts?	**BTL-1**	Remembering	**PO1**
15	What are the types of cotter joint?	**BTL-1**	Remembering	**PO1**
16	What is a gib? Why is it provided in a cotter joint?	**BTL-1**	Remembering	**PO1,PO2**
17	Differentiate between a cotter joint and a knuckle joint.	**BTL-2**	Understanding	**PO1**
18	List the advantages of cotter joint over threaded joints.	**BTL-1**	Remembering	**PO1**
19	Classify the rivet heads according to IS specifications	**BTL-2**	Understanding	**PO1**
20	What are the possible modes of failure of riveted joint?	**BTL-1**	Remembering	**PO1**

21	What is a rivet? What are the different working processes used for making riveting?	**BTL-1**	Remembering	**PO1**
22	Name the possible modes of failure of riveting joint.	**BTL-1**	Remembering	**PO1,PO6**
23	Define welding. Why are welded joints preferred over riveted joints?	**BTL-1**	Remembering	**PO1**
24	What are the types of welded joints?	**BTL-2**	Understanding	**PO1**
25	Define butt and lap joint?	**BTL-1**	Remembering	**PO1**
26	What is the total shear in a double strap butt joint with equal length of straps?	**BTL-1**	Remembering	**PO1**
27	Define Tee joint and corner joint.	**BTL-1**	Remembering	**PO1**
28	When will the edge preparation need?	**BTL-1**	Remembering	**PO1**
29	What is the minimum size for fillet weld? If the required weld size from strength consideration is too small how will you fulfill the condition of minimum weld size?	**BTL-1**	Remembering	**PO1**
30	Why throat is considered while calculating stresses in fillet welds?	**BTL-1**	Remembering	**PO1**
31	When will the weld deposit be weaker?	**BTL-1**	Remembering	**PO1**
32	What is the bending stress induced in a 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?	**BTL-1**	Remembering	**PO1**
33	State the two types of eccentric welded connections.	**BTL-2**	Understanding	**PO1**
34	Define circumferential joint.	**BTL-1**	Remembering	**PO1**
35	State the disadvantages of welded joints?	**BTL-1**	Remembering	**PO1**
PART-B & PART-C				
Q. No.	**Questions**	**BT Level**	**Competence**	**PO**
1	Figure 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. Estimate the tensile load on each top bolt and the maximum shearing force on each bolt. Find the bolt size, if permissible stress is 65 MPa in shear. All dimensions in mm.	**BTL-5**	Evaluating	**PO1,PO2,PO3**

				
2	A steel bolt of M16x2 is 300 mm long carries an impact load of 500 Nm. If the threads stop adjacent to the Nut and E = 2.1 x 10^5MPa. (i) Find the stress in the root area (ii) Find the stress if the shank area is reduced to root area.	**BTL-5**	Evaluating	**PO1**
3	A steam engine cylinder of 30 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.	**BTL-5**	Evaluating	**PO1,PO2,PO3,PO6**
4	A steel plate is subjected to a force of 5 kN and fixed to a channel by means of three identical bolts as shown in Fig. The bolts are made of from 50C8 steel (S_{yt} = 380 N/mm^2) and the factor of safety is 3. Specify the size of the bolts. 	**BTL-6**	Creating	**PO1,PO2,PO3,PO6**
5	Fig 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.	**BTL-6**	Creating	**PO1,PO2,PO3**

				
6	Design a knuckle joint to withstand a load of 100 kN. All the parts of the joint are made of the same material of the same material with $\sigma_{ut}=\sigma_{uc}$= 480 MPa, and τ_u= 360 MPa. Use factor of safety of 6 on Ultimate strength.	**BTL-6**	Creating	**PO1,PO2,PO3,PO6**
7	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.	**BTL-6**	Creating	**PO1,PO2,PO3,PO6**
8	Design a double riveted butt joint with two cover plates for the longitudinal steam of a boiler shell 1.5 m in diameter subjected to a steam pressure of 0.95 N/mm^2. Assume joint efficiency as 75%, allowable tensile stress in the plate 90 MPa; compressive stress140 MPa and shear stress in the rivet 56 MPa.	**BTL-6**	Creating	**PO1,PO2,PO3**
9	A welded connection, as shown below is subjected to an eccentric force of 60 kN in the plane of welds. Determine the size of the welds, if the permissible shear stress for the weld is 90 N/mm^2. Assume static conditions. 	**BTL-5**	Evaluating	**PO1,PO2,PO3**
10	(i) A butt welded joint with ground and flush surface is subjected to tensile load which varies from 50 kN to 100 kN. Plates are 10 mm thick. Determine the length of	**BTL-5**	Evaluating	**PO1,PO2,PO3**

	weld required for over 2,500,000 cycles. (ii) The fig below shows an angle welded to a column and carries a static load F as shown. Determine the ratio of the weld lengths L_a and L_b and F_a and F_b in terms of F.  			
11	An ISA 200 x 100 x 100 angle is welded to a steel plate by means of fillet welds as shown in Fig (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. (a)	**BTL-5**	Evaluating	**PO1,PO2,PO3**
12	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 N/mm^2.  	**BTL-6**	Creating	**PO1,PO2,PO3**
13	A cylindrical beam of size 60 mm is attached to support by a complete circumferential fillet weld of 6 mm. Find (i) torque and (ii) bending moment that can be applied if limiting shear stress is 140 MPa.	**BTL-5**	Evaluating	**PO1**

UNIT IV ENERGY STORING ELEMENTS AND ENGINE COMPONENTS

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.

PART-A

CO Mapping : C304.4

Q.No.	Questions	BT Level	Competence	PO
1	What is spring and where it is employed?	**BTL-1**	Remembering	**PO1**
2	By what materials the springs can be made?	**BTL-1**	Remembering	**PO1**
3	Define (a) spring index (b) spring rate.	**BTL-1**	Remembering	**PO1**
4	Write the formula for natural frequency of spring.	**BTL-1**	Remembering	**PO1**
5	What is the effect of increase in wire diameter on the allowable stress value?	**BTL-1**	Remembering	**PO1**
6	State any two function of springs.	**BTL-1**	Remembering	**PO1**
7	What are the various types of springs?	**BTL-1**	Remembering	**PO1**
8	How will you find whether the given helical spring is a compression spring or tension spring? (or) Distinguish between close coiled and open coiled springs.	**BTL-1** **BTL-2**	Remembering Understanding	**PO1**
9	What are conical springs?	**BTL-1**	Remembering	**PO1**
10	What are the purposes of composite springs?	**BTL-1**	Remembering	**PO1**
11	What are torsion springs?	**BTL-1**	Remembering	**PO1**
12	How the stiffness of the spring can be increased?	**BTL-1**	Remembering	**PO1**
13	What are the advantages of leaf springs over helical springs?	**BTL-1**	Remembering	**PO1**
14	Sketch the stresses induced in the cross section of a helical spring, considering Wahl's effect.	**BTL-1**	Remembering	**PO1**
15	While designing helical springs, K is introduced in the shear stress equation, why?	**BTL-1**	Remembering	**PO1**
16	What are active coils?	**BTL-1**	Remembering	**PO1**
17	What are the end conditions of the spring?	**BTL-1**	Remembering	**PO1**
18	What is fly wheel? What is the application of flywheel?	**BTL-1**	Remembering	**PO1**
19	What type of stresses is produced in a disc flywheel?	**BTL-1**	Remembering	**PO1**
20	What is the main function of a flywheel in an engine?	**BTL-1**	Remembering	**PO1**
21	State any two type of flywheel.	**BTL-2**	Understanding	**PO1**
22	What is flywheel effect?	**BTL-1**	Remembering	**PO1**

23	Define coefficient of fluctuation of speed in the case of flywheel? Define the term fluctuation of energy	**BTL-1**	Remembering	**PO1**
24	What are the stresses induced in flywheels arms?	**BTL-1**	Remembering	**PO1**
25	How does the function of flywheel differ from that of governor?	**BTL-1**	Remembering	**PO1**
26	Brief why flywheels are used in punching machines.	**BTL-1**	Remembering	**PO1**
27	At what angle of the crank the twisting moment is maximum in the crankshaft?	**BTL-1**	Remembering	**PO1**
28	Why is piston end of a connecting rod kept smaller than the crank pin end?	**BTL-1**	Remembering	**PO1**
29	Under what force, the big end bolts and caps are designed?	**BTL-1**	Remembering	**PO1**
30	What are functions of crankshafts? Classify crankshafts	**BTL-1**	Remembering	**PO1**
31	What is a connecting rod? What are materials used for connecting rod?	**BTL-1**	Remembering	**PO1**
32	What are the stresses set up in an IC engine connecting rod? Why I- section is chosen for the connecting rod?	**BTL-1**	Remembering	**PO1,PO2**
33	What type of external forces act on connecting rod?	**BTL-1**	Remembering	**PO1**
PART-B& PART-C				
Q.No.	**Questions**	**BT Level**	**Competence**	**PO**
1	Design a leaf spring for the following specifications for a truck: Assume FOS = 2. Maximum load on springs = 100 kN; Number of springs = 4 ; Material of springs = Cr Va Steel (σu = 1380 MPa and E = 206 x 10^3MPa); Span of the spring = 1000 mm ; Width of central band = 150 mm; Permissible deflection = 100 mm. Assume 2 full length leaves and 6 graduated leaves.	**BTL-6**	Creating	**PO1,PO2,PO3, PO6**
2	Design of helical compression spring to sustain an axial load of 4 kN. The deflection is 80 mm. Spring index is 6. The shear stress is not to exceed 350 MPa. Rigidity modulus for spring material is 81 GPa.	**BTL-6**	Creating	**PO1,PO2,PO3**
3	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	**BTL-5BTL-6**	Evaluating Creating	**PO1,PO2,PO3**

	of 1250 MPa and modulus of rigidity of 81.37 GPa. The permissible shear stress for the spring 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.			
4	A spring loaded safety valve for a boiler is required to blow off at a pressure of 0.8 MPa. The diameter 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.	**BTL-6**	Creating	**PO1,PO2,PO3**
5	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.	**BTL-5**	Evaluating	**PO1,PO2,PO3**
6	Design a closed coil 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.	**BTL-6**	Creating	**PO1,PO2,PO3**
7	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 750 N/mm^2. Due to space limitations, the outer diameter of the spring should not exceed 42 mm. The spring is to be designed for minimum weight. Calculate the wire diameter and the mean coil diameter of the spring.	**BTL-5**	Evaluating	**PO1,PO2,PO3**
8	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.	**BTL-6**	Creating	**PO1,PO2,PO3**

9	The areas of the turning moment diagram for one revolution of a multicylinder 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^2. The scale for abscissa and ordinate are : 1 mm = 2.4^o and 1 mm = 650 Nm respectively. The main speed is 300 rpm with a percentage of 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 material may be taken as 7200 kg/m^3. Neglect the effect of the boss and arms	**BTL-5**	Evaluating	**PO1,PO2,PO3**
10	A punching machine carries out punching 10 holes per minute. Each hole of 36 mm diameter in 16 mm thick plate requires 7 N-m of energy/mm^2 of the sheared area. The punch has a stroke of 90 mm. Determine the power of the motor required to operate the machine. If the total fluctuation of speed is not to exceed 2.5% of the mean speed; determine the mass of the flywheel. The mean speed of the flywheel is 15 m/s.	**BTL-5**	Evaluating	**PO1,PO2,PO3, PO4**
11	A punching machine makes 25 workings stokes per minute and is capable of punching 25 mm diameter holes in 18 mm thick steel plates having 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.	**BTL-6**	Creating	**PO1,PO2,PO3, PO4**

UNIT V BEARINGS

Sliding contact and rolling contact bearings - Hydrodynamic journal bearings, Sommerfeld Number, Raimondi

and Boyd graphs, -- Selection of Rolling Contact bearings.

