M.V.S.R. ENGINEERING COLLEGE

Department of Mechanical Engineering

Nadergul, Hyderabad -501510.

QUESTION BANK

Design of Machine Elements

(Code: ME 303)

B.E. (Mechanical Engineering) III year-I Semester

(Code: PC 403 ME)

B.E. (Mechanical Engineering) IV Semester (CBCS)

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DPARTMENT OF MECHANICAL ENGINEERING

CONTENTS

PC 403 ME

DESIGN OF MACHINE ELEMENTS

Instruction	4	Periods per week
Duration of University Examination	3	Hours
University Examination	75	Marks
Sessional	25	Marks

Corse objectives:

1. To understand the basics of mechanics of materials and design of a machine for static and fatigue strength, rigidity and wear criterions, use of codes and standards.
2. To know the principles of ergonomic design and use of theories of failure for safe design.
3. To learn the principles of design of shafts, keys, belt drives, joints and couplings.

UNIT-I

Design considerations of Machine Elements. Materials used in machine design and their specifications according to Indian Standards. Codes and standards used in design. Important mechanical properties of materials used in design. Preferred numbers. Manufacturing considerations in design. Review of types of loads and simple stresses. Stresses due to Biaxal and Triaxal loads. Factor of safety. Theories of failures. Design of components subjected to impact loading.

UNIT-II

Design for Fatigue: Fluctuating stresses, fatigue strength and endurance limit Stress, concentration factor and Notch sensitivity. Factors affecting fatigue strength. S-N diagram, Soderberg and Modified Goodman's diagrams for fatigue design. Cumulative fatigue - Miner's rule.

UNIT-III

Design of shafts: solid, hallow and splined shafts under torsion and bending loads. Design of keys.
Design of couplings: Muff, Split muff, Flange, Flexible, Marine type couplings.

UNIT-IV

Design of Joints: Cotter and Knuckle joints. Design of bolts and nuts, Locking devices for nuts, Bolts of uniform strength. Bolted joints under eccentric loads. Design of gasket joints.
Chain Drives: Design of chain drives
Pulleys: Design of pulleys.

UNIT-V

Design of Screws: Design of power Screws and screw jack. Differential and Compound Screws.
Riveted & Welded Joints: Design of riveted and welded joints under direct and eccentric loads.

Suggested Reading:

1. M.F. Spotts, "*Design of Machine Elements*", Pearson Edu, 7th edn. 2003.
2. V. B. Bhandari, "*Design of Machine Elements*", Tata McGraw-Hill Publ, 3rd Edn. 2010.
3. P.C. Sharma & D.K. Aggarwal, *"Machine Design"*, S.K. Kataria & Sons, 10th edn, 2003.
4. P. Kannaiah, *Machine Design*, Sci-Tech Publ., 2009.
5. J.E. Shigley & Charles R. Mischke "*Mechanical Engineering Design*", Tata McGraw-Hill., 6th ed. 2010.

Department of Mechanical Engineering

Vision:

To provide educational opportunities that will prepare students for productive careers as competent professionals in Mechanical Engineering, and for higher studies and research.

Mission:

The department strives to provide the engineering foundation as well as professional, innovative and leadership skills to the students through the following activities:

1. Laying sound foundation in the areas of mechanics, design, thermal sciences and production processes, as well as allied engineering areas.
2. Enrich the undergraduate experience through experimental learning, and fostering a personalized and supportive environment that makes learning joyful and stimulating
3. Provide opportunities to design mechanical engineering components and systems to meet specific needs through select courses
4. Provide opportunities to develop good communication skills, and to encourage creativity and entrepreneurial skills
5. Create awareness in professional responsibility, ethics, global impact of engineering solutions, and of the need for life-long learning.
6. Providing opportunities for training in the latest automotive technologies and encourage product development.
7. Providing research and intellectual resources to address contemporary and complex problems of industry and to advance research and applications.

Course Outcomes:

At the end of this course, Students would be able to

CO	Outcome	POs	PSOs
C303.1	Identify the elements of design process and select suitable materials for mechanical systems based on its properties and design requirement.	1,2,3,4,5,12	2
C303.2	Apply and appropriate Theories of Failures and design of components subjected to Impact loading.	1,2,3,5	2
C303.3	Understand the influence of fatigue and cumulative fatigue on machine components.	1,2,3,8,12	2
C303.4	Practice design of machine elements like shafts, keys, couplings.	1,2,3,4,8,12	1,2
C303.5	Apply the design principles to design machine components like Power screws, welded joints, riveted joints, bolted joints, knuckle joints under direct and eccentric loads.	1,2,3,8,12	1,2

Program Outcomes:

1. **Engineering Knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **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.
3. **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.
4. **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.
5. **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.
6. **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.
7. **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.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and the 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.
11. **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.
12. **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.

PSO's (Program Specific Outcome):

1. ***Research Potential***: Usage of advanced software packages commonly used in industry for modelling, assembly and to carry out Multiphysics analysis.
2. ***Competent areas***: Design and build components and systems related to mechanical and allied disciplines, using various manufacturing methods.

Unit-I
Design considerations of Machine Elements

Part-A

1) What are various types of loads that machine elements are subjected to and specify the factor of safety uses in each case.
2) Mention various types of Design considerations of machine elements.
3) What are various different manufacturing considerations used in design?
4) Mention various types of criteria considered for the design of machine elements.
5) What are the various phases of design process?
6) What are important mechanical properties of materials used in design?
7) Define the terms (i) Ductility (ii) Malleability (iii) Hardness (iv) rigidity (v) Toughness
8) List the various types of materials used in machine design.
9) Suggest suitable materials used for the following applications also state the reason
   (i) Turbine Blade (ii) Ball Bearing (iii) Helical spring
10) Illustrate the meaning of the following designation of steels with percentage of composition
    (i) FeE230 (ii) 15 Cr 65
11) Write the percentage composition of the following steels.
    (i) 55 C8 (ii) 17 Mn 1 Cr 95
12) Explain how plain carbon steels are designated based on their compositions and tensile strength.
13) How plain carbon steels are classified? Give the carbon percent in each case.
14) Define the terms (i) CODES (ii) STANDARDS used in design.
15) What are preferred numbers? Explain their importance in design.
16) Define load? How loads are classified?
17) What is an impact load? Give examples.
18) Distinguish between gradually applied load, suddenly applied load and an impact load.
19) Sketch the states of stress in biaxial and tri-axial systems of loading.
20) Distinguish yield stress and ultimate stress.
21) Define principal plane and principal stress?
22) Differentiate between induced stresses and allowable stresses.
23) Define factor of safety? What is its importance in design? What are various factors to be considered in deciding the factor of safety?
24) Name various theories of failures and mention their applications.
25) Why normal stress theory is not suitable for ductile materials?
26) Write the equations for factor of safety for various theories of failure.

