A

Assignment on

Machine Drawing

&

Elements of Machine Design

(BE03000231)

B.E. Semester 3

(New Syllabus)

Mechanical Engineering/ Automobile Engineering /

Mechatronics / Manufacturing Engineering & Allied Branch

Institute logo

Directorate of Technical Education, Gandhinagar, Gujarat

Government Engineering College, Patan

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Certificate of Completion

This is to certify that Mr./Ms. ___________________________________, a student of the 3rd Semester Mechanical Engineering (Enrolment No. ________________), has successfully and satisfactorily completed all practical and tutorial work prescribed for the course **"Machine Drawing and Elements of Machine Design" (Course Code: BE03000231)** at [Institute Name] during the academic year 2025–26.

Date of Submission__________

Faculty In charge **External Examiner** **Head of Department**

Practical—Course Outcome matrix

Course Outcomes (COs):

Sr. No	Course Outcomes	Level
1	Interpret various stress-strain, CG, and MI of machine components and their design procedure.	U
2	Evaluate machine components under static loading and application of various basic theories of failures.	E
3	Design and analyze of levers, shafts, keys , couplings and power screw	C
4	Analyze machine components under fluctuating loading and design for finite and infinite life.	N
5	Make use of modelling/ drafting software for machine drawing and production drawing.	A

Sr. No.	Objective(s) of Experiment	CO1	CO2	CO3	CO4	CO5
1.	Introduction to modeling software					√
2.	Elements of 2D drawing in modeling/drafting software					√
3.	2D drawing of machine components in software					√
4.	Orthographic drawing of machine components using software					√
5.	Isometric view, Isometric projection using software					√
6.	Assembly drawing using software			√		√
7.	Production Drawing using software			√		√
8.	Design of machine components as per content and computerized production drawings.	√	√	√	√	√
9	Case study	√	√	√	√	√
10						
11						

Justification of Program Outcomes (PO1–PO12)

PO No.	Program Outcome	Justification – How the Course Addresses This PO
PO1	Engineering knowledge	Students apply the fundamentals of mechanics, strength of materials, and design methodology to machine elements, enhancing core engineering knowledge.
PO2	Problem analysis	Through the application of stress analysis and failure theories, students learn to identify, analyze, and solve mechanical design problems.
PO3	Design/development of solutions	Students design components like levers, shafts, and screws using industry practices, ensuring safe and functional engineering solutions.
PO4	Conduct investigations of complex problems	Students engage in design-based investigations such as fluctuating load cases and fatigue failure to derive reliable design parameters.
PO5	Modern tool usage	Students utilize advanced CAD software for modeling, drafting, and simulating machine assemblies, aligning with current industry tools.
PO6	The engineer and society	By focusing on safety factors and failure prevention, the course supports the development of socially responsible engineering solutions.
PO7	Environment and sustainability	Through optimal material selection and design efficiency, the course fosters awareness of sustainable engineering practices.
PO8	Ethics	Students learn the ethical implications of accurate and safe designs, including the necessity of adhering to established codes and standards.
PO9	Individual and teamwork	Group design tasks and collaborative software exercises promote teamwork and leadership in an engineering context.
PO10	Communication	The course enhances technical communication skills through structured drawing practices, annotations, and design documentation.
PO11	Project management and finance	Exposure to software tools and real-world case studies prepares students for managing technical resources and design workflows effectively.
PO12	Life-long learning	The course encourages adaptability by introducing students to evolving software tools and contemporary design methodologies.

Laboratory Instructions for Machine Drawing and Elements of Machine Design

1. **Be Prepared**
   - Read the lab manual and understand the objectives before coming to the lab.
   - Review related theory from the textbook or class notes.
2. **Maintain Discipline**
   - Arrive on time and maintain decorum throughout the session.
   - Follow the instructor's guidelines at all times.
3. **Software Familiarity**
   - Learn basic commands and operations of the modeling/drafting software (e.g., AutoCAD, FreeCAD, etc.).
   - Do not install unauthorized software or tamper with system settings.