PART-A

CO Mapping : C304.5

Q.No.	Questions	BT Level	Competence	PO
1	What is bearing?	**BTL-1**	Remembering	**PO1**
2	Classify the types of bearings.	**BTL-2**	Understanding	**PO1**
3	What type of bearings can take axial load?	**BTL-1**	Remembering	**PO1**
4	State the components of rolling contact bearings.	**BTL-1**	Remembering	**PO1**
5	What are anti-friction bearings?	**BTL-1**	Remembering	**PO1**
6	Give an example for anti-friction bearing.	**BTL-1**	Remembering	**PO1**
7	Classify the roller bearings.	**BTL-2**	Understanding	**PO1**
8	List any four advantages to rolling contact bearings over sliding contact bearings.	**BTL-1**	Remembering	**PO1**
9	What is meant by life of an individual (orantifriction) bearing?	**BTL-1**	Remembering	**PO1**
10	Define the term Reliability of a bearing.	**BTL-1**	Remembering	**PO1,PO6**
11	What are the types of radial ball bearings?	**BTL-2**	Understanding	**PO1**
12	State the advantages of thrust ball bearing.	**BTL-1**	Remembering	**PO1**
13	List the basic assumptions used in the theory of hydrodynamic lubrication.	**BTL-1**	Remembering	**PO1**
14	List the advantages of hydrostatic bearings?	**BTL-1**	Remembering	**PO1**
15	What is load rating?	**BTL-1**	Remembering	**PO1**
16	Define the term bearing life.	**BTL-1**	Remembering	**PO1,PO6**
17	Define static capacity of bearing.	**BTL-1**	Remembering	**PO1**
18	Explain the term Dynamic load carrying capacities of rolling contact bearing?	**BTL-2**	Understanding	**PO1**
19	List any six types of bearing materials.	**BTL-2**	Understanding	**PO1**
20	What are the required properties of bearing materials?	**BTL-1**	Remembering	**PO1**
21	What is the advantage of Teflon which is used for bearings?	**BTL-1**	Remembering	**PO1**
22	What is journal bearing?	**BTL-1**	Remembering	**PO1**
23	What are types of journal bearings depending upon the nature of contact?	**BTL-2**	Understanding	**PO1**
24	What are the types of journal bearing depending upon the nature of lubrication? (or) Classify the sliding contact bearings according to the thickness of the layer of the lubricant between the bearing and the journal	**BTL-2**	Understanding	**PO1**
25	Plot the friction induced in various bearings based on shaft speed.	**BTL-1**	Remembering	**PO1**

26	For a journal bearing, the maximum operating temperature must be less than 80^{o}c. Why?	**BTL-1**	Remembering	**PO1**
27	In hydrodynamic bearing, what are factors which influence the formation of wedge fluid film?	**BTL-1**	Remembering	**PO1**
28	What is meant by square journal bearing?	**BTL-1**	Remembering	**PO1**
29	What is sommerfeld number? State its importance in the design of journal bearing?	**BTL-1**	Remembering	**PO1**
30	What is self-aligning ball bearing? State its unique feature.	**BTL-1**	Remembering	**PO1**
31	What is critical pressure?	**BTL-1**	Remembering	**PO1,PO3,PO6**
32	What is known as self-acting bearing?	**BTL-1**	Remembering	**PO1**
33	What are seals? What are the main types of seals?	**BTL-1**	Remembering	**PO1**
34	What are the essential requirements in an end face seal?	**BTL-1**	Remembering	**PO1**
35	How is "O" ring designated?	**BTL-1**	Remembering	**PO1**
PART-B& PART-C				
1	Enumerate the detail steps involved in the selection of bearings from the manufacturer's catalogue.	**BTL-6**	Creating	**PO1**
2	Design a journal bearing for 12 MW, 1000 rpm steam turbine, which is supported by two bearings. Take the atmospheric temperatures as 60^{o}C. Assume viscosity of oil as 23 centistokes.	**BTL-6**	Creating	**PO1,PO2,PO3**
3	Load on a hydrodynamic full journal bearing is 30 kN. The diameter and speed of the shaft are 150 mm and 1200 mm respectively. Diametral clearance 0.2 mm. Sommerfield number is 0.631. L/D ratio 1:1. Calculate temperature rise of oil, quantity of the oil, heat generated and type of oil required.	**BTL-5**	Evaluating	**PO1,PO2,PO3**
4	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 tolerance is 1000. The bearing is lubricated with oil whose absolute viscosity at the operating temperature of 75^{o}c may be taken as 0.011 kg/m-s. The room temperature is 35^{o}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^{o}c. Take specific heat of the oil as 1850 J/kg/^{o}c.	**BTL-5**	Evaluating	**PO1,PO2,PO3**
5	Design a journal bearing for a 49.9 mm diameter journal. It is ground and hardened and is rotating at 1500 rpm in a bearing of diameter and length both 50	**BTL-6**	Creating	**PO1,PO2,PO3**

	mm. The inlet temperature of oil 65^{o}C. Determine max radial load that the journal can carry and power loss.			
6	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 the power lost in friction and increase in the oil temperature. Assume Hg = Hd. Absolute viscosity = 20 x 10^{3}Pas, Sp.Gravity of oil 0.8, Sp.Heat of oil 2.1 kJ/Kg^{o}C.	**BTL-5**	Evaluating	**PO1,PO2,PO3**
7	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.	**BTL-5**	Evaluating	**PO1,PO2,PO3**
8	A ball bearing is subjected to a radial load of 10 kN and a thrust load of 5 kN. The inner ring rotates at 1000 rpm. The average life is to be 5000 hours. What basic load rating must be used to select a bearing for this purpose? Take F_a/C_o = 0.5 and assume service factor 1.5.	**BTL-5**	Evaluating	**PO1,PO2,PO3, PO6**
9	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 rpm. The bearing is required to have a minimum life of 9000 hours. Check whether the bearing selected can serve the purpose.	**BTL-5**	Evaluating	**PO1,PO2,PO3**
10	A ball bearing subjected to a radial load of 5 kN is expected to have a life of 8000 hours at 1450 rpm with a reliability of 99%. Calculate the dynamic load capacity of the bearing so that it can be selected from the manufacturer's catalogue based on a reliability of 90%.	**BTL-5**	Evaluating	**PO1,PO2,PO3, PO6**
11	Find the rated load of deep groove ball bearing for the following load cycle. SN RADIAL LOAD (N) AXIAL LOAD (N) % OF TIME 1 3500 1000 15 2 3500 1000 20 3 3500 10 30 4 500 2000 35 Also find the 90% life of ball bearing if bearing	**BTL-5**	Evaluating	**PO1,PO2,PO3, PO4,PO6**

	used is 6207 with dynamic capacity 19620 N.			

UNIT I STEADY STRESSES AND VARIABLE STRESSES IN MACHINE MEMBERS

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.

PART-A

1. **Define design. What are the various phases of design process? How the machine design may be classified? (Nov 2016)**

   Design is a process of activities to gather all the information necessary to realize the designer's idea as real product. The steps involved in design process are: (i) Recognition of need (ii) Definition of problem (iii) Synthesis (iv) Analysis and optimization (v) Evaluation (vi) Presentation.

   Machine design is classified as

   (i)Adaptive design

   (ii) Development design

   (iii) New design

   a) Rational design
   b) Empirical design
   c) Industrial design
   d) Optimum design
   e) Element design
   f) Computer aided design.

2. **What is Adaptive design? Where is it used? Give examples. (Nov 2012)**

   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. Examples: Die design for a small sized product which is similar to an existing large sized product.

3. **What do you mean by Optimum design? What are the various optimization methods available? (Nov 2011)**

   Optimization is the process of maximizing a desired quantity or minimizing an undesired one. The various optimization methods are:

   (i) Optimization by evaluation

(ii) Optimization by intuition

(iii) Optimization by trial& error

(iv) Optimization by numerical algorithm

4. What are the factors that govern selection of materials while designing a machine component? (Nov 2010)

a) Material properties
b) Nature of load
c) Surface finish and tolerances
d) Manufacturability
e) Ergonomics and aesthetics
f) Working atmosphere
g) Mode of failure
h) Safety and reliability
i) cost.

5. What are the common materials used in mechanical engineering design? (Nov 2015)

Metals and their alloys such as iron, steel, copper, aluminium etc. Non-metals such as glass, rubber, plastic etc.

6. Describe material properties hardness, stiffness and resilience.

Hardness is the ability of material to resist scratching and indentation. Stiffness is the ability of material to resist deformation under loading. Resilience is the ability of material to resist absorb energy and to resist shock and impact load.

7. Define modulus of resilience and proof resilience. (May 2017)

Proof resilience is defined as the maximum energy that can be absorbed up to the elastic limit, without creating a permanent distortion. The modulus of resilience is defined as the maximum energy that can be absorbed per unit volume without creating a permanent distortion.

8. Differentiate hardness and toughness. (Nov 2017)

Hardness is the measurement of how much a material resists to penetration from a semi-static force. It is tested for with an indenter hardness machine usually (but not solely) by measuring the size of the indentation after releasing the load. A well-known hard material is diamond.

Toughness is the ability of a material to absorb energy when impacted. It is tested with impact Charpy or Izod testing machines by measuring how much a predetermined weight will rise after impacting and breaking the piece under test. Materials known to be very tough are stainless steels and titanium alloys.

9. Define factor of safety?

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

Factor of safety= Maximum stress/ working stress

10. List the important factors that influence the magnitude of factor of safety. (Nov 2011)

i) Material properties

ii) Nature of load

iii) Presence of localized stresses

iv) Presence of initial stress

v) Mode of failure.

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

a. Steady load.

b. Variable load.

c. Shock load

d. Impact load.

12. What is an impact load? Give examples.

If the time load application is less than one third of the lowest national period of vibration of the part, the load is called an impact load. Example: Punching presses, hammers, loads exerted on cams during the motion due to eccentricity, loads imposed on gear teeth due to irregular tooth profile.