Part-B

27) A mild steel shaft of 50mm diameter is subjected to a bending moment of 2000 N-m and a torque T. if the yield point of the steel in tension is 200MPa. Find the maximum value of this torque without causing yielding of the shaft according to: (i) Maximum Normal stress theory (ii) Maximum shear stress theory (iii) Distortion Energy theory (iv) Maximum strain energy theory of yielding. **(Dec 2017) (Dec 2016) (Dec 2016 O) (Dec 2011)**
28) A cylindrical shaft made of steel of yield strength 700 MPa is subjected to static loads consisting of bending moment of 10kN-m and a torsional moment 30kN-m. Determine the diameter of the shaft using two different theories of failure, and assuming a factor of safety of 2. Take E = 210 GPa and Poisson's ratio 0.25. **(May 2017) (May 2017 O) (July 2014) (Dec 2012 O)**

29) A machine member of 50mm and 250mm long is supported at one end as a cantilever. The arrangement of load on the member is shown in figure 1. Determine the tensile, compressive and shear stresses at appoint A. **(Dec 2015)**

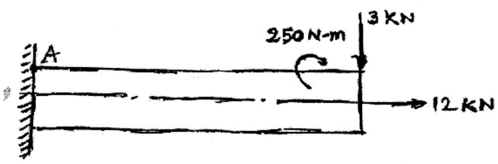


Figure 1

30) A bolt is subjected to an axial force of 10000N with transverse shear force of 5000N. Find the diameter of the bolt required according to all 5 theories of failure. It is assumed that the permissible tensile stress at elastic limit = 100 N/mm^2 and poison's ratio = 0.29 **(June 2016) (Dec 2015) (June 2012)**

31) A rod is subjected to tensile load of 20kN and transverse shear force of 15kN. Suggest suitable of rod according to (i) Maximum Principal stress theory (ii) Maximum shear stress theory Take yield strength in tension as 360MPa and a factor of safety 3. **(June 2015)**

32) (a) With a neat flow chart explain general procedure in machine design.
(b) According to Indian standard specifications, explain the meaning of the following designations used for steels: (i) Fe E 290 (ii) 40C8 **(Dec 2014)**

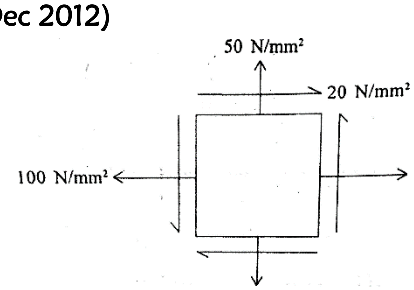
33) A propeller shaft transmits a twisting moment of 100kN-m, and an axial thrust of 250kN. The propeller if fitted very close to the bearing so that the bending effect may be neglected. The external and internal diameters of the shaft are 250mm and 180mm respectively. Determine the maximum values of the compressive and shear stresses. **(June 2013)**

34) At a critical section in a shaft, the following stresses are induced. Bending stress = 60 MPa and torsional shear stress = 40 MPa. Determine the factor of safety, according to i) Maximum normal stress theory ii) Maximum shear stress theory, and iii) Maximum principal strain theory. The proportional limit is a simple tension list is found to be 300 MPa. Take Poisson's ratio as 0.3. **(Nov 2013)**

35) An I-section beam of depth 250 mm and M.I. of 8x10^7 mm^4 is supported 4m apart. It is loaded by a weight of 4 KN through a height of 'h' and striking the beam at mid span. Determine the height of fall if allowable stress of beam material = 120 N/mm^2 and E=210 KN/mm^2.**(Dec 2012)**

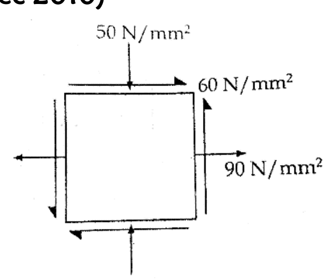
36) The principle stresses induced at a point in a machine component made of steel 50C4 (S_{yt}=460 MPa) are as follows σ_1 = 200 MPa, σ_2 = 150MPa, σ_3 = 0. Calculate the factor of safety by (a) Maximum shear stress theory (b) The distortion energy theory. **(Dec 2012)**

37) For the state of stress at a ppoint of a bi-axially loaded member shown in fig, determine the factor of safety using: (a) Rankine theory (b) Tresca Theory (c) Von Mises criterion. Take the critical stress of the material as 300 N/mm^2. **(June 2011)**



38) A critical section in a shaft is subjected to bending and twisting moment simultaneously. The bending moment causes a maximum bending stress of 31.5 MPa. Determine the factor of safety according to a) Maximum normal stress theory b) Maximum shear stress theory c) Distortion energy theory of tensile test gives a yield limit of 284 MPa. **(July 2010) (Dec 2010)**

39) Consider the state of stress at a point of a bi-axially loaded member as shown in the fig. Determine the principal stresses and calculate the factor of safety using all theories of failure. Take the value of critical stress of the material as 300 N/mm^2. **(Dec 2009)**

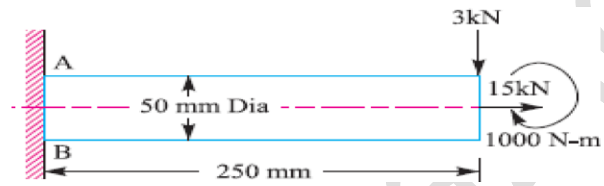


40) A critical section in a shaft is subjected to twisting moment of 20kN-m and bendig moment of 16kn-m. The yield strength of the shaft material is

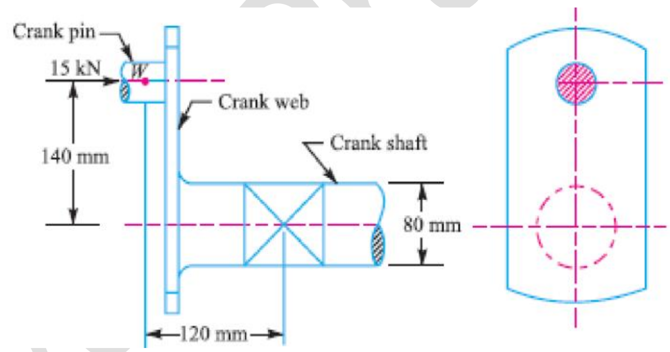
700MPa. Determine the diameter of the shaft according to any three theories of failure. Take factor of safety=3, E=210 GPa and Poisson's ratio 0.25 **(June 2009)**

41) A mass of 600kg falls through a distance 'h' at the middle of a beam of span 4.5m. The end connections of the beam may be considered as simply supported. Determine the value of 'h' such that the maximum induced stresses in the beam does not exceed 160MPa. The modulus of the section of the beam may be taken as 200cm³ and second moment of area as 1000 cm⁴. **(June 2009)**

42) A cylinder bar of 500mm diameter and 250mm long is fixed at one end. At the free end it is loaded as shown in fig. with an axial load of 15kN and a downward transverse load of 5kN and torque of 2kN-m. Calculate the maximum stresses at point 'A' of the bar.