4. **Workstation Handling**
    - Use only assigned computer systems.
    - Save your work regularly and back up your files.
5. **File Management**
    - Use consistent naming conventions (e.g., `Name_ExpNo.dwg`) for all drawing files.
    - Maintain a separate folder for each practical assignment.
6. **Drawing Standards**
    - Follow BIS standards for dimensioning, tolerances, and drawing formats.
    - Ensure clarity in sectioning, annotation, and labeling.
7. **Data Entry and Design Inputs**
    - Use appropriate design values such as material properties, loads, and dimensions.
    - Validate inputs for designing machine components using formulas and references.
8. **Group Collaboration**
    - Collaborate effectively during assembly and case study work.
    - Share responsibilities and document contributions.
9. **Documentation**
    - Maintain a practical file with printed or PDF copies of completed work.
    - Write clear explanations of steps and design choices taken.
10. **Safety and Ethics**
    - Use equipment responsibly and avoid plagiarism.
    - Report any system malfunctions or issues immediately to the lab in-charge.
11. **Assessment Readiness**
    - Keep all drawings and simulations ready for viva/practical evaluation.
    - Be prepared to explain the design process and justify choices.
12. **Clean Workspace**
    - Log off and shut down the system properly after use.
    - Leave the workspace clean and tidy.

Attainment Rubric for Practical’s (As per NBA Requirements)

Course Code: BE03000231
Course Name: Machine Drawing and Elements of Machine Design

Pr. No.	Title	Mapped CO(s)	Assessment Tool	Performance Criteria	Rubric Levels (Marks Range)
1	Introduction to modeling software	CO5	Observation + Viva	Understanding of UI, navigation, tool identification	L3: Confident use, no help (8–10) L2: Basic operations with some help (5–7) L1: Unable to operate independently (0–4)
2	Elements of 2D drawing in software	CO5	Drawing File + Viva	Correct use of lines, dimensions, constraints	L3: Precise & clean 2D drawing (8–10) L2: Minor errors (5–7) L1: Incomplete/inaccurate drawing (0–4)
3	2D drawing of machine components	CO5	Drawing File + Viva	Geometry, views, dimensioning as per standard	L3: Standards followed correctly (8–10) L2: Minor dimensioning issues (5–7) L1: Major errors or incomplete (0–4)
4	Orthographic drawing	CO5	Drawing File	Proper front, top, side views with projection lines	L3: All views correct & clean (8–10) L2: One view missing/inaccurate (5–7) L1: Incomplete views (0–4)
5	Isometric view and projection	CO5	Drawing File	Accurate 3D representation of part from 2D	L3: Isometric views correct (8–10) L2: Shape correct, proportions off (5–7) L1: Incorrect or missing drawing (0–4)
6	Assembly drawing	CO3, CO5	Assembly File + Viva	Logical placement, constraints, bill of materials	L3: Fully constrained, well-labeled (8–10) L2: Minor missing parts/labels (5–7) L1: Poorly constrained/incomplete (0–4)
7	Production Drawing	CO3, CO5	Drawing File	Tolerances, fits, and notes included per standard	L3: Complete with correct symbols (8–10) L2: Missing 1–2 elements (5–7) L1: Lacks standard detail (0–4)
8	Component design and drawing	CO1–CO5	File + Calculations + Viva	Calculation correctness, model accuracy	L3: Accurate design & drawing (10) L2: Minor calculation errors (6–9) L1: Incomplete or wrong design (0–5)

9	Case study	CO1–CO5	Report + Viva	Design evaluation, innovation, software use	L3: In-depth analysis + original design (10) L2: Moderate depth, mostly correct (6–9) L1: Lacks analysis or unclear (0–5)