13. What are the modes of fracture? Explain Griffith theory. (Or) State the condition for crack growth.

a. Mode I (Opening mode) – Displacement is normal to crack surface.

b. Mode II (Sliding mode) – Displacement is in the plane of the plate.

c. Mode III (Tearing mode) – Out of plane shear.

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

14. What are the types of fracture? Distinguish them.

a. Ductile fracture

b. Brittle fracture

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

15. What are the various theories of failure?

a. Maximum principal stress theory (or) Rankine theory

b. Maximum shear stress theory (or) Guest's theory (or) Coloumb theory (or) Tresca theory

c. Maximum strain theory (or) Venant's theory

d. Maxium strain energy theory

e. Distortion energy theory (or) Von Mises- Henky theory

16. What is the use of Goodman &Soderberg diagrams? Write Soderberg equation for machine component subjected to (a) combination of mean and variable torques (b) combination of mean and variable bending moments. (Nov 2010)

Goodman andSoderberg diagramsare used to solve the problems of variable stresses.

$$\sigma_{eq} = \frac{\sigma_y}{n} = \sigma_m + \frac{\sigma_a \sigma_y}{\sigma_{-1}}$$

$$\tau_{eq} = \frac{\tau_y}{n} = \tau_m + \frac{\tau_a \tau_y}{\tau_{-1}}$$

17. Which theory of failure is suitable for the design of brittle materials? (or) Why normal stress theory is not suitable for ductile materials? (Nov 2015)

Maximum principal stress theory or Maximum normal stress theory or Rankine theory is used for brittle materials. Ductile materials are mostly undergone by shearing. But this theory takes into account the effect of tensile and compressive stress only.

18. What is curved beam? Give some example for curved beam.

In curved beam the neutral axis does not coincide with the centroidal axis. Some examples are: C frame, crane hook.

19. State the difference between straight beams and curved beams. (Nov 2012)

Feature	Straight beam	Curved beam
Centroidal axis and neutral axis	Are concident.	Are not coincident. Neutral axis is shifted towards the centre of curvature.
Stress developed	Same throughout the section.	Different at inner and outer radii of the section.

20. Why non-symmetrical I and T sections are preferred in design of curved beams? (May 2017)

Symmetrical cross-sections are mostly used in structural elements that are subject to bending as beams and columns. The symmetry of the cross-section prevents it from being subject to additional stresses; like torsional stresses for example.

On the other hand, unsymmetrical sections are used in structural elements subject to normal forces like members of a truss or bracing members. Just by converting a beam system to a truss system, bending is no more put into consideration and all the forces the system is subject to are normal forces of small magnitudes; these forces can be resisted easily by non-symmetric sections like angles and T-sections, which is also more economic.

21. Define principal plane and principal stresses?

A plane where only normal stresses act, with no shear stress acting is called principal plane. The (normal) stress acting on this plane is called principal stresses

22. Why normal stress theory is not suitable for ductile materials?

Ductile materials mostly fail by shearing. But this theory considers only tensile or compressive stresses. So this is not suitable for ductile materials.

23. Define stress concentration and stress concentration factor.

Stress concentration is the increase in local stresses at points of rapidchange in cross section or discontinuities.Stress concentration factor is the ratio of maximum stress at critical section to the nominal stress.

24. State the various methods of finding stresses concentration factors?

a. Photo elasticity method
b. Grid method
c. Brittle coating method
d. Strain gauge method
e. Finite element techniques

25. Give some methods of reducing stress concentration?

a. Avoiding sharp corners
b. Providing fillets
c. Use of multiple holes instead of single holes

26. 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 stressconcentration is actually reached. The relation is, $K_f = 1 + q (K_t - 1)$

27. What are the factors that affect notch sensitivity?

a. Materials
b. Notch radius
c. Size of component
d. Type of loading
e. Grain Structure

28. What is shock factor and what does it indicate? (Nov 2017)

29. What are the types of variable stresses?

a. Completely reverse or cyclic stresses
b. Fluctuating stresses
c. Repeated stresses
d. Alternating stresses

30. Differentiate between repeated stress and reversed stress.

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

31. 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

32. Define fatigue. What are the methods used to improve fatigue strength?

When a material is subjected to repeated stress, it fails at stresses below the yieldpoint stress; such type of failure of the material is called fatigue. The methods used to improve:

(i) Cold working like short peening, burnishing

(ii) Heat treatments like induction hardening

(iii) Pre stressing

33. What is an S-N curve? What is low and high cycle fatigue? (Nov 2016)

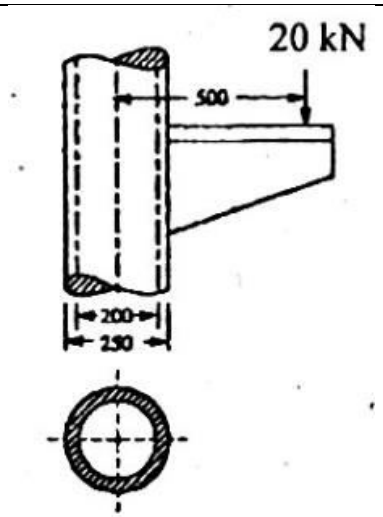
An S-N curve has fatigue stress on Y- axis and number of loading cycles in X- axis. It is used to find the fatigue stress value corresponding to a given number of cycles.Fatigue within 10^3 cycles is known as low cycle fatigue. Fatigue at high number cycles is called high cycle fatigue.

PART-B

1. A Circular bar of 500 mm length is supported freely at it 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 1.5, size effect of 0.85, surface finish factor of 0.9. The material properties of bar as given by: ultimate strength of 650 MPa, yield strength of 500 MPa and endurance strength of 350 MPa. **(Nov 2016)**

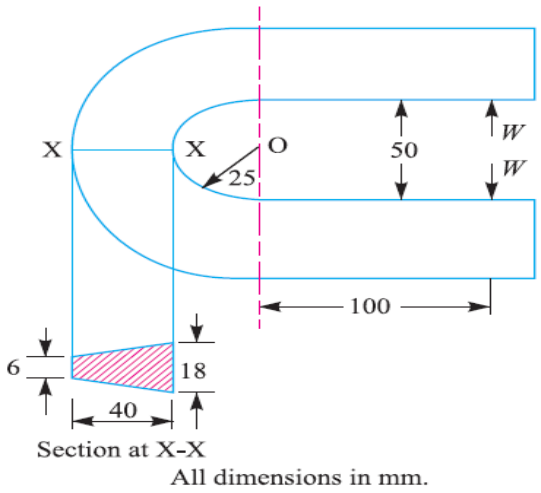
   Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No163.

2. A hollow circular column of external diameter 250 mm and internal diameter 200 mm carries a projecting bracket on which a load of 20 kN rests, as shown in Fig. The centre of the load from the centre of the column is 500 mm. Find the stresses at the sides of the column. All dimensions in mm. **(Nov 2016)**



Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No 105.

3. (i) Theframeofapunchpressisshowninfigure below.Findthestressesattheinnerand outersurfaceat section X-X ofthe frame, ifW=5000 N. **(May 2014)**



Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No 132.

ii) What is factor of safety? List the factors to be considered while deciding the factor of safety. **(May 2014)(May 2015)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 77 to 79.

4. (i) What are the factors influencing machine design? Explain it.

Refer: "Joseph Shigley, Charles Mischke, Richard Budynas and Keith Nisbett "Mechanical Engineering Design", 8th Edition, Tata McGraw-Hill, 2008", Page No 8.

(ii)Write short notes on the following: (a) Interchangeability (b) Tolerance (c) Allowance. **(May 2014)(May 2017, May 2011)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 65 to 69.

5. An unknown weights fall through 10 mm 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 2 mm. What is the corresponding stress and the value of the weight? Take E = 200 kN/mm^2. **(Nov 2014)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 180 to 181.

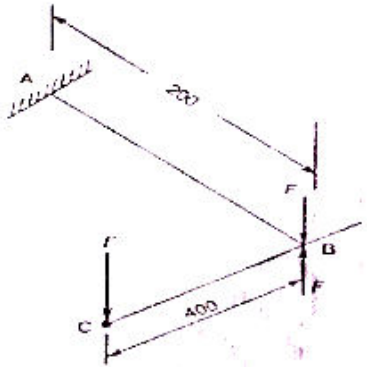
6. A mass of 50 kg drops through 25 mm at the center of a 250 mm long simply supported beam. The beam has a square cross section. It is made of steel 30C8 (Syt = 400 N/mm^2) and the factor of safety is 2. The modulus of elasticity is 207000 N/mm2. Determine the dimension of the cross section of the beam. **(Nov 2017)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 180 to 181.

7. 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 σ_u= 650 N/mm^2, σ_y= 480 N/mm^2, Size factor B = 0.85 and surface finish factor C = 0.5. **(Nov 2014)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 169 to 172.

8. 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 30Mn2 steel having a allowable shear strength equal to 100 N/mm^2. Determine the diameter of the shaft. **(May 2015)**



Refer: "Joseph Shigley, Charles Mischke, Richard Budynas and Keith Nisbett "Mechanical Engineering Design", 8th Edition, Tata McGraw-Hill, 2008", Page No from 97 to 99.

9. The load on a bolt consists of a direct load of 25kN together with a shear load of 15kN. Considering the following theories of failure, determine the diameter of bolt required if the material of the bolt is C15 having 200 N/mm^2 yield strength. According to 1. Maximum principal (normal) stress theory; 2. Maximum shear stress theory; 3. Maximum principal strain theory; 4. Maximum strain energy theory and 5. Maximum distortion energy (von mises) theory. Assume F.O.S = 2.**(Nov 2015)(Nov 2017)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 112 to 116.

10. A solid circular shaft of diameter 45 mm is loaded by bending moment 650 Nm, torque 900 Nm and axial tensile force of 30 kN. The shaft material is ductile with yield strength of 280 MPa. Determine the factor of safety according to Maximum principle stress, Tresca and Von misses theories of failure. **(May 2017)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 112 to 116.