43) An overhang crank with pin and shaft is shown in Fig. a tangential load of 15kN acts on the crank pin. Determine the maximum principal stress and the maximum shear stress at the centre of the crankshaft bearing.



Unit-II
Design for Fatigue

Part-A

1) What are the different types of variable stresses?
2) Write short notes on S-N diagram.
3) What is Miner's rule?
4) Define the terms "equivalent bending moment" and "equivalent twisting moment"?
5) Define "Stress concentration" and "Notch sensitivity"?
6) Explain the following terms in connection with design of machine members subjected to variable loads:
   (a) Endurance limit, (b) Size factor, (c) Surface finish factor, and (d) Notch sensitivity.
7) What is meant by endurance strength of a material? Mentions the factors affecting the endurance strength.
8) What is the difference between standard specimen and actual specimen?
9) How do you estimate endurance limit for actual components (which is not a standard specimen)?
10) Distinguish between fatigue strength and fatigue life?
11) What is endurance limit?
12) What are the factors effects the fatigue strength and what are the methods used to improve fatigue strength?
13) Define form stress concentration factor and fatigue stress concentration factor?
14) What is S-N diagrams? Draw S-N diagram for ductile material from that define endurance limit.
15) What is low and high fatigue cycle?
16) What is meant by 'stress concentration factor'? How do you take it into consideration in case of a component subjected to dynamic loading?
17) Illustrate how the stress concentration in a component can be reduced.
18) Explain how the factor of safety is determined under steady and varying loading by different methods.
19) Write Soderberg's equation and state its application to different type of loadings. What information do you obtain from Soderberg diagram?
20) What is Gerber theory?
21) What id modified goodman diagram?
22)
23) Distinguish between Gerber methods, Goodman method, and Soderberg method adopted for calculating the safe values of fluctuating stresses.
24) Define finite life and infinite life with refence to engineering material subjected to cyclic loads?
25) What is modified Goodman's diagram?

Part-B

26) Determine the diameter of circular rod made of ductile material with fatigue strength σ_e = 265MPa and tensile yield strength of 350MPa. The member is subjected to a varying axial load from W_{min} = -300 X 10^3 N to W_{max} = 700 X 10^3 N and a stress concentration factor = 1.8. use factor of safety = 2. **(Dec 2017) (Dec 2016 O)**
27) A circular bar of 500 mm length is supported freely at its two ends. It is acted upon by a Central concentrated cyclic load having a minimum value of 50kN. Determine the diameter of bar by taking factor of safety of 1.5, size effect of 0.85, surface finish factor of 0.9. The material properties

of bar is given by: Ultimate Strength of 650 MPa, yield strength of 500 MPa and endurance strength of 350MPa. **(May 2017)**

28) A forged steel bar, ϕ50mm in diameter, is subjected to a reverse bending stress of 250 MPa. The bar is made of steel 40C8 (S_{ut} = 600MPa). Calculate the life of the bar for a reliability of 90%. Given K_a = 0.43, K_b = 0.85, K_c = 0.897, K_d = 1.0 **(Dec 2016)**

29) Determine the size of piston rod subjected to a total load having cyclic fluctuations from -150kN to +50 kN. Th endurance limit is 360MPa and yield strength is 400MPa. Given factor of safety 1.5, surface finish factor 0.88. theoretical stress concentration factor K_t = 2.25. **(June 2016)**

30) A steel rod is subjected to reversed axial load of 280 kN. Find the diameter of the rod for a factor of safety 2. Neglect column effect. σ_{ut} = 1070 MPa, σ_{yt} = 910 MPa. In reversed bending, σ_e = 0.5 σ_{ut}. Other factors: K_a = 0.7, K_{sur} = 0.8, K_f = 1.0. **(Dec 2015)**

31) A rod of diameter 40mm is subjected to a variable axial load which varies from 200 to 1000N. if the endurance limit and the yield point of the material are 200 and 350 N/mm^2 respectively. Determine factor of safety. **(July 2015) (Dec 2009)**

32) A simply supported beam has a concentrated load at the center which fluctuates from a value of P to 4P. The span of the beam is 500mm and its cross section is circular with a diameter of 60mm. taking form the beam material an ultimate stress of 70MPa, yield stress of 500MPa, and endurance limit of 330MPa for reverse bending and a factor of safety of 1.3. calculate the maximum value of P. Take a size factor of 0.85 and surface finish factor of 0.9. **(Dec 2014)**

33) A circular bar of 500 mm length is supported freely at its two ends. It is acted upon by a Central concentrated cyclic load having a minimum value of 20kN and a maximum value of 50kN. Determine the diameter of bar by taking factor of safety of 1.5, size effect of 0.85, surface finish factor of 0.9. The material properties of bar is given by: Ultimate Strength of 650 MPa, yield strength of 500 MPa and endurance strength of 350MPa. **(July 2014) (Dec 2011)**

34) A rod of circular cross section is subjected to an alternating tensile force, varying from 20kN to 70kN. Determine the diameter of the rods according to i) Gerber method ii) Goodman method iii) Soderberg method; using the following material properties: ultimate tensile strength = 1000 MPa, Yield strength = 550MPA, take factor of safety as 2. Neglect stress concentration effect and other correction factors. **(Nov 2013)**

35) A steel rod of circular section is subjected to an axal load varying from 20kN to 50kN; as the bending moment varies from 500N-m to 1000N-m. The maximum bending moment and maximum axial load occurs at the same incident. Determine the diameter of the rod using the following. Factor of safety = 2.25, ultimate strength is 560MPa, and yield strength is 220MPa. **(June 2013)**

36) A bar of circular cross section is subjected to alternating tensile force varying from a minimum of 200 KN to a maximum of 500 KN. It is to be manufactured of a material with σ_{ut}= 900 MPa, σ_e = 700 MPa. Determine the diameter of the bar and using FS=3.5 and a stress concentration factor K_f=1.65; Use Goodman criteria and Soderberg criteria for design. **(Dec 2012)**

37) A rod is subjected to a variable tensile load which varies from -300 to 900N. If the endurance limit and the yield point of the material are 200 and 350 N/mm^2 respectively. Determine the diameter of the rod using factor of safety of 3. **(Dec 2012 O) (June 2011)**

38) A leaf spring in an automobile is subjected to cyclic stresses. The mean stress is 150MPa and Amplitude stress is 5MPa. Estimate under what factor of safety the spring is working by

Goodman's and Soderberg considerations? Ultimate strength of the material is 300MPa, yield strength of the material is 200MPa, and endurance limit is 150MPa. **(June 2012)**

39) A shaft is subjected to bending moment that varies from +400N-m to -200N-m and a twisting moment at the critical section varies from 300N-m clockwise to 100N-m counter clockwise also a tensile load of +500 N to -250 N. determine the diameter of the shaft for the following data. Factor of safety = 2, ultimate strength = 560MPa, yield stress = 230MPa, endurance stress = 280MPa. Size correction factor = 0.85, surface correction factor = 0.85, fatigue stress concentration factor = 1.4. **(July 2010) (Dec 2010)**