Rubric for Dynamics of Machinery Lab Experiment

Sr. No.	Criteria	Excellent >80%	Very Good >70 %	Good > 60%	Fair>40%
		5	**4**	**3**	**1-2**
1	**C1-Interpretation and understanding objective of experiment.** **25% Marks**	Interpret and understand experiments accurately.	Interpret and understand experiments with few errors.	Interpret practical but difficult to understand experiments.	Difficulties in Interpreting practical and understanding experiments.
2	**C2-Clearity in Practical concepts** **25% Marks**	Students can thoroughly understand the concept of practical and clarity in the practical.	Students can understand the concept of practical and clarity in the practical.	Students can partially understand the concept of practical and partially understanding the practical.	Poor understanding of concept and lack of attitude for clarity in practical
3	**C3-Ethical conduct and Teamwork in Lab session** **25% Marks**	Always shows ethical conduct & attitude of working in a team.	Shows ethical conduct & attitude of working in a team many times.	Shows ethical conduct & attitude of working in a team sometimes.	Shows ethical conduct sometimes but does not perform any duties of the assigned role.
4	**C4-Timely completion and quality of lab report** **25% Marks**	All captions and readings are accurate with neat diagrams/graphs and submits in time.	All captions and readings are accurate with neat diagrams/graphs but do not submit in time.	Few captions/readings /diagrams/graphs need correction and do not submit in time.	Many captions/readings /diagrams/graphs need correction and do not submit in time.

TUTORIAL NO: 01

BASICS OF STRESS, STRAIN AND MACHINE DESIGN

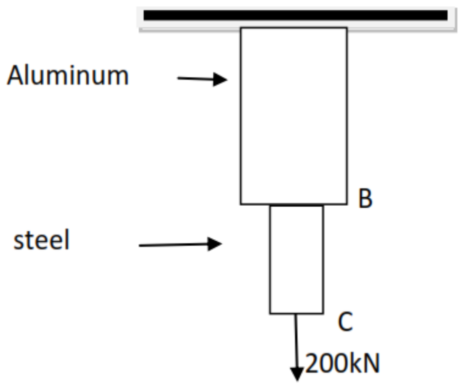
Part: A

1. What is the fundamental relationship between stress and resultant strain? Explain with figure.
2. Define factor of safety.
3. Explain about modulus of rigidity.
4. Define stress and strain.
5. Define tensile stress and compressive stress.
6. Define young's Modulus.
7. State the relationship between young's modulus and modulus of rigidity.
8. Define Shear stress and Shear strain
9. Define volumetric strain. 9 Define thermal stress.
10. Define Bulk modulus.
11. State compound bar?
12. Discuss about the use of Mohr's circle?
13. Define elastic limit.
14. Define principal planes and principal stresses.
15. Define modulus of resilience.
16. Define proof resilience
17. Define: Resilience
18. Define Poisson's Ratio.
19. Discuss about the Elastic Constants?
20. Explain Hooke's Law?
21. Define the following terms
    A) Stress & strains
    B) Elasticity & Plasticity
    C) hooks law & factor of safety
    D) Lateral & longitudinal strains
    E) Strain energy & resilience
22. Derive the relation between the three elastic constants
23. Define stress and strain and specify the units for both. Write two examples for each of the ductile material and brittle material.

Part: B

1. A hollow steel tube 305m long has external diameter of 120mm. In order to determine the internal diameter, the tube was subjected to a tensile of load of 400 kN and extension was measured to be 2 mm. If the modulus of elasticity for the material is 200 GPa, determine the internal diameter of the tube.
2. Two wires, one of steel and the other of copper, are of the same length and are subjected to the same tension. If the diameter of the copper wire is 2 mm, find the diameter of the steel wire, if they are elongated by the same amount. Take E for steel as 200GPa and for copper as 100GPa.
3. A compound bar ABC 1.5m long (Fig: 1.1) is made up of two parts of aluminum and steel and that cross sectional area of aluminum bar is twice that of steel bar. The rod is subjected to an axial tensile load of 200 kN. If the elongations of aluminum and steel parts are equal, find the length of the two parts of compound bar. Take E for steel as 200 GPa and for aluminum as one third of Steel.