11. A cantilever rod of length 120 mm with circular section is subjected to a cyclic transverse load; varying

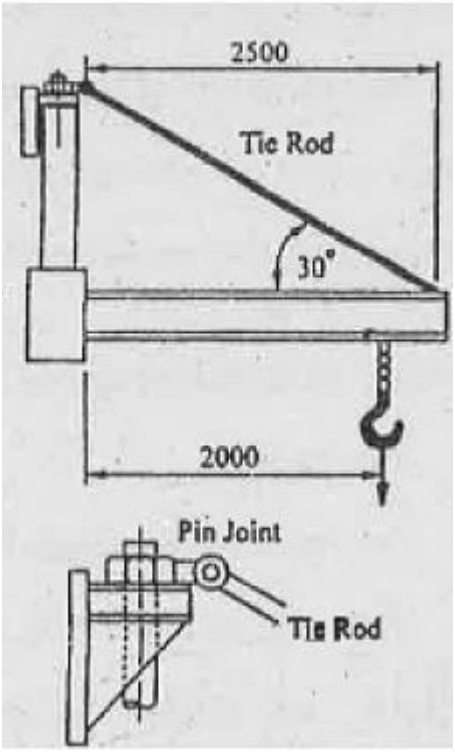
from -100 N and 300 N at its free end. Determine the diameter 'd' of the rod, by (i) Goodman method and (ii) Soderberg method using the following data. Factor of safety = 2; Theoretical stress concentration factor = 1.4; Notch sensitivity factor = 0.9; Ultimate strength = 550 MPa; Yield strength = 320 MPa; Endurance limit = 275 MPa; Size correction factor = 0.85; Surface correction factor = 0.9. **(Nov 2015)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 169 to 172.

12. 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 relation ii) Modified Goodman relation and iii) Soderberg relation. Take yield strength = 0.55 Ultimate strength; Endurance strength = 0.5 Ultimate strength; and factor of safety = 2.**(Nov 2017)**

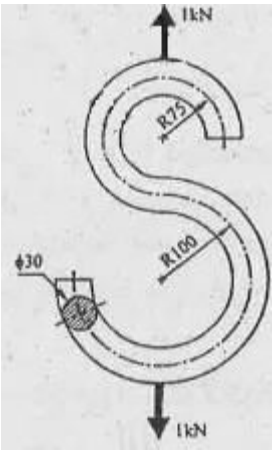
Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from from 169 to 172.

13. A wall crane with a pin – joint tie rod is as shown in Fig. The crane hook is to take a maximum load 35 kN, when the load is at a distance of 2 m from the wall. The tie rod and pin are made of steel FeG 250 (Syt = 250 N/mm^2) and the factor of safety is 5. Calculate the diameter of the tie rod and the pin. **(May 2017)**



Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No 83.

14. A link shaped in the form of a letter S is made up of 30 mm diameter bar, as shown in Fig. Determine the maximum tensile stress and maximum shear stress in the link. (**May 2017)**



Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 131 to 133.

UNIT II SHAFTS AND COUPLINGS

Design of solid and hollow shafts based on strength, rigidity and critical speed – Keys, keyways and splines - Rigid and flexible couplings.

PART-A

1. What is a shaft? Differentiate between shaft, axle and spindle?

A shaft is a rotatingmachine element, which transits power from onepoint to another point.

An axle though similar in shape to the shaft is a stationary machine element and is used for transmission of bending momentonly.it simply act as a support for some rotating body. Spindle is a short shaft that imparts motion either to a cutting tool or to a work piece.

2. **What are the materials used for shafts**?

For ordinary shaft - mild steel

For high strength shafts - alloy steel such as nickel,

Ni-Cr steel and Cr-v steels

3. What arethe types of shaft?

- Line shaft
- Spindle
- Stub shaft
- Countershaft

4. On what basis shafts are designed?

a) Based on rigidity and stiffness

b) Based on strength

c) Based on critical speed.

5. What arethe types ofrigidity?

(i) Torsional rigidity

(ii) Lateral rigidity

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

The diameter of the shaft is obtained from the equation, $T/J=G\theta/L$ where

θ = Torsional deflection or angle of twist in radians,
T = Twisting moment or torque on the shaft,
J = Polar moment of inertia of the cross-sectional area about the axis of rotation,

$= \frac{\pi}{32} \times d^4$ ...(For solid shaft)

$= \frac{\pi}{32}\left[(d_o)^4 - (d_i)^4\right]$ ...(For hollow shaft)

G = Modulus of rigidity for the shaft material, and

7. Whyis maximum shear stress theoryusedforshaft?

Since, the shaft is madeof ductile material; maximum shear stress thus is used.

8. What is the significanceof slenderness ratio in shaft design?

Ifslenderness ratio is increased theshaft deviatesfrom its "stub" behaviour and itis essential to consider buckingwhile designingthe shaft.

9. Why rotating shafts are generally made with circular cross section?

Stress distribution pattern will be uniform throughout the circular cross section.

10. Definethe term criticalspeed of a shaft. (Nov 2016)

Thespeedat which theshaft runs so that the additional deflection ofthe shaft from the axis of rotation becomes infinite, is known as critical speed.

11. What do you mean by stiffness and rigidity with reference to shafts? (Nov 2010)

Stiffness is the resistance offered by the shaft for twisting and rigidity is the resistance offered by the shaft for lateral bending.

12. Whyahollow shaft hasgreater strength and stiffness than solid shaft of equal weight? (Nov 2012)

Stresses aremaximum atthe outer surfaceof ashaft. A hollow shaft has almost allthe material concentrated at theoutercircumferenceand so has a better strength andstiffness for equal weight.

13. State any two reasons for preferring hollow shafts over solid shafts.

The two reasons for preferring hollow shafts over solid shafts are

For same weight of shaft, hollow shaft can transmit 1.5 times the torque transmitted by solid shaft.

For a particular power transmission, hollow shaft requires minimum weight.

14. Define equivalent torsional moment of a shaft. (May 2017)

15. A shaft of 750 mm long is subjected to shear stress of 40 MPa and has an angle of twist 0.017 radian. Determine the diameter of the shaft. Take G = 0.8x10^{5}MPa. (Nov 2013)

Given Data:

Length of the shaft, $l = 750mm$

Shear stress, $\tau = 40MPa = 40N/mm^2$

Angle of twist, $\theta = 0.017radian$

Modulus of rigidity, $G = 0.8 \times 10^5 MPa = 0.8 \times 10^5 N/mm^2$

To find:

Diameter of the shaft, d

Solution:

We know that the torsional moment of the shaft

$$M_t = \frac{\pi}{16} \times \tau \times d^3 \text{ and}$$

Angle of twist, $\theta = \frac{M_t \times l}{GJ} = \frac{\frac{\pi}{16} \times \tau \times d^3 \times l}{G \times \left(\frac{\pi d^4}{32}\right)} = \frac{2\tau l}{Gd}$

$$0.017 = \frac{2 \times 40 \times 750}{0.8 \times 10^5 \times d}$$

$$d = 44.11mm$$

The standard diameter is, $d = 45mm$

Result:

Diameter of the shaft, $d = 45mm$

16. What is column factor?

If a long shaft is subjected to axial load in addition to torsion and bending, a factor must be introduced to take the column effect into account.

If L/K<115 $\alpha = 1/ (1 - 0.0044(L/K))$

If L/K>115 $\alpha = \sigma Y(L/K)2/ C \pi 2E$

17. Suggest suitable couplings for (i) Shafts with parallel misalignment (ii) Shafts with angular misalignment of 10^o (iii) shafts in perfect alignment. (Nov 2010)

Flexible coupling such as spring coupling can be used for shafts with parallel misalignment. Universal coupling is suitable for shafts with angular misalignment of 10^o. Rigid coupling can be used for shafts in perfect alignment.

18. What is shock factor and what does it indicate? (Nov 2017)

During operation, the shaft is subjected to shock due to bending and twisting conditions. The shock factor should be multiplied with twisting and bending moments in order to find the equivalent twisting and bending moments.

19. What is a key? What types of stressaredeveloped in thekey? (Nov 2014)

A keyis a devicewhich is used for connectingtwo machine parts for preventingrelativemotion of rotation with respect to each other. Shear stress andcrushing stress are developed.

20. What arethe types of key?

- Saddle key
- Tangent key
- Sunk key
- Round keyand taper pins.

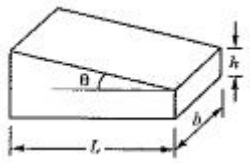
21. What is the effect of keyway cut into shaft?

The keyway cut into the shaft reduces the load carrying capacity of the shaft. This is due to the stress concentration near the corners of the keyway and reduction in cross sectional area of the shaft. In other words the torsional strength of the shaft is reduced.

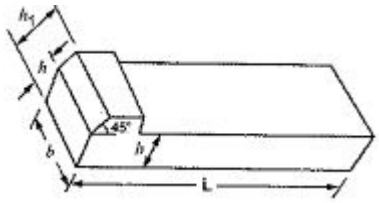
22. List the different types of sunk keys and draw any one. (Nov 2017)

a) Parallel sunk key

b) Taper sunk key



c) Gib head sunk key



23. What is the main useof woodruff keys?

A woodruffkeyis used to transmit smallvalue oftorquein automotive and machine tool industries. Thekeywayin theshaft is milled in a curved shapewhereas the keywayin thehub isusuallystraight.

24. Differentiate between keys and splines. (Nov 2011)

SI No	KEYS	SPLINES
1	A shaft is having single keyway.	A shaft is having multiple keyways.
2	Keys are used in couplings.	Splines are used in automobiles and machine tools.

25. What is coupling?

The elements which jointwo shafts are coupling.It is used to connect sections of longtransmissions shaft to the shaft ofadrivingmachine. Couplings areused to connect sections of longtransmission shafts andto connect theshaft ofadriving machine to the shaft ofadriven machine.

26. 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 for disconnection 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.

27. State the reasons for which the couplings are located near the bearings. (May 2017)

Couplings tend to produce unbalanced forces due to misalignments of shafts which cause vibrations in rotating machinery, leading to lower amplitude of vibrations.

28. Under what circumstances flexible couplings are used? (Nov 2012)

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.

29. Whereare flexible couplings used?

- Vehicle
- Stationerymachinery
- Automotive drives
- Machine tools

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

The threaded portion of the pin in the right hand flange should be a tapping fit in the couplinghole to avoid bending stresses.The threaded length of the pin should be as small as possible so that the direct shear stress canbe taken by the unthreaded neck.

31. What is the advantageof gearcoupling?

Gearcouplingis agrid couplingwith some flexibilitybecauseof using curved external teeth Strength ofgearcoupling is veryhigh. Mostcompact coupling forhigh power transmission.

32. What is a flange coupling? What are the different types of flange coupling?

Flange coupling is a coupling having two separate cast iron flanges. Each flange is mounted on the shaft end and keyed to it. The faces are turned up at right angles to the axis of shaft. One of the flanges has a projected portion and other face has a corresponding recess. This helps to bring the shaft into line and maintain alignment.

The different types of flange coupling are,

a) Unprotected type flange coupling

b) Protected type flange coupling

c) Marine type flange coupling

33. What is the difference between rigid and flexible coupling? (Nov 2016)(Nov 2017)

Rigid coupling	Flexible coupling
It is used to connect two shafts which are perfectly aligned	It is used to connect two shafts having both lateral and angular misalignment.
It is used to join the straight ends of shafts	It is used to join the abutting ends of shafts

34. Differentiate between a cotter joint and a knuckle joint?

Cotter joint is used to connect two rigid rods for transmitting motion without rotation. This joint is subjected to axial forces.Knuckle joint is used for connecting two rods and transmitting axial force. This joint permits a small amount of flexibility.