Unit-III
Design of shafts, Keys and Couplings

Part-A

1) Define shaft and specify the types of the shaft?
2) What is spline shaft? Give example for its application.
3) What is the difference between shaft, axle and spindle?
4) Define equivalent bending moment and equivalent twisting moment?
5) Briefly explain about torsional stiffness of the shaft?
6) Define critical speed of the shaft?
7) What is splined shaft? Explain with neat sketch and mention its applications.
8) Mention the applications of hallow and splined shafts.
9) Among a solid shaft and a hollow shaft of same outer diameter and same material, which shaft is preferred under torsion why?
10) How do you design a shaft when it is subjected to torsion, bending and axial load all together?
11) What factors are to be considered for design of shafts using ASME code? What are the values of those factors for different types of loads?
12) Shafts are subjected to what kind of deformation?
13) What is the function of a key? Classify various types of keys and mention their applications with neat sketches.
14) What is the effect of keyway cut into the shaft?
15) Which of the following keys doesn't require a slot in the shaft? (a) Woodruff key (b) Gib headed key (c) saddle key (d) Kennedy key
16) Why Gib head is provided to a key
17) What is Kennedy key? What is its application?
18) Draw neat sketches of (i) Woodruff key (ii) Saddle key.
19) Define the coupling, state the different types of couplings.
20) What is the purpose of coupling? Give its applications.
21) Differentiate between rigid coupling and flexible coupling? What are their advantages and disadvantages?
22) Mention the application of flexible couplings.
23) Mention the applications of muff and split muff coupling.
24) Distinguish between split muff and flange coupling.
25) Why a flexible coupling is called by that name? Explain with a sketch.

Part-B

26) A steel shaft 1.25 m long, supported between bearings carries 1250 N pulley at its mid-point. The pulley is keyed to the shaft and receives 20 kW at 200 rpm. The belt drive is horizontal and the ratio of the belt tensions is 3:1. The diameter of the pulley is 600 mm. Compute the shaft diameter.
(Dec 2017) (Dec 2016 O) (July 2014)
27) A mild steel shaft transmits 23kW at 200 rpm. It carries a central load of 900N and is simply supported between the bearings 2.5\m apart. Determine the size of the shaft if the allowable shear stress is 42MPa and the maximum tensile or compressive stress is not to exceed 56MPa. What size of the shaft is required if it is subjected to gradually applied loads.
(May 2017) (May 2017 O)

28) A horizontal shaft of 1.2m, long is supported on bearings at its end and transmits 2kW at 1440 rpm. The critical section of the shaft which is at the mid span is subjected to a vertical load of 500N, a horizontal load of 400N. determine the diameter of the shaft for an allowable shear of 50MPa. **(Nov 2016)**

29) An overhung shaft carries a 1m diameter pulley, whose centre is 250mm from the centre of the nearest bearing. The weight of the pulley is 600 N and the angle of lap of the belt may be assumed as 180^0. The pulley is driven by a motor, placed below it, at an angle of 45^0. If the permissible tension in the belt is 2500N and coefficient of friction is 0.3. Determine the size of the shaft. Assume the permissible shear stress in the shaft materials as 50 MPa. Take shock and fatigue factors for torsion and bending as 2 and 1.5 respectively. State the position of the motor so that the size of the shaft required is the least, and also determine its size. **(Nov 2013) (June 2012)**

30) A steel solid shaft transmitting 15kW at 200 r.p.m is supported on two bearings 750mm apart and has two gears keyed to it. The pinion having 30 teeth of 5mm module is located 100mm to the left of the right hand bearing and delivers power horizontally to the right. The gear having 100 teeth of 5mm module is located 150mm to the right of the left hand bearing and receives power in vertical direction from below. Using an allowable stress of 54 MPa in shear, determine the diameter of the shaft. **(Dec 2011)**

31) A steel shaft 120mm in diameter and 1m long was a flywheel fitted at one end and rotate at 240 rpm. When the shaft is suddenly stopped, determine the angle of twist and shear stress induced in the shaft. The mass of the flywheel is 100kg and its radius of gyration is 350mm. take G= 0.84 x 10^5 MPa **(Dec 2011)**

32) A mild steel shaft has to transmit 70kW at 240 r.p.m. The allowable shear stress in the material is limited to 45MPa, and the angle of twist is not exceeded to 1^0 in length of 20 times of the shaft diameter. Determine the shaft diameter and design a CI flange coupling of protected type for the shaft. The shear stress in the coupling bolts is to be limited to 30MPa. **(June 2013)**

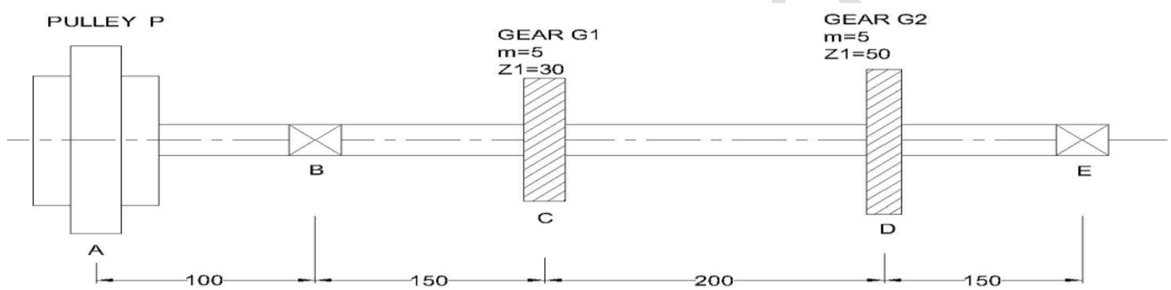
33) A shaft supported at the ends in ball bearings carries a straight tooth gear and its mid span and is to transmit 7.5kW at 280r.p.m. The pitch circle diameter of the gear is 150mm. The distances between the center line of bearings and gear are 100 each. If the shaft is made of steel and allowable shear stress is 40MPa, determine the diameter of the shaft. The pressure angle of the gear may be taken as 20^0. **(May 2009)**

34) A Mild steel shaft rotating at 720 r.p.m is supported between two bearings 80cm apart. It carries two pulleys A and B at distance of 30cm and 60cm respectively from left bearing. 10kW power is fed into the pulley A with a diameter of 40cm and taken out the pulley B with a diameter of 30cm by vertical belt drives having the same ratio of driving tensions which was observed to be 2.5. Assuming the following working stress and design the diameter of shaft. Take σ_t = 75N/mm^2, τ_s = 45 N/mm^2.

35) A shaft is supported on bearings A and B, 80mm between centers. A 20^0 straight tooth spur gear having 600mm pitch diameter is located 200mm to the right of the left hand bearing A, and a 700mm diameter pulley is mounted 250mm towards the left of bearing B. the gear is driven by a pinion with a downward tangential force while the pulley drives a horizontal belt having 180^0 angle of wrap. The pulley also serves as flywheel and weighs 2000N. the maximum belt tension is 3000N and tension ratio is 3:1. Determine maximum bending moment and the necessary shaft diameter if the allowable shear stress of the material is 40MPa.