Figure: 1.1



4. A circular steel bar ABCD, fixed at A and D is subjected to axial loads of 50kN and 100kN at B and C as shown in fig.1.2 Find the load shared by each part of the bar and displacement of point B and C. Take E for steel 200GPa.

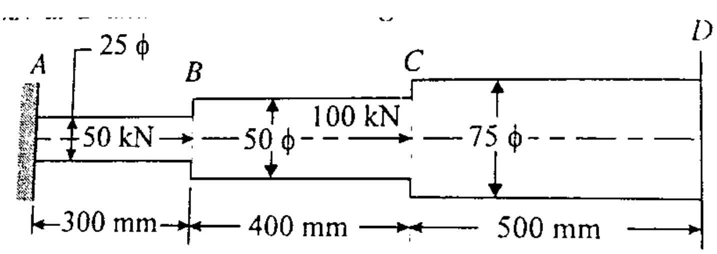


Figure: 1.2

5. A steel rod ABC is firmly held between two rigid supports as shown in fig. 1.3 Find the stresses developed in the two portions of the rod, when it is heated through 15 K. Take a = 12 x 10 /K and E= 200GPa

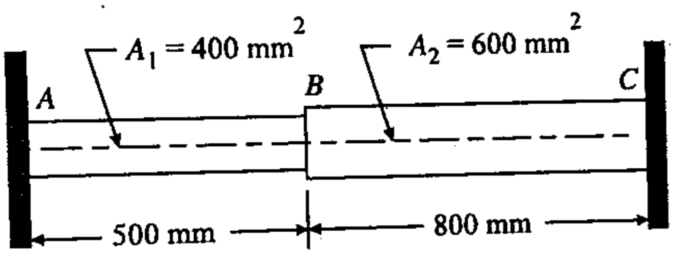


Figure: 1.3

6. A metallic bar 300 mm x 100 mm x 50 mm is subjected to a force of 6 kN (tensile), 8 kN (tensile) and 5 kN(tensile) along x, y and z direction respectively. Determine the change in the volume of the block. Take E = 2 x 105 N/mm2 and Poisson's ratio = 0.25.
7. Derive the relation between E and K.
8. Find the young's modulus of a rod of diameter 30mm and of length 300mm which is subjected to a tensile load of 60 KN and the extension of the rod is equal to 0.4 mm.
9. A bar of 30 mm diameter is subjected to a pull of 60 kN. The measured extension on gauge length of 200 mm is 0.09 mm and the change in diameter is 0.0039 mm. calculate the Poisson's ratio and the values of the three moduli.

Rubric Wise Marks Obtained:

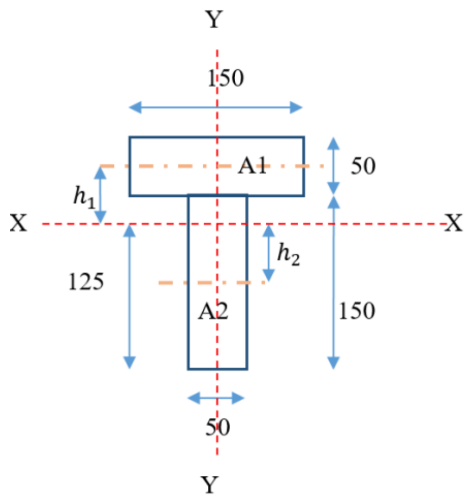
Rubrics	1	2	3	4	Total
Marks					

Faculty Sign

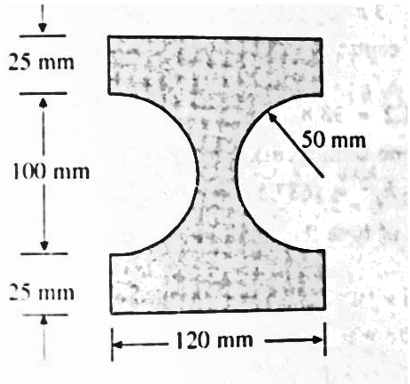
TUTORIAL NO: 02

MOMENT OF INERTIA OF PLANAR CROSS -SECTIONS

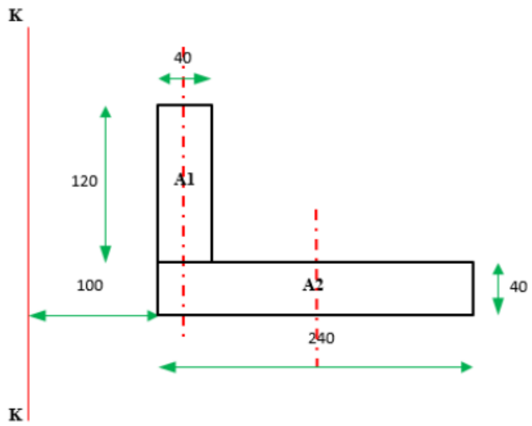
1. Find the moment of inertia of a T section shown in fig 4 about X-X and Y-Y axes through the center of gravity of the section. (Fig 1.4)



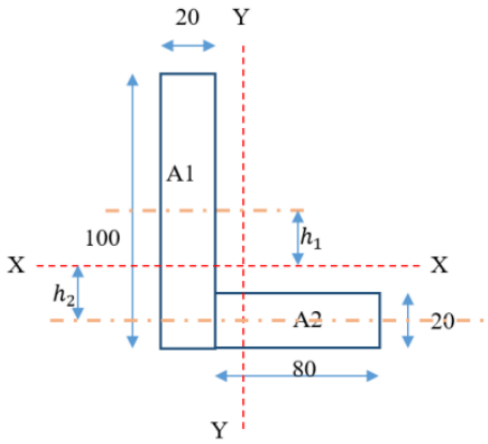
2. Figure 1.5 shows the cross section of cast iron beam. Determine the moments of inertia of the section about horizontal and vertical axes passing through the centroid of the section.



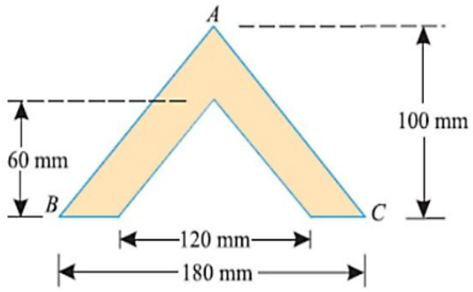
3. Figure below shows an area ABCDEF. Compute the moment of inertia of the above area about axis K-K.



4. Find the moment of inertia about the centroid X-X and Y-Y axes of the angle section shown in Figure below



5. A hollow triangular section shown in Figure is symmetrical about its vertical axis. Find the moment of inertia of the section about the base BC.



6. Find the centre of gravity of a channel section 100 mm × 50 mm × 15 mm
7. An I-section has the following dimensions in mm units: Bottom flange = 300 × 100. Top flange = 150 × 50, Web = 300 × 50. Determine mathematically the position of center of gravity of the section.
8. Find the moment of inertia of a rectangular section 30 mm wide and 40 mm deep about X-X axis and Y-Y axis.
9. Find the moment of inertia of a hollow rectangular section about its centre of gravity if the external dimensions are breadth 60 mm, depth 80 mm and internal dimensions are breadth 30 mm and depth 40 mm respectively.

Rubric Wise Marks Obtained:

Rubrics	1	2	3	4	Total
Marks					

Faculty Sign

TUTORIAL NO: 03

THEORY OF BENDING

1. Two beams are simply supported over the same span and have the same flexural strength. Compare the weights of these two beams, if one of them is solid and the other is hollow with internal diameter half of the external diameter.
2. A rectangular beam 60 mm wide and 150 mm deep is simply supported over a span of 6 m. if the beam is subjected to central point load of 12 kN, find the maximum bending stress induced in the beam.
3. A hollow steel tube having external and internal diameter of 100 mm and 75 mm respectively is simply supported over a span of 5m. The tube carries a concentrated load of W at a distance of 2 m from one of the supports. What is the value of W, if maximum bending stress is not to exceed 100 MPa.
4. A bell-crank lever is subjected to a force of 7.5 kN at the short arm end. The lengths of the short and long arms are 100 and 500 mm respectively. The arms are at right angles to each other. The lever and the pins are made of steel FeE 300 ($S_{yt} = 300\ N/mm^2$) and the factor of safety is 5. The permissible bearing pressure on the pin is $10\ N/mm^2$. The lever has rectangular cross-section and the ratio of the fulcrum pin is 1.5:1. Calculate:

   (i) Diameter and the length of the fulcrum pin

   (ii) Shear stress in the pin

   (iii) Dimensions of the boss of the lever at the fulcrum pin

   (iv) Dimensions of the cross-section of the lever

   Assume that the arm of bending moment on the lever extends up to the axis of the fulcrum.
5. A right angle bell crank lever is shown in Fig. 3.1 The load W = 4.5KN. The lever consists of forged steel material and a pin at the fulcrum. Take the following permissible stress for the pin and lever material. Safe stress in tension = 75MPa, Safe stress in shear = 60MPa, Safe bearing pressure on pin = 10N/mm2. The length of fulcrum pin is 1.25 times the diameter of fulcrum pin. Calculate the following:

   (1.) Reaction at fulcrum pin (2). Fulcrum pin dimensions (3). Lever dimensions

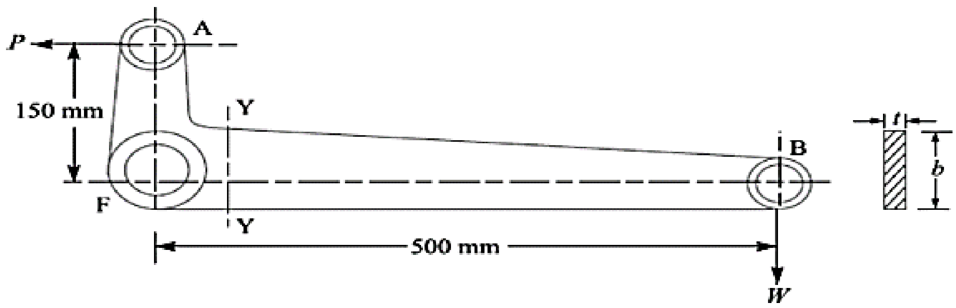


Figure. 3.1

6. Design a rocker arm lever Fig 3.2 having equal arms of 160 mm length inclined at 135 o for an exhaust valve of a gas engine subjected to a maximum force 2500 N at roller end. Consider – I cross section 6t x 2.5t x t size (where t = thickness of web and flange) for lever. The permissible stresses for the lever material are 80MPa in tension and design bearing pressure is pin 6 MPa for pin.