PART-B & PART-C

1. In an axial flow rotary compressor, the shaft is subjected to maximum twisting moment and maximum bending moment of 1500 Nm and 300 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. **(Nov 2014)**

   Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 331 to 333.

2. 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 rpm. The maximum axial propeller thrust is 500 kN and the shaft weighs 70 kN. Determine (i) The maximum shear stress developed in the shaft and (ii) The angular twist between the bearings. **(Nov 2016)**

   Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 344 to 345.

3. Ahollow shaft is required to transmit 600 kW at 110 rpm, 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 internal diameter to the external diameter is 3/8. Take modulus of rigidity as 84 GPa. **(May 2013)**

   Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 344 to 345.

4. 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 side for each pulley is 2.5:1. The yield strength of the shaft material σ_y = 380 MPa and factor of safety is 3. Estimate the suitable diameter of the shaft. **(Nov 2015)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 331to 333.

5. A shaft is supported by two bearings placed 1100 mm apart. A pulley of diameter 620 mm is keyed at 400 mm to the right of the left hand bearing and this drives a pulley directly below it with a maximum tension of 2.75 kN. Another pulley of diameter 400 mm is placed 200 mm to the left of the right hand bearing and is driven with a motor placed horizontally to the right. The angle of contact of the pulleys is 180o and the coefficient of friction between the belt and the pulleys is 0.3. Find the diameter of the shaft. Assume K_b = 3, K_t= 2.5, S_{yt}= 190 MPa, S_{Ut} = 300 MPa.**(May 2017)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 331 to 333.

6. A 600 mm diameter driven by a horizontal belt transmits power through a solid shaft to a 262 mm diameter pinion which drives a mating 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 (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. **(Nov 2017)**

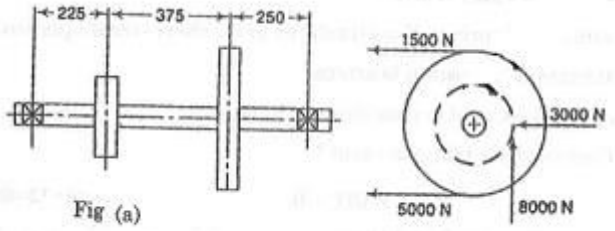


Fig (a)

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 331to 333.

7. 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 = 0.3MPa. **(Nov 2015) (May 2014)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 371 to 373.

8. (i) 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 (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. **(May 2015, May 2017)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 357 to 358.

(ii) It is required to design square key for fixing a gear on a shaft of 30 mm diameter. The shaft is transmitting 20 kW power at 600 rpm to the gear. The key is made of steel 50C4 (S_{yt} = 460 N/mm^2) and the factor of safety is 4. For key material, the yield strength in compression can be assumed to be equal

to the yield strength in tension. Determine the dimensions of the key. **(May 2015)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 350 to 351.

9. It is required to design square key for fixing a gear on a shaft of 30 mm diameter. The shaft is transmitting 20 kW power at 600 rpm to the gear. The key is made of steel 50C4 (Syt = 460 N/mm^2) and the factor of safety is 4. For key material, the yield strength in compression can be assumed to be equal to the yield strength in tension. Determine the dimensions of the key.**(Nov 2017)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 350to 351.

10. Design a rectangular key for the following application: A shaft 65 mm diameter transmits power at maximum shear stress of 67 MPa. The shear stress in the key should not exceed 75% of the stress developed in the shaft. The key should be at least 2.5 times strong in crushing compared to shear failure of the key.**(May 2017)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No351.

11. A shaft made of AISI 1030 cold drawn steel (σ_u = 520 MPa and σ_y = 440 MPa) transmits 50 kW at 900 rpm through a gear. Select an appropriate square key for the gear. **(Nov 2017)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 350to 351.

12. A rigid coupling is used to transmit 60kW at 350 rpm. There are six bolts. The outer diameter of the flanges is 250 mm, while the recess diameter is 175 mm. The coefficient of friction between the flanges is 0.15. 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. **(May 2015)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 364 to 366.

13. 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^o in a length of 20 meters. The allowable shear stress in the coupling bolt is 30 MPa. Take G = 84 kN/mm^2. **(Nov 2014) (May 2016)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 364 to 366.

UNIT III TEMPORARY AND PERMANENT JOINTS

Threaded fasteners - Bolted joints including eccentric loading, Knuckle joints, Cotter joints – Welded joints, riveted joints for structures - theory of bonded joints.

PART-A

1. What are stresses that act on screw fastening?

Stresses that act on screw fastening are,

- initial stresses due to screwing up

- stresses due to external forces.
- Combined stresses

2. Give some examples for temporary joints and permanent joints?

Some examples for temporary joints and permanent joints are,

Permanent joints – Riveted joints, Welded joints, bonded joints

Temporary joints – Threaded joints, cotter joints, knuckle joints.

3. State there conditions where tap bolts are used. (Nov 2010)

a. One of the parts being joined has enough thickness to accommodate a threaded hole.

b. Insufficient space for a nut.

c. Material is strong enough so that the threads have long life.

4. What do you understand by the single start and double start threads? (Nov 2011)

Single-start means that there is only one "ridge" wrapped around the cylinder of the screw's body. Each time that the screw's body rotates one turn (360^o), it has advanced axially by the one pitch advance. "Double-start" means that there are two "ridges" wrapped around the cylinder of the screw's body. Each time that the screw's body rotates one turn (360^o), it has advanced axially by the two pitch distance.

5. Define the term self-locking of power. (Nov 2012)

If the friction angle (φ) is greater than helix angle (α) of the power screw, the torque required 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. The efficiency of the self-locking screw is less than 50%.

6. What is a stud?

A stud is a boltin which thehead is replaced byathreadedend.It passes through oneof theparts to be connected andis screwed into the other part.

7. Howis a bolt designated?Give example.

A thread is designatedwith Letter M followed by Nominal diameter in mm and Pitch in mm[for fine pitches only] Md×pIfcoarsepitchesareusedthen P valueis omitted. Thus M20×2.5 means, Nominal diameteris 20mm 2.5mmpitch, finethread. M20 means, 20mm nominal diameterwith coarsethreads.

8. Why are ACME threads preferred over square thread for power screw? (Nov 2014)

ACME threads are stronger than the square thread. These threads are frequently used on screw cutting lathes, brass valves, cocks and bench vices.

9. What are the essential stresses induced due to screwing up forces?

- The initial stresses induced due to screwing up forces are,
- Tensile stresses dye to stretching of bolt
- Torsional shear stress caused by frictional resistance of threads during its tightening

- Shear stress across threads
- Compression or crushing stress on threads

10. What is bolt of uniform strength? What are the ways to produce bolts of uniform strength?

A bolt of uniform strength has equal strength at the thread and shank position. The ways to produce bolts of uniform strength are:

- Reducing shank diameter equal to root diameter
- Drilling axial holes

11. Statethe advantages ofthreaded joints?

- High clamping
- Small tighteningforcerequirement
- Easymanufacturing
- Simple design

12. What are the different applications of screwed fasteners? (Nov 2016)

The helical thread screw is the basis of power screws which change angular motion into linear motion to transmit power or to develop larger forces (presses, jacks, etc).

13. Determine the safe tensile load for a bolt of M20, Assume a safe tensile stress of 40 Mpa?

From PSGDB 5.42, for M20,

Stress area $A_c = 245$ mm^2,

$\sigma = P / A_c \Rightarrow P = \sigma A_c = 40 \times 245 = 9800$ N.

14. What is known as proof load in bolts? (Nov 2017)

The proof load is the maximum load (force) that a bolt can withstand withoutacquiring a permanent set. The proof strength is the quotient of the proof load andthe tensile-stress area.

15. What are the types of cotter joint?

1.Socket and Spigot 2.Sleeve and cotter 3.Gib and Cotter joints.

16. What is a gib? Why is it provided in a cotter joint?

A gib is an element made up of mild steel with thickness equal to the cotter. A gib is used in combination with cotter to provide the following advantages.

(i) Reduce bending of socket end

(ii) Increasing the bearing area of contact between the mating surfaces.

17. Differentiate between a cotter joint and a knuckle joint?

Cotter joint is used to connect two rigid rods for transmitting motion without rotation. This joint is subjected to axial forces.Knuckle joint is used for connecting two rods and transmitting axial force. This joint permits a small amount of flexibility.

18. List the advantages of cotter joint over threaded joints. (May 2017)

A cotter joint is a temporary fasteningand is used to connect rigidly two co-axial rods or barswhich are subjected to axial tensile or compressive forces.

The main disadvantage of the screwed joints is the stressconcentration in the threaded portions which are vulnerable points under variable load conditions.

19. Classify the rivet heads according to IS specifications. (Nov 2011)

According to Indian standard specifications, the rivet heads are classified into the following three types:

a) Rivet heads for general purposes (below 12 mm diameter) according to IS : 2155 – 1982 (Reaffirmed 1996)

b) Rivet heads for general purposes (From 12 mm to 48 mm diameter), according to IS: 1929 – 1982 (Reaffirmed 1996)

c) Rivet heads for boiler work (from 12 mm to 48 mm diameter), according to IS : 1928 – 1961 (Reaffirmed 1996).

20. What are the possible modes of failure of riveted joint? (Nov 2012)

(i) Crushing of rivets

(ii) Shear of rivets

(iii) Tearing of the plate at the edge

(iv) Tearing of the plate between rivets.

21. What is a rivet? What arethe differentworkingprocesses usedformakingriveting?

A rivet is a round bar provided with ahead on oneside and atail on the otherside. The working processes used are:

- Cold riveting
- hot riveting

22. Name thepossible modes of failureof riveting joint.

- Crushingof rivets
- Shear of rivets
- Tearingof theplate at the edge
- Tearingof theplate between rivets.

23. Definewelding? Whyare welded jointspreferred over riveted joints?(Nov 2010)

Weldingcan bedefinedas a process of joiningtwo similaror dissimilar metals with or without application ofpressurealongwith or without addition of filler material.

Material is saved in welded joints andhencethe machine element willbe light if welded joints areusedinstead of riveted joints.Leak proofjoints can be easily obtained bywelded joints compared riveted

joints.

24. What arethe types ofwelded joints?

- Buttjoints
- Lap joints
- T joints
- Corner joints
- Edgejoints

25. Definebuttand lap joint?

Buttjoint is madebyweldingthe endsor edges oftwo plates. Lap joint is madebytwo plates areoverlappingeach other fora certain distance. Then it is welded. Such weldingis called fillet weld.

26. What is the total shear in a double strap butt joint with equal length of straps? (Nov 2015)

In a double strap butt joint, the edges of the main platesbutt against each other and two cover plates are placed onboth sides of the main plates and then riveted together.