36) A solid shaft is supported on bearings 1.8m apart and rotates at 250r.p.m. A 20^0 involute gear D 300mm diameter is keyed to the shaft at a distance of 150mm to the left on the right hand bearing. Two pulleys B and C are located on the shaft at a distance of 600mm and 1350mm respectively to the right of the left hand bearing. The diameter of the pulleys B and C are 750mm and 600mm respectively. 30kW power is supplied to the gear; out of which 18.5 kW is taken by off at pulley C and 11.25 kW from pulley B. the drive from B is vertically downward while from C the drive is downward at an angle of 60^0 to the horizontal. In both cases the belt tension ratio is 2, and the angle of lap is 180^0. The combined fatigue and shock factors for torsion and bending may be taken as 1.5 and 2 respectively. Design a suitable shaft taking working stress to be 42MPa in shear and 84MPa in tension.

37) A gear box shaft is supported on two bearings which are 500mm apart and carries a pulley and two gears mounted as shown in fig.1. The shaft rotates at 300rpm. The pulley at A of diameter 450mm, receives 15kW from below. The power is delivered to a shaft lying vertically below the given shaft through either gear G1 or gear G2 depending upon which gear is in mesh with gears mounted on the lower shaft. Bothe the gears have 200 involute tooth. Design the shaft from strength consideration only. The gears and pulleys are keyed on the shaft. Neglect the effect of weight of the pulley, gears and the shaft on the bending moment.



38) Design and draw a protective type of cast iron flange coupling for a steel shaft transmitting 15 kW at 200 r.p.m and having an allowable shear stress of 400 MPa. The working stress in the bolts should not exceed 30MPa. Assume the same material is used for the shaft and the key and that the crushing stress twice the value of its shear stress. The maximum torque is 25% greater than the full load torque. The shar stress for cast iron is 14MPa.
(Dec 2017) (Nov 2016 O) (Dec 2014)

39) Design and draw a rigid flange coupling to transmit a torque of 250N-m between two co-axial shafts. The shaft is made of alloy steel, flanges out of cast iron and bolts of steel. Four bolts are used to couple the flanges. The shafts are keyed to flange hub. Th permissible stresses are given below: shear stress of the t is 100MPa, bearing or crushing stress n the shaft is 250MPa. Shear stress on keys = 100MPa, bearing stress on key = 250MPa, shear stress of cast iron = 200MPa. Shear stress on bolts = 100MPa. **(May 2017) (May 2017 O)**

40) Design a C.I flange coupling (Protective type) to connect wo shafts 100mm diameter running at 300 rpm for transmitting 5000N-m torque. Assume permissible shear stress for shaft, bolt and key is 50MPa. Crushing stress for the bolt and the key is 150MPa, and the shear stress for the flange is 8MPa. **(Nov 2016)**

41) Design a flange coupling to transmit 60kW power at 350 rpm. Allowable shear stress may be taken as $30N/mm^2$. **(June 2016) (Dec 2009)**

42) Design a bushed pin type flexible coupling to connect two shafts of diameter 50mm. power transmitted is 20kW at 1000 rpm. Allowable bearing pressure on rubber bushes is 0.3 MPa. The working stress in the martials of the pins is 20MPa **(Dec 2015)**

43) Design a cast iron protective type flange coupling to transmit 15 kW at 900 r.p.m. from an electric motor to a compressor. The service factor may be assumed as 1.35. The following permissible stresses may be used: Shear stress for shaft, bolt and key material = 40 MPa, Crushing stress for bolt and key = 80 MPa, Shear stress for cast iron = 8 MPa. Draw a neat sketch of the coupling. **(June 2015) (July 2014) (Dec 2012) (Dec 2010) (July 2010)**

44) It is required to design a square key for fixing a gear on a shaft of 25mm diameter; 15kW power at 720r.p.m is transmitted from the shaft to the gear. The key is made of steel (σ_y = 460MPa) and the factor of safety is 3. The yield strength in compression can be assumed to be equal to the yield strength in tension. Determine the dimensions of the key. **(Dec 2014)**

45) A shaft and key are made of same material, and the key width is 1/3rd of the shaft diameter. (i) Considering shear only, determine the minimum length of the key in terms of the shaft diameter. (ii) Determine the thickness of the key to make the key equally strong in shear and crushing; taking shear strength of the key material as 40% of its crushing strength. **(Nov 2013)**

46) Desgn a clamp coupling to 30kw at 120 rpm. The shaft and the key are made of mild steel for which permissible shear stress is 40MPa. The two halves are connected by 4 bolts. And the permissible tensile stress in the bolt sis 70MPa. Th coefficient of friction between the sleeve and the shaft surface may be taken as 0.3. **(Nov 2013)**

47) Design and draw a cast iron flange coupling for a mild steel shaft transmitting 90 kW at 250 r.p.m. The allowable shear stress in the shaft is 40 MPa and the angle of twist is not to exceed 1° in a length of 20 diameters. The allowable shear stress in the coupling bolts is 30 MPa. **(Dec 2012 O)**

48) A shaft is subjected to twisting moment and bending moments of 1500N-m and 1000N-m respectively. If the permissible stresses are 65 MPa in tension and compression, 45MPa in shear, determine the diameter of the shaft. **(June 2012)**

49) A 30kW power is transmitted at 240 r.p.m from 400mm diameter shaft by means of two Kennedy keys of 1x12 mm cross section. Determine the length of the keys. For the keys, take permissible shear stress as 60MPa and crushing stress as 90MPa. **(June 2012)**

50) Design a marine type flange coupling to transmit 2500kW at 110rpm. Allowable shear stress may be taken as 30N/mm^2. **(June 2011)**

51) A marine type flange coupling is used to transmit 3.75 MW at 150 r.p.m. The allowable shear stress in the shaft and bolts may be taken as 50 MPa. Determine the shaft diameter and the diameter of the bolts.

52) Design a muff coupling to connect two shafts transmitting 40 kW at 120 r.p.m. The permissible shear and crushing stress for the shaft and key material (mild steel) are 30 MPa and 80 MPa respectively. The material of muff is cast iron with permissible shear stress of 15 MPa. Assume that the maximum torque transmitted is 25 per cent greater than the mean torque.

53) Design a compression coupling for a shaft to transmit 1300 N-m. The allowable shear stress for the shaft and key are 40 MPa and the number of bolts connecting the two halves are 4. The permissible tensile stress for the bolts material is 70 MPa. The coefficient of friction between the muff and the shaft surface may be taken as 0.3.

Unit-IV
Design of Joints, Screws, Pulleys, and Chains

Part-A

1) Distinguish between belt drive and chain drive. State the advantages and disadvantages.
2) Enumerate the role of locking devices for nuts.
3) Sketch a screw joint.
4) Briefly describe bolts of uniform strength.
5) What is the principle in cotter joints which keeps the cotter in locket position?
6) Mention the applications of cotter and knuckle joints.
7) Name the modes of failure of a cotter in cotter joint.
8) What is the purpose of Gib along with cotter in a cotter joint?
9) Write the assumptions made in the design of gasket joint.
10) What is the effect of gasket on the resultant load on the bolt, in the bolted joint?
11) State the factors and assumptions to be considered in the design of gasket joints.
12) Why gaskets are provided at joints?
13) What is the effect of gasket, on the resultant load on the bolt, in a bolt jont?
14) What are the various types of locking devices? Discuss their relative merits and demerits?
15) Sketch any two locking devices for joints with bolts and nuts.
16) What are the minimum and maximum number of sprocket teeth for a roller chain?
17) Explain the purpose of turn buckle.
18) Write brief note on (i) Hoisting and hauling chains (ii) conveyer chains (iii) silent chains
19) What is positive drive?
20) Distinguish between rope drive, belt drive and chain drive, state their advantages and disadvantages.
21) What do you understand by single start and double start threads?
22) Explain about M24 x 2
23) What is the difference between bolt and stud?
24) Explain the terms Pitch and Lead?
25) What are the different types pulleys used in belt drives?
26) Why the face of the pulley is crowned?
27) Explain the 'Fast and loose pulley' with the help of a neat sketch.
28) Name the materials used for pulleys.

Part-B

29) Design a knuckle joint to transmit a load of 150kN. The design stresses may be taken as 75MPa in tension, 60MPa in shear and 150MPa in compression. **(June 2017) (June 2017 O) (Dec 2012)**
30) Design a knuckle joint to connect two tension rods subjected to an axial load of 15KN. Consider σ_t = 65MPa, τ = 50MPa, σ_c = 80MPa. **(June 2016) (Dec 2016)**
31) Design a knuckle joint to withstand a load of 100kN. All the parts of the joint are made of same material with $\sigma_{ut} = \sigma_{uc}$ = 480MPa and τ_s = 360MPa. Use factor of safety of 6 on ultimate strength. Where σ_{ut} and σ_{uc} are ultimate tensile strength and ultimate compressive strength and τs is ultimate shear strength. Draw its neat sketch. **(Dec 2014) (Nov 2013)**

32) Design a knuckle joint to withstand an axial load of 70kN. All the parts of made up of mild steel having permissible stresses of 75MPa in tension 50MPa in shear and 90MPa in compression. Draw a neat sketch of the joint. **(Dec 2010)**

33) Design a knuckle joint to withstand an axial load of 90kN. All the parts of made up of mild steel having permissible stresses of 75MPa in tension 50MPa in shear and 90MPa in compression. Draw a neat sketch of the joint. **(July 2010)**

34) Design a knuckle joint to transmit a load of 3kN. Take allowable stress values in tension and shear as 60 N/mm^2 and 25 N/mm^2 respectively. Draw its neat sketch **(Dec 2009)**

35) Two mils steel rods are constructed by a knuckle joint to transmit an axial load of 150kN. Design the joint. Assume the working stresses for both the pin and rod material as 75MPa in tension, 60MPa in shear and 150MPa in crushing. **(June 2009)**

36) Design a cotter joint to connect piston rod to the cross head of a double acting steam engine. The diameter of the cylinder is 300mm, and the steam pressure is $1N/mm^2$. The allowable stresses for the material of the cotter and piston are as follows: σ_t = 50MPa, τ = 40MPa, σ_c = 84MPa. **(Dec 2017) (July 2014)**

37) Design a cotter joint to connect piston rod to the cross head of a double acting steam engine. The diameter of the cylinder is 300mm, and the steam pressure is $1N/mm^2$. The allowable stresses for the material of the cotter and piston are as follows: σ_t = 50MPa, τ = 40MPa, σ_c = 50MPa. **(Dec 2016 O)**

38) Design a sleeve and cotter joint to resist a tensile load of 60KN. All parts of the joint are made of the same material with the following allowable stresses. σ_t = 60MPa, τ = 70MPa, σ_c = 125MPa. **(Dec 2015)**

39) Design a cotter joint for transmitting a tensile load of 20kN. Take the allowable stresses in tension, shear and crushing as 80, 45 and 100 MPa respectively. **(July 2015)**

40) Design a cotter joint of socket and spigot type, which may be subjected to a pull or push of 30kN. All the parts of the joint are made of the same material with permissible stresses, 55MPa in tension, 70MPa in compression and 40MPa in shear. **(June 2013) (June 2012)**

41) Design a cotter joint to transmit a load of 2kN. Take allowable stress values in tension and shear as 70 N/mm^2 and 30 N/mm^2 respectively. Draw its neat sketch. **(Dec 2012 O) (July 2011)**

42) For supporting the travelling crane in a workshop, the brackets are fixed on steel column as shown in figure below. The maximum load that comes on the bracket is 12kN acting vertically at a distance of 400mm from the face of the column. The vertical face of the bracket is secured to a column by four bolts, in two rows (two in each row) at a distance of 50mm from the lower edge of the bracket. Determine the size of the bolts if the permissible value of tensile stresses for the bolt material is 84MPa. Also find the cross section of the beam of the bracket which is rectangular. **(Dec 2011)**

Unit-V

Design of Power Screws, Welds and Rivets

Part-A

1) What is meant by a power screw?
2) What are the applications of power screws?
3) Distinguish between differential and compound screw.
4) What type of threads are preferred for (a) Differential screws and (b) Compound screws, and mention the reasons for the same.
5) Explain why square threads are preferred, compared to V-threads, for power transmissions.
6) Where do you find lead screw? What is its necessity? What are design considerations?
7) Mention the functions of screw jack and illustrate its applications?
8) What is the condition for self-locking of a power screw?
9) Why modified square thread is preferred to square thread?
10) Classify different types of riveted joints with neat sketch and mention their applications.
11) Diamond type riveted joint is also called as_________________?
12) What is meant by eccentric riveted joint?
13) Explain the following terms. (i) Pitch (ii) back pitch (iii) Diagonal pitch
14) How do you calculate efficiency of a riveted joint?
15) What do you understand by the term efficiency of a riveted joint?
16) What are the possible failures of riveted joint?
17) Explain the terms Caulking and Fullering.
18) Differentiate between structural and boiler joints?
19) Sketch triple riveted lap joint.
20) Classify different types of welded joints with neat sketch and mention their applications.
21) State the assumptions made in the design of welded joints.
22) Through a net sketch, explain what is meant by (i) leg lengths (ii) Throat thickness of a weld section.
23) What is an eccentrically loaded weld joint? What are the steps in design of a welded joint loaded eccentrically?
24) What is meant by throat thickness?
25) Sketch any 4 welded joints.
26) Compare the riveted joints with weld joints?