27. DefineTeejoint and corner joint?

T joint:the two plates arearranged in shapewhich means theplates are located at right angles toeach other.

Corner weld:Twoplates arearranged at right angles such that it forms anangle.

28. When willthe edgepreparation need?

Ifthe two plates to bewelded havemorethan 6mmthickness, the edge preparation should be carried out.

29. What is the minimumsize for fillet weld?If therequired weld size from strength consideration is too smallhow willyou fulfilthecondition of minimum weld size?

It is the defined as the minimum sizeof theweld foragiven thickness of the thinnerpart joined orplateto avoid cold crackingbyescapingthe rapidcooling.

30. Why throat is considered while calculating stresses in fillet welds? (May 2017)

The minimum area of the weld is obtained at the throat, which is givenby the product of the throat thickness and length of weld.

31. When willthe weld deposit beweaker?

When the components aremadeof high carbonsteel or alloysteel, the weld becomesweaker.

32. What is the bending stress induced in a 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? (Nov 2015)

Bending stress $\sigma_{bmax} = 5.66\ M / \pi\ s\ d^2 N/mm^2$

33. State the two types of eccentric welded connections. (Nov 2016) (Nov 2013)

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

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

(iii) Welded connections subjected to direct shear, bending and torsional loads.

34. Define circumferential joint.

The ends of theplates arejoined to the required length of theshell andtoclose its ends.

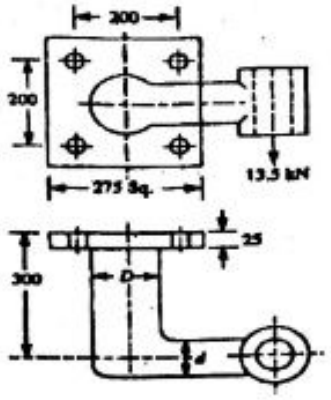
35. State the disadvantages of welded joints? (Nov 2017)

(i) Since there is an uneven heating and cooling during fabrication, therefore the membersmay get distorted or additional stresses may develop.

(ii) It requires a highly skilled labour and supervision.

PART-B& PART-C

1. Figure 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. Estimate the tensile load on each top bolt and the maximum shearing force on each bolt. Find the bolt size, if permissible stress is 65 MPa in shear. All dimensions in mm. **(Nov 2016)**



Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 236 to 237.

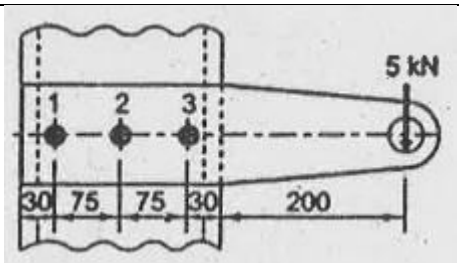
2. A steel bolt of M16x2 is 300 mm long carries an impact load of 500 Nm. If the threads stop adjacent to the Nut and E = 2.1 x 10^5MPa. (i) Find the stress in the root area (ii) Find the stress if the shank area is reduced to root area. **(Nov 2014)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 238 to 239.

3. A steam engine cylinder of 30 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. **(Nov 2015)**

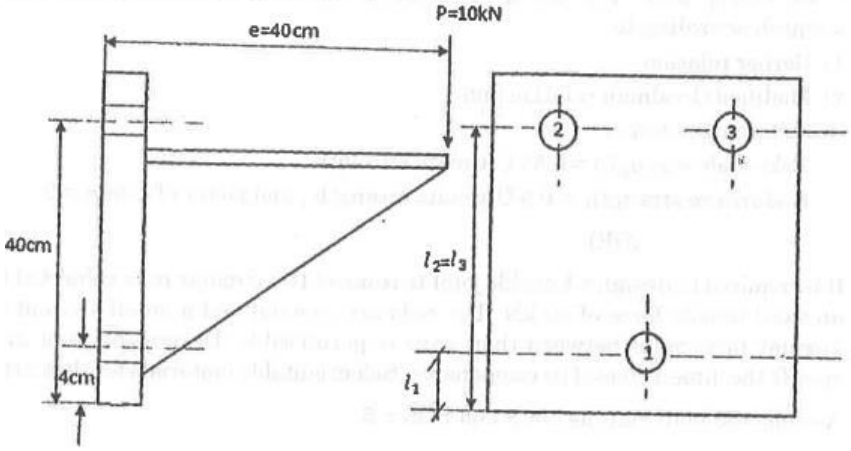
Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 248 to 249.

4. A steel plate is subjected to a force of 5 kN and fixed to a channel by means of three identical bolts as shown in Fig. The bolts are made of from 50C8 steel (S_{yt} = 380 N/mm^2) and the factor of safety is 3. Specify the size of the bolts. **(May 2017)**



Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 233 to 235.

5. Fig 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. **(Nov 2017)**



Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 237 to 238.

6. Design a knuckle joint to withstand a load of 100 kN. All the parts of the joint are made of the same material of the same material with $\sigma_{ut}=\sigma_{uc}$= 480 MPa, and τ_u= 360 MPa. Use factor of safety of 6 on Ultimate strength. **(Nov 2015)**

Refer: "Joseph Shigley, Charles Mischke, Richard Budynas and Keith Nisbett "Mechanical Engineering Design", 8th Edition, Tata McGraw-Hill, 2008", Page No 129.

7. 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. **(Nov 2017)**

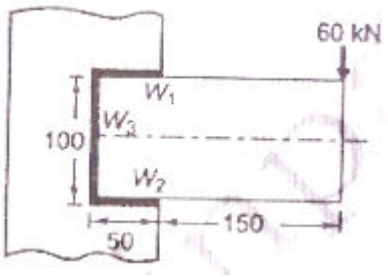
Refer: "Joseph Shigley, Charles Mischke, Richard Budynas and Keith Nisbett "Mechanical Engineering Design", 8th Edition, Tata McGraw-Hill, 2008", Page No 129.

8. Design a double riveted butt joint with two cover plates for the longitudinal steam of a boiler shell 1.5 m in diameter subjected to a steam pressure of 0.95 N/mm^2. Assume joint efficiency as 75%, allowable tensile stress in the plate 90 MPa; compressive stress140 MPa and shear stress in the rivet 56 MPa. **(Nov 2016)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010",

Page No from 318 to 320.

9. A welded connection, as shown below is subjected to an eccentric force of 60 kN in the plane of welds. Determine the size of the welds, if the permissible shear stress for the weld is 90 N/mm^2. Assume static conditions. **(May 2015)**

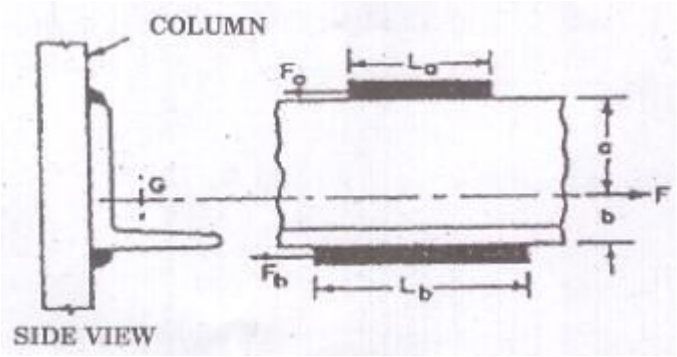


Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 285 to 287.

10. (i) A butt welded joint with ground and flush surface is subjected to tensile load which varies from 50 kN to 100 kN. Plates are 10 mm thick. Determine the length of weld required for over 2,500,000 cycles. **(May 2015)**

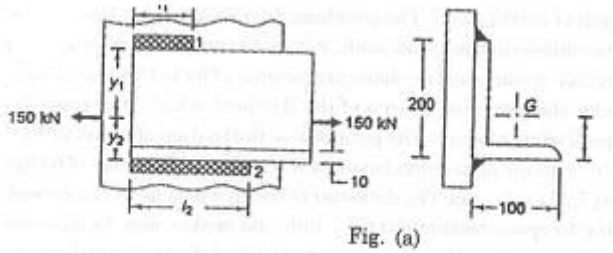
Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 296 to 297.

(ii) The fig below shows an angle welded to a column and carries a static load F as shown. Determine the ratio of the weld lengths L_a and L_b and F_a and F_b in terms of F. **(May 2015)**



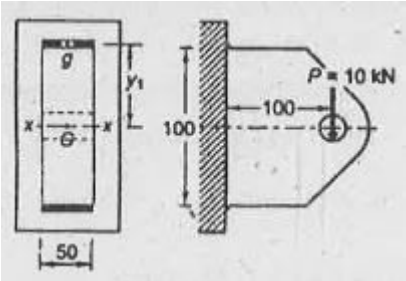
Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No 284.

11. An ISA 200 x 100 x 100 angle is welded to a steel plate by means of fillet welds as shown in Fig (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. **(Nov 2017)**



Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 284 to 285.

12. 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 N/mm^2. **(May 2017)**



Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 294 to 295.

13. A cylindrical beam of size 60 mm is attached to support by a complete circumferential fillet weld of 6 mm. Find (i) torque and (ii) bending moment that can be applied if limiting shear stress is 140 MPa. **(Nov 2014)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 295 to 296.

UNIT IV ENERGY STORING ELEMENTS AND ENGINE COMPONENTS

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.

PART-A

1. What is spring and where it is employed?

A spring is an elastic body, which distorts when loading and recover its original shape when the load is removed. It finds application in many places such as automobiles, railway wagons, brakes, clutches, watches and so on.

2. By what materials the springs can be made?

Springs are made of oil tempered carbon steel containing 0.6 to 0.7% carbon and 0.6 to 1% manganese. Phosper bronze, monel metal, beryllium copper are used for special purpose.

3. Define (a) spring index (b) spring rate. (Nov 2011)

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

Stiffness, q = Load / Deflection = P / y.

4. Write the formula for natural frequency of spring. (Nov 2012)

$$f_n = \frac{d}{2\pi D^2 . n}\sqrt{\frac{6\,G.g}{\rho}} \text{ cycles/s}$$

Where d = Diameter of the wire,

D = Mean diameter of the spring,

n = Number of active turns,

G = Modulus of rigidity,

g = Acceleration due to gravity, and

ρ = Density of the material of the spring.

5. What is the effect of increase in wire diameter on the allowable stress value? (Nov 2010)

The direct shear stress is α $(1/d^2)$ and torsional shear stress is α $(1/d^3)$. Hence, increase in wire diameter reduces the allowable stress value.

6. State anytwofunction ofsprings. (Nov 2016)

a. To measureforces in springbalancemeters andengine indicators

b. To store energy

7. What arethe various types ofsprings?

(i) helical spring

(ii) spiral spring

(iii) leaf spring

8. Howwillyoufindwhetherthegivenhelicalspringisacompressionspringor tension spring? (or) Distinguish between close coiled and open coiled springs. (Nov 2014)

Endsofcompressionspringsareflatwhereasfortensionspringshooks willbeprovidedattheends.Coilwillbeslightly opentocompressionina compression springs whereas in tension springcoil areveryclose. Compressive or tensile stresses in helical compression spring and both tensile and compressive stresses in case of torsional spring are due to bending.