Part-A

27) A double riveted lap joint with Zig-Zag riveting is to be designed for 13mm thick plates. Assume tensile stress = 80MPa, shear stress = 60MPa, crushing stress = 120MPa. State how the joint will fail and find the efficiency of the joint. **(Dec 2017) (June 2017 O)**
28) Two plates of 7 mm thick are connected by a triple riveted lap joint of zig-zag pattern. Calculate the rivet diameter, rivet pitch and distance between rows of rivets for the joint. Also state the mode of failure of the joint. The safe working stresses are as follows: σ_t = 90 MPa; σ_s = 60 MPa; and σ_c = 120 MPa. **(June 2016)**
29) Design a Zig-Zag double riveted lap joint to fasten two plates, each of thickness 9mm. take the allowable stresses as 80MPa, 50MPa and 140MPa in tension, shear and crushing respectively. **(Dec 2015)**

30) Design a triple riveted lap joint to join two plates, each of thickness 12mm. Take the permissible stresses in tension, shear and crushing as 70, 35 and 130MPa. Determine all the efficiencies of the joint. **(June 2015)**

31) Two mild steel tie bars for a bridge structure are to be joined by a double cover riveted butt joint. The thickness of the tie bar is 20 mm and carries a tensile load of 45 tones. Design the joint if the allowable stresses are: f_t =90N/mm^2, f_s =75 N/mm2, f_c =150 N/mm^2. **(July 2014)**

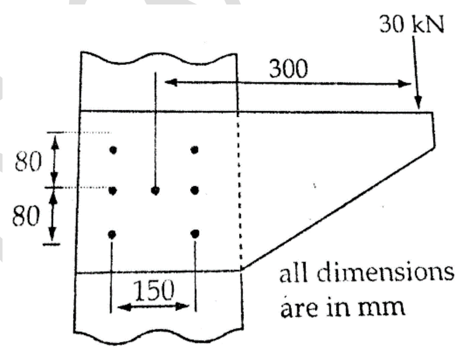
32) Design a triple riveted lap joint to join two plates of 6 mm thick. The permissible stresses are σ_t = 80 MPa, σ_c = 100 MPa and τ_s= 60 MPa. Calculate the rivet diameter rivet petels, and distance between the rows of rivets. Use zig-zag riveting state how the joint will fail. **(Nov 2013)**

33) Design a double riveted butt joint with two cover plates for the longitudinal seam of a boiler shell 1.5 m in diameter subjected to a steam pressure of 0.95 N/mm^2. Assume joint efficiency as 75%, allowable tensile stress in the plate 90 MPa; compressive stress 140 MPa; and shear stress in the rivet 56 MPa. **(Dec 2011)**

34) A triple riveted lap joint with Zig-Zag is used to join two plates of 8 mm thickness. Design the joint fully and show how it may fail. Take σ_t = 120 MPa, σ_c = 150 MPa and τ_s= 100 MPa. **(Dec 2010)**

35) A triple riveted butt zig-zag riveting joint is used to connect two plates of 6mm thickness. Design the joint fully and show how it may fail. Take σ_t = 120 MPa; σ_c = 150 MPa; and shear stress τ_s = 100 MPa. **(June 2010)**

36) Determine the size of the rivet required for the arrangement shown in figure below. Take the allowable shear stress for the rivet material as 50 N/mm^2. **(Dec 2009)**

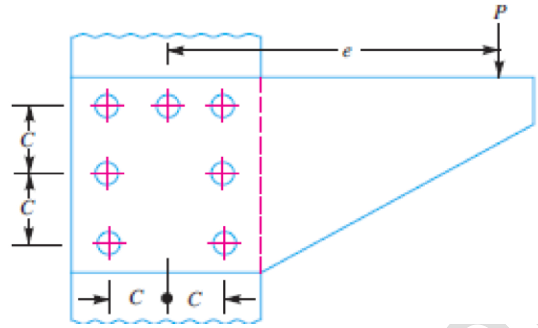


37) A double riveted double cover butt joint in plates 20 mm thick is made with 25 mm diameter rivets at 100 mm pitch. The permissible stresses are : σ_t = 120 MPa; τ_s = 100 MPa; σ_c = 150 MPa Find the efficiency of joint, taking the strength of the rivet in double shear as twice than that of single shear.

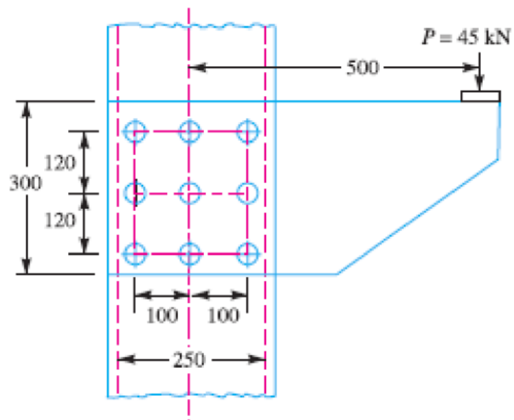
38) Design the longitudinal joint for a 1.25 m diameter steam boiler to carry a steam pressure of 2.5 N/mm^2. The ultimate strength of the boiler plate may be assumed as 420 MPa, crushing strength as 650 MPa and shear strength as 300 MPa. Take the joint efficiency as 80%. Sketch the joint with all the dimensions. Adopt the suitable factor of safety.

39) A steam boiler is to be designed for a working pressure of 2.5 N/mm^2 with its inside diameter 1.6m. Give the design calculations for the longitudinal and circumferential joints for the following working stresses for steel plates and rivets: In tension = 75 MPa; In shear = 60 MPa; In crushing = 125 MPa. Draw the joints to a suitable scale.

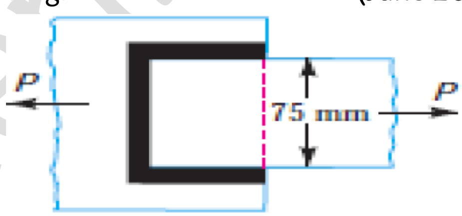
40) An eccentrically loaded lap riveted joint is to be designed for a steel bracket as shown in Fig. The bracket plate is 25 mm thick. All rivets are to be of the same size. Load on the bracket, P = 50 kN; rivet spacing, C = 100 mm; load arm, e = 400 mm. Permissible shear stress is 65 MPa and crushing stress is 120 MPa. Determine the size of the rivets to be used for the joint.



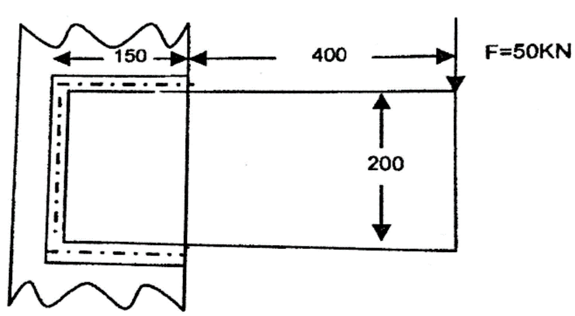
41) The bracket as shown in Fig is to carry a load of 45 kN. Determine the size of the rivet if the shear stress is not to exceed 40 MPa. Assume all rivets of the same size.