9. Whatareconical springs?

It is madeof round wirewound in the shapeofcone.

10. What are the purposes of composite springs?

a)To obtain greater spring force within a given space.

b)To ensure the operation of a mechanism in the event of failure of one of the springs.

11. What are torsion springs?

Torsion springs may be of helical or spiral type.The helical type may be used only in applications where the load tends to wind-up the spring and are used in various electrical mechanisms. The spiral type is also used where the load tends to increase the number of coils and when made of flat strips are used in watches and

clocks.

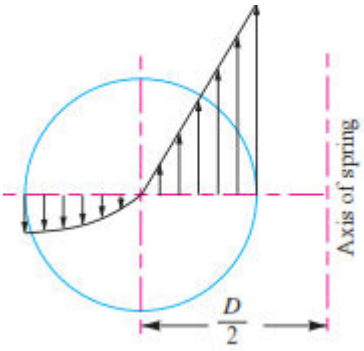
12. How the stiffness of the spring can be increased?

The stiffness of the spring can be increased by decreasing the number of turns.

13. What are the advantages of leaf springs over helical springs?

Leaf springs are made out of flat plates.The advantages of leaf spring over the helical spring is that the end of the spring may be guided along a defined path as it deflects to act as a structural member in addition to energy absorbing device.

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



Maximum shear stress induced in the wire,

$$\tau = K \times \frac{8\,W.D}{\pi\,d^3} = K \times \frac{8\,W.C}{\pi\,d^2}$$

$$K = \frac{4C-1}{4C-4} + \frac{0.615}{C}$$

where

15. While designing helical springs, K is introduced in the shear stress equation, why? (Nov 2017)

In order to consider the effects of both direct shear as well as curvature of the wire, a Wahl'sstress factor (K) introduced by A.M. Wahl may be used.

16. What are activecoils?

Those coils which are freeto deflect under loadcalled active coil.

17. Whatarethe endconditionsofthe spring?

(i) plain end

(ii) plain and ground end

(iii) squared end

(iv) Squaredandgroundend.

18. What is flywheel? Whatis the applicationof flywheel?

Fly wheelisamachineelementusedtominimizethefluctuationofspeed in an engine. In some cases the power is supplied at uniform rate. While the requirement ofpowerfromthedrivenmachinery

isvariable.Eg:punchingpress drivenby theelectricmotor,rollingmilldrivenbyanelectricmotor.Inthiscasethe flywheel storeenergyduring the idleportion oftheworkcyclebyincreasingits speed and delivers this energy.Duringthepeak load period ofpunching.

19. What type of stresses is produced in a disc flywheel? (Nov 2010)

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

20. What is the main function of a flywheel in an engine? (Nov 2013) (Nov 2015)

A flywheel is a heavy rotating mass which is placed between the power source and the driven member to act as a reservoir of energy. The primary function of flywheel is to act an 'energy accumulator'. It will absorb energy when demand is less than the supply of energy and will release it when the demand is more than the energy being supplied.

21. State anytwo typeof flywheel.

(i) Disctype
(ii) Web type.

22. What is flywheeleffect?

Themassmomentofinertiarequiredforthefly wheelistermedas flywheel effect.

23. Define coefficient of fluctuation of speed in thecaseof flywheel? Definethe term fluctuation of energy. (Nov 2014)

Coefficientoffluctuationofspeedistheratioofmaximumchangeof speed to mean speed of the flywheel. Theratiooffluctuationofenergytothemeanenergyiscalledcoefficient of fluctuation of energy.

24. What arethe stresses induced in flywheels arms?

(i) tensilestress due to centrifugalforce
(ii) bendingstress due to torque
(iii)stress due to belttension

25. Howdoes the function of flywheel differfrom that ofgovernor? (Nov 2016)

A governor regulates the mean speed of an engine when there are variationsinthemeanloads.Itautomatically controlsthesupply ofworkingfluidto engine withthevaryingloadconditionandkeepsthe meanspeedwithinthe limits.It doesnotcontrolthespeedvariationcaused by thevaryingload.Aflywheeldoesnot maintain constant speed.

26. Brief why flywheels are used in punching machines. (Nov 2017)

In machines where the operation is intermittent like punching machines, shearing machines,riveting

machines, crushers etc., the flywheel stores energy from the power source during the greaterportion of the operating cycle and gives it up during a small period of the cycle. Thus the energy fromthe power source to the machines is supplied practically at a constant rate throughout the operation.

27. At what angle of the crank the twisting moment is maximum in the crankshaft? (Nov 2011)

The crank angle for maximum twisting moment usually lies between 25^o and 35^o from TDC for petrol engines and between 30^o and 40^o for diesel engines.

28. Why is piston end of a connecting rod kept smaller than the crank pin end? (Nov 2010)

The piston end of the connecting rod experiences less bending moment than the crack end. Hence, on the basis of 'beam of uniform strength', the piston end of the performance & life.

29. Under what force, the big end bolts and caps are designed? (Nov 2011)

The big end bolts and caps are designed for inertia (F_i) force due to reciprocating parts.

30. What are functions ofcrankshafts? Classifycrankshafts.

Crankshafts areusedto convent lotterymotion into reciprocatingmotion. Two types are:

Single throw crankshafts and Multithrow crankshafts.

31. What is a connecting rod? What are materials used for connecting rod?

Connecting rod is a machine member, which used to transmit power from a reciprocating member to rotary one or vice versa.Mild steel and alloy of aluminium for light duty. Alloy steels of molybdenum and chromium are used for heavy duty.

32. What are the stresses set up in an IC engine connecting rod? Why I- section is chosen for the connecting rod?

Types of stresses are: Tensile stress, Compressive stress and Bending stress due to inertia force.The "I" section of the connecting rod is used due to its lightness and to keep the inertia forces as low as possible. It can also with stand high gas pressure.

33. What type of external forces act on connecting rod?(May 2017)

- The external forces acting on connecting rod are Forces due to gas or steam pressure and inertia of reciprocating parts
- Inertia forces.

PART-B& PART-C

1. Designaleafspringforthefollowingspecifications for a truck: Assume FOS = 2. Maximum load on springs =100kN;Number ofsprings=4; Material of springs = Cr Va Steel (σ_u = 1380 MPa and E = 206 x 10^3MPa); Spanofthe spring =1000mm; Width of central ban = 150 mm; Permissibledeflection=100mm. Assume 2 full length leaves and 6 graduated leaves. **(May 2015)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010",

	Page No from 437 to 438.
2.	Design of helical compression spring to sustain an axial load of 4 kN. The deflection is 80 mm. Spring index is 6. The shear stress is not to exceed 350 MPa. Rigidity modulus for spring material is 81 GPa. **(May 2015)** *Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 407 to 408.*
3.	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 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. **(Nov 2015)** *Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 413 to 415.*
4.	A spring loaded safety valve for a boiler is required to blow off at a pressure of 0.8 MPa. The diameter 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.**(Nov 2017)** *Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 417 to 418.*
5.	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. **(Nov 2015)** *Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 760 to 761.*
6.	Design a closed coil 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. **(Nov 2014)** *Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 419 to 420.*
7.	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 750 N/mm^2. Due to space limitations, the outer diameter of the spring should not exceed 42 mm. The spring is to be designed for minimum weight. Calculate the wire diameter and the mean coil diameter of the spring. **(May 2017)** *Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 407 to 408.*
8.	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. **(Nov 2014)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 758 to 759.

9. The areas of the turning moment diagram for one revolution of a multicylinder 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^2. The scale for abscissa and ordinate are : 1 mm = 2.4° and 1 mm = 650 Nm respectively. The main speed is 300 rpm with a percentage of 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 material may be taken as 7200 kg/m^3. Neglect the effect of the boss and arms. **(Nov 2016)(May 2014)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 764 to 765.

10. A punching machine carries out punching 10 holes per minute. Each hole of 36 mm diameter in 16 mm thick plate requires 7 N-m of energy/mm^2 of the sheared area. The punch has a stroke of 90 mm. Determine the power of the motor required to operate the machine.

If the total fluctuation of speed is not to exceed 2.5% of the mean speed; determine the mass of the flywheel. The mean speed of the flywheel is 15 m/s.**(May 2017)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 763 to 764.

11. A punching machine makes 25 workings stokes per minute and is capable of punching 25 mm diameter holes in 18 mm thick steel plates having ultimate shear strength of 3000 kg/cm2. 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/cm2 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. **(Nov 2017)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 761 to 762.

UNIT V BEARINGS

Sliding contact and rolling contact bearings - Hydrodynamic journal bearings, Sommerfeld Number, Raimondi and Boyd graphs, -- Selection of Rolling Contact bearings.

PART-A

1. What is bearing?

Bearingis a stationarymachine element which supports a rotatingshafts or axles and confines its motion.

2. Classify the types of bearings. (Nov 2016)

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

a) Radial bearing b) Thrust bearings

ii) Depending upon the nature of contact

a) Sliding contact b) Rolling contact or Antifriction

3. What type of bearings can take axial load? (Nov 2017)

An angular contact bearing is shown in Fig have one side of the outer race cut away to permit the insertion of more balls than in a deep groovebearing but without having a notch cut into both races. This permits the bearing to carry a relativelylarge axial load in one direction while also carrying a relatively large radial load.

4. Statethe components of rollingcontact bearings?

- Outer race
- Inner race
- Rollingelement
- Retainingcage

5. What are anti-friction bearings? (May 2017)

In rolling contact bearings, the contact between thebearing surfaces is rolling instead of sliding as in sliding contact bearings. A rolling contact bearinghas a low starting frictionover a sliding bearing.Due to this low friction offered by rolling contact bearings,these are called antifriction bearings.

6. Give an example for anti-friction bearing? (Nov 2015)

In an antifriction bearing, the main relative motion is rolling. A follower may either rollor slide on the cam. Gear teeth mate with each other by a combination of rolling andsliding. Pistons slide within their cylinders. All these applications require lubrication toreduce friction, wear, and heating.

7. Classifythe roller bearings?

- Cylinder roller bearings
- Needle roller bearing
- Taper roller bearing

8. Listanyfour advantages to rollingcontact bearings over slidingcontact bearings?

- Startingfriction is low
- Lubrication is simple
- It requires lessaxial space and morediametric space
- Heavierloads and higherspeeds arepermissible

9. What is meant by life of an individual (or antifriction) bearing? (May 2013)

For an individual rolling bearing, the number of revolutions which one of the bearing rings (or washers) makes in relation to the other rings (or washers) under the prevailing working conditions before the first evidence of fatigue develops in the material of one of the rings (or washers) or rolling elements. In other words, the life of bearings is expressed as statistical life. The rating life of a group of identical bearings is defined as the number of revolutions or hours at some constant speed that 90%. According to Wiebull, the relation between the bearing life and the reliability,

$$\frac{L}{L_{90}} = \left[\frac{\log_e (1/R)}{\log_e (1/R_{90})}\right]^{1/b} \quad \ldots (\because b = 1.17)$$

10. Define the term Reliability of a bearing. (Nov 2016)

Reliability is defined as the ratio of the number of bearings which have successfully completed L million revolutions to the total number of bearings under test. Sometimes it becomes necessary to select a bearing having a reliability of more than 90% of a group of identical bearing, will complete or exceed before the first evidence of fatigue failure occurs.

11. What are the types of radial ball bearings? (May 2012)

i) Deep grove ball bearing
ii) Self-aligning ball bearing
iii) Angular contact ball bearing
iv) Filling notch bearing
v) Double row bearing.

12. Statethe advantages ofthrust ball bearing?

- High initial cost
- Lesscapacityto withstand shock
- Noisyoperation at veryhigh speed
- Lifeis finite
- Design of bearinghousingis complicated

13. List the basic assumptions used in the theory of hydrodynamic lubrication. (Nov 2011)

The theory of hydrodynamic lubrication is based on Reynolds equation which is based on the following assumptions:

a. Ignore the body forces such as gravity force, magnetic force, and so on.
b. There is non-slip on the interface between solid and liquid.
c. Across the film thickness, ignore the variations of pressure.
d. The film thickness compared to the radius of the bearing surface can be ignored. Therefore, linear

velocity is used to calculate instead of rotational speed to neglect speed to neglect the influence of film curvature.

e. Lubricants are Newtonian.
f. The flow is laminar and it is not a boundary layer or turbulence.
g. Compared to the viscous force, the inertia force can be ignored, including the acceleration force and centrifugal force.
h. Across the lubricant film thickness, viscosity remains unchanged.

14. List the advantages of hydrostatic bearings? (Nov 2017)

The hydrostatic bearings are thosewhich can support steady loads without any relative motion between the journal and the bearing.This is achieved by forcing externally pressurized lubricant between the members.

15. What is load rating?

Theload carryingcapacityofa rolling element bearingiscalled load rating.

16. Define the term bearing life.

The life of a radial ball bearing is the number of revolutions or hours at a given constant speed that the bearing runs before the first evidence of fatigue develops in the material of either ring or in a ball.

17. 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 diameter.

18. Explain the term Dynamicload carrying capacities of rollingcontact bearing? (Nov 2012)

Dynamicload ratingis defined as theradial load in radial bearings that can becarried foraminimum lifeof onemillion revolutions.

19. Listanysix types of bearingmaterials?

- Lead basebabbit
- Tin basebabbit
- Leaded bronze
- Copper lead alloy
- Gun metal
- Phosphor bronze

20. What are the required properties of bearing materials?

i) High compressive strength
ii) Low coefficient of friction
iii) High thermal conductivity
iv) High resistance to corrosion

v) Sufficient fatigue strength

vi) It should be soft with a low modulus of elasticity

vii) Bearing materials should not get weld easily to the journal material.

21. What is the advantageofTeflon which is usedforbearings?

Teflon has high fatiguestrength, hardness andmore resistant to abrasive.

22. What is journal bearing? (May 2013)

A journal bearingis a slidingcontact bearing which gives lateral support to the rotatingshaft.

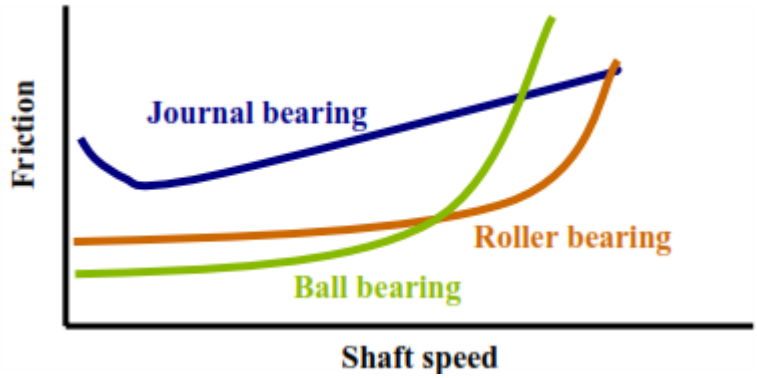
23. What aretypes of journal bearings dependingupon the natureofcontact?

- Fulljournal bearing
- Partial bearing
- Fitted bearing

24. What arethe types ofjournal bearingdependingupon the natureof lubrication? (or) Classify the sliding contact bearings according to the thickness of the layer of the lubricant between the bearing and the journal. (May 2012)

- Thick film type
- Thin filmtype
- Hydrostaticbearings
- Hydrodynamicbearing

25. Plot the friction induced in various bearings based on shaft speed. (May 2017)



It isobserved that for the lower shaft speeds the journal bearing have more frictionthan roller and ball bearing and ball bearing friction being the lowest. For thisreason, the ball bearings and roller bearings are also called as anti-frictionbearings. However, with the increase of shaft speed the friction in the ball and roller bearing phenomenally increases but the journal bearing friction is relativelylower than both of them. Hence, it is advantageous to use ball bearing and roller bearing at low speeds. Journal bearings are mostly suited for high speeds andhigh loads.

26. For a journal bearing, the maximum operating temperature must be less than 80°c. Why? (Nov 2010)

Temperature rise will result in the reduction of the viscosity of the oil used in the bearing. This would lead to metal to metal contact, thereby affecting the bearing performance & life.

27. In hydrodynamic bearing, what are factors which influence the formation of wedge fluid film? (Nov 2014)

In hydrodynamic bearing, there is a thick film of lubricantbetween the journal and the bearing. A pressure is buildup in the clearance space when the journal is rotatingabout an axis that is eccentric with the bearing axis.The load can be supported by this fluid pressure withoutany actual contact between the journal and bearing. The load supporting pressure in hydrodynamicbearings arises from either1. the flow of a viscous fluid in a converging channel (known as wedge film lubrication), or2. the resistance of a viscous fluid to being squeezed out from between approaching surfaces(known as squeeze film lubrication).

28. What is meant by square journal bearing? (Nov 2015)

The length to diameter ratio for square journal bearing is 1.

29. What is sommerfeld number? State its importance in the design of journal bearing? (May 2015)

Sommerfeld number is a dimensionless bearing characteristic number. $\text{Sommerfeld number} = \frac{ZN}{p}\left(\frac{d}{c}\right)^2$

Z = Absolute viscosity of the lubricant, in kg / m-s,
N = Speed of the journal in r.p.m.,
p = Bearing pressure on the projected bearing area in N/mm^2,
= Load on the journal ÷ $l \times d$
d = Diameter of the journal,
l = Length of the bearing, and
c = Diametral clearance.

30. What is self-aligning ball bearing? State its unique feature. (May 2015)

Self-aligning ball bearing has two rows of balls and a common sphered raceway in the outer ring. The bearings are insensitive to angular misalignment of the shaft relative to the housing.

31. What is critical pressure?

The minimum operating pressure known as “critical pressure” is the pressure at which the oil film breaks down and metal-to-metal contact begins.

32. What is known as self-actingbearing?

Thepressure is created within thesystem due to rotation of theshaft known as self-actingbearing.

33. What areseals?Whatarethe main types of seals?

Seals andgaskets areelements used to control orprevent leakagefrom a controlled environment. Typesarestaticseals, dynamicseals

34. What are the essential requirements in an end face seal? (Nov 2013)

i) Surfaces of the seals (stationary and rotating) should be polished and perfectly flat.

ii) Seal faces must be perpendicular to the shaft.

iii) Spring force should be sufficient to hold the sea faces in contact.

iv) No friction between shaft and seal parts.

35. Howis "O" ringdesignated?

An "O"ringis designated as "internal diameter×thickness".

PART-B& PART-C

1. Enumerate the detail steps involved in the selection of bearings from the manufacturer's catalogue. **(May 2015)**
   Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 573 to 575.
2. Design a journal bearing for 12 MW, 1000 rpm steam turbine, which is supported by two bearings. Take the atmospheric temperatures as 60^{o}C. Assume viscosity of oil as 23 centistokes. **(Nov 2016)**
   Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 629 to 630.
3. Load on a hydrodynamic full journal bearing is 30 kN. The diameter and speed of the shaft are 150 mm and 1200 mm respectively. Diametral clearance 0.2 mm. Sommerfield number is 0.631. L/D ratio 1:1. Calculate temperature rise of oil, quantity of the oil, heat generated and type of oil required. **(May 2015)**
   Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 629 to 630.
4. 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 tolerance is 1000. The bearing is lubricated with oil whose absolute viscosity at the operating temperature of 75^{o}c may be taken as 0.011 kg/m-s. The room temperature is 35^{o}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^{o}c. Take specific heat of the oil as 1850 J/kg/^{o}c. **(Nov 2015)**
   Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 632 to 633.
5. Design a journal bearing for a 49.9 mm diameter journal. It is ground and hardened and is rotating at 1500 rpm in a bearing of diameter and length both 50 mm. The inlet temperature of oil 65^{o}C. Determine max radial load that the journal can carry and power loss. **(May 2017) (Nov 2017)**
   Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 629 to 630.
6. 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 the power lost in friction and increase in the oil temperature. Assume Hg = Hd. Absolute viscosity = 20 x 10^{3}Pas, Sp.Gravity of oil 0.8, Sp.Heat of oil 2.1 kJ/Kg^{o}C**. (Nov 2014)**
   Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 630 to 631.
7. 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. **(Nov 2015)**

Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 582 to 583.

8. A ball bearing is subjected to a radial load of 10 kN and a thrust load of 5 kN. The inner ring rotates at 1000 rpm. The average life is to be 5000 hours. What basic load rating must be used to select a bearing for this purpose? Take $F_a/C_o = 0.5$ and assume service factor 1.5.**(May 2017)**

   Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 584 to 585.

9. 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 rpm. The bearing is required to have a minimum life of 9000 hours. Check whether the bearing selected can serve the purpose. **(Nov 2017)**

   Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 583 to 584.

10. A ball bearing subjected to a radial load of 5 kN is expected to have a life of 8000 hours at 1450 rpm with a reliability of 99%. Calculate the dynamic load capacity of the bearing so that it can be selected from the manufacturer's catalogue based on a reliability of 90%. **(Nov 2016)**

    Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 593 to 594.

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

SL NO	RADIAL LOAD (N)	AXIAL LOAD (N)	% OF TIME
1	3500	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. **(Nov 2014)**

    Refer: "Bhandari V, "Design of Machine Elements", 3rd Edition, Tata McGraw-Hill Book Co, 2010", Page No from 594 to 595.