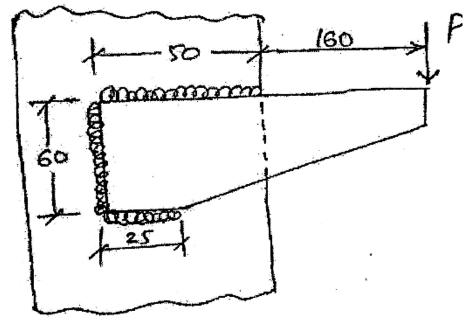
42) A plate 75 mm wide and 12.5 mm thick is joined with another plate by a single transverse weld and a double parallel fillet weld as shown in fig. The maximum tensile and shear stresses are 70 MPa and 56 MPa respectively. Find the length of each parallel fillet weld, if the joint is subjected to both static and fatigue loading. **(June 2017) (Dec 2016 O)**



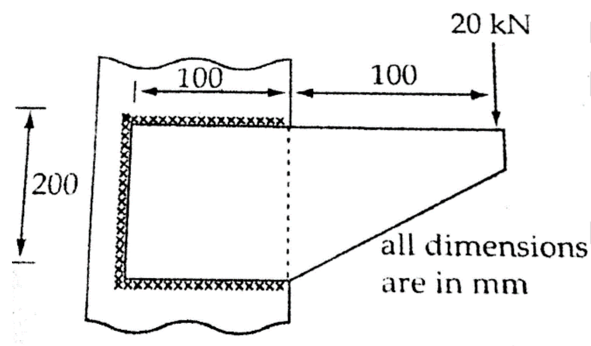
43) Figure shows an eccentrically loaded welded joint. Determine the weld size if shear stresses in the same is not to exceed 80MPa. **(Dec 2016) (June 2013) (June 2009)**



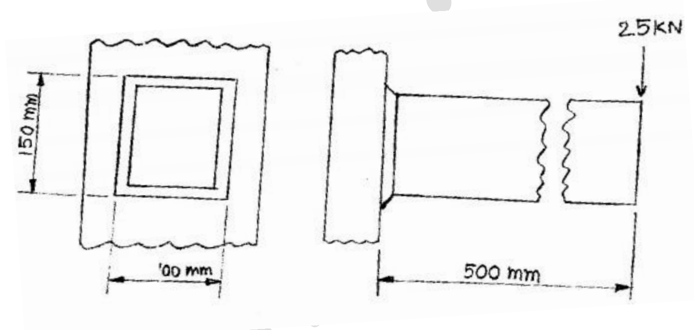
44) Load P = 1200N is to be carried by a welded joint as shown in figure below. Determine size of the weld required. Take allowable stresses for the weld material as 85MPa. **(June2015)**

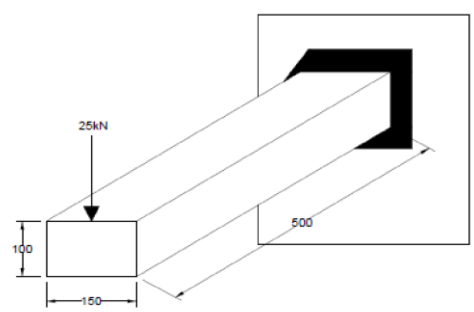


45) Determine the size of the weld required for the joint in the figure. Allowable stress for the weld material is 80N/mm². **(June 2016)** **(Dec 2009)**



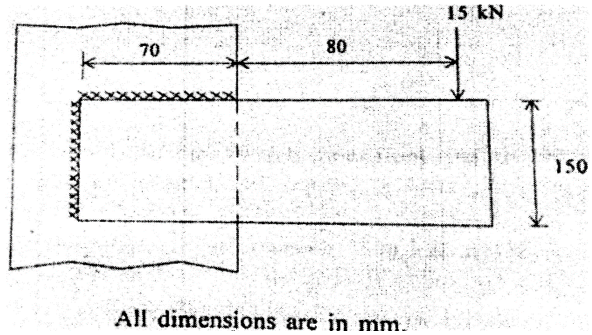
46) A Shaft of rectangular cross section is welded to a support by means of fillet welds as shown in figure. Determine the site of welds, if the permissible shear stress in the weld is limited to 75 MPa. **(Dec 2012)**



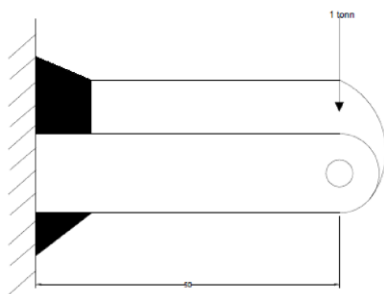


47) A boiler is made by welding the plates longitudinally and circumferentially. The diameter of the boiler is 1m. The maximum pressure is 1.5N/mm². Design both the joints using single V butt weld for both the joints. The permissible tensile stress in the plate material is 30MPa. Assume that the strength of the plate and weld is same. **(June 2012)**

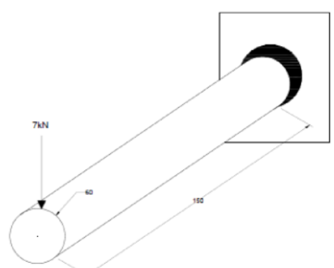
48) Determine size of the weld required for the joint as shown in figure. Allowable stress for the weld material is 80 N/mm². **(June 2011)**



49) A bracket of width 35mm and length 50mm is welded to a machine frame as shown in fig. the maximum load on bracket is 1 ton. Find the size of the weld at top and bottom of the weld.



50) A circular shaft 60mm in diameter is welded to a support plate by means of a fillet weld as shown in figure. Determine size of the weld if permissible shear stress in the weld is limited to 85MPa.



51) In a hand vice, the screw has a double start square thread of 26mm diameter. If the lever of length 0.25m and the maximum force that can be applied at the end of the lever is 300N, determine the force with which the job is held between the jaws of the vice. Take the coefficient of friction as 0.14. **(Dec 2016)**

52) A load of 12kN is raised by a screw with single start square threads of 50mm mean diameter and 12mm itch. The screw is operated by a hand wheel, the boss of which is threaded to ac as nut. The load is resisted by a thrust collar, which supports wheel boss and has a mean radius of 30mm. the coefficient of friction is 0.15 for the screw and 0.18 for the collar. If the tangential force applied by each hand on the wheel is 120kN. Determine the diameter of hand wheel required. **(Dec 2014)**

53) Design a screw jack to lift a load of 50kN. **(Dec 2012) (June 2011)**

54) A power screw is used to raise a load of 10kN. The nominal diameter is 60mm, and the pitch is 9mm. the threads are ACME type ($2\varnothing = 29^0$) and the coefficient of friction at the screw threads is 0.15, neglecting collar friction. Calculate

(a) The torque required to raise the load (b) The torque required to lower the load

(c) The efficiency of the screw for lifting the load. **(June 2010) (Dec 2010)**