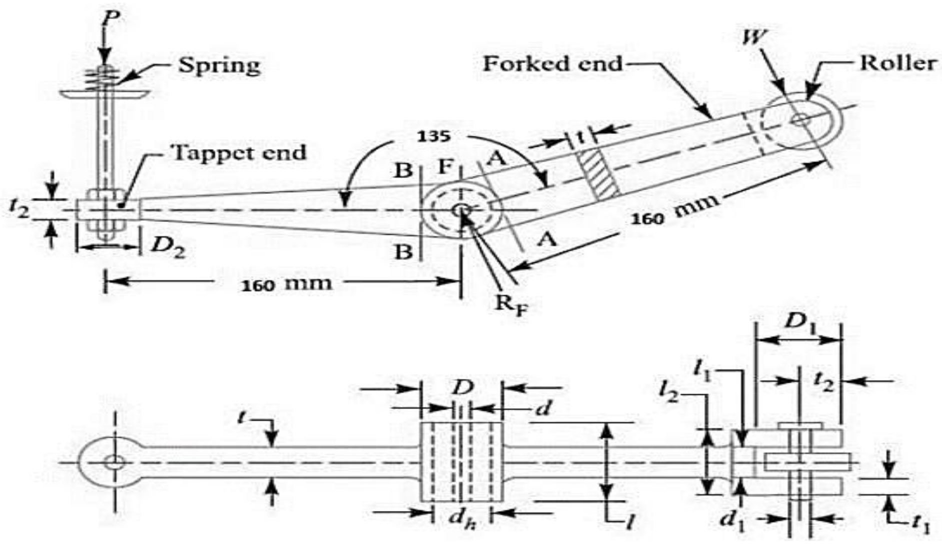


Figure. 3.2

7. Design a foot lever (brake lever) from following data: Length of lever from the center of the shaft to point of application of load= 1 m and Max. Load on the foot plate = 800 N and Allowable tensile stress = 75 MPa and Allowable shear stress =72 MPa.
8. What is deflection of beam?
9. What causes deflection of beam? How do you control beam deflection?
10. State the relationship between shear force and bending moment.
11. What are the different types of beams?
12. Name the various types of load.
13. Define shear force at a section of a beam.
14. Define bending moment at a section of a beam.
15. What is meant by point of contraflexure?

16. Mention the different types of supports.
17. State the relationship between the load and shear force.
18. What is section modulus?
19. What is moment of resistance?
20. What are the assumptions made in the theory of simple bending?
21. A cantilever beam of span 3 m carries a point load of 10 kN at the free end. Find the value of moment at the fixed end?

Rubric Wise Marks Obtained:

Rubrics	1	2	3	4	Total
Marks					

Faculty Sign

TUTORIAL NO: 04

THEORY OF TORSION

1. Define torsion.
2. What are the assumptions made in the theory of torsion?
3. Define polar modulus.
4. Why hollow circular shafts are preferred when compared to solid circular shafts?
5. A hollow shaft with diameter ratio 3/5 is required to transmit 450 kW at 120 rpm. The shearing stress in the shaft must not exceed 60 N/mm and the twist in a length of 2.5 m is not to exceed 1°. Calculate the minimum external diameter of the shaft. C = 80 kN/mm2
6. A steel shaft is required to transmit 75 kW power at 100 rpm. and the maximum twisting moment is 30% greater than the mean. Find the diameter of the steel shaft if the maximum stress is 70 N/mm .Also determine the angle of twist in a length of 3m of the shaft. Assume the modulus of rigidity for steel as 90 kN/ mm2
7. Calculate the maximum intensity of shear stress induced and the angle of twist produced in degrees in solid shaft of 100 mm diameter, 12 m long, transmitting 150 kW at 200 rpm. Take G=82kN/mm2
8. The internal and external diameter of a hollow shaft is in the ratio of 2:3. The hollow shaft is to transmit a 400 kW power at 120 rpm. The maximum expected torque is 15% greater than the mean valve. If the shear stress is not to exceed 50 Mpa, find section of the shaft which would satisfy the shear stress and twist conditions. Take G=0.85×105 MPa
9. A hollow shaft, having an inside diameter is 60% of it is outer diameter is to replace the solid shaft is transmitting in the same power and same speed. Calculate percentage in saving materials, if the materials are to be also the same.
10. A solid shaft has to transmit the power 105 kW at 2000 rpm. The maximum torque transmitted in each revaluation exceeds the mean by 36%. Find the suitable diameter, if the shear stress is not to exceed 75 N/mm2 and maximum angle of twist is 1.5◦ in a length of 3.30m and G=0.80×10

<u>Rubric Wise Marks Obtained:</u>

Rubrics	1	2	3	4	Total
Marks					

Faculty Sign

TUTORIAL NO: 05

DESIGN AND DRAWING AGAINST STATIC LOAD

(Different joints and problems of eccentric loading.)

1. Two rods are connected by means of a knuckle joint as shown in Fig.5.1 The axial force P acting on the rods is 25 kN. The rods and the pin are made of plain carbon steel 45C8 ($S_{yt} = 380\ N/mm^2$) and the factor of safety is 2.5. The yield strength in shear is 57.7% of the yield strength in tension. Calculate: (i) the diameter of the rods, and (ii) the diameter of the pin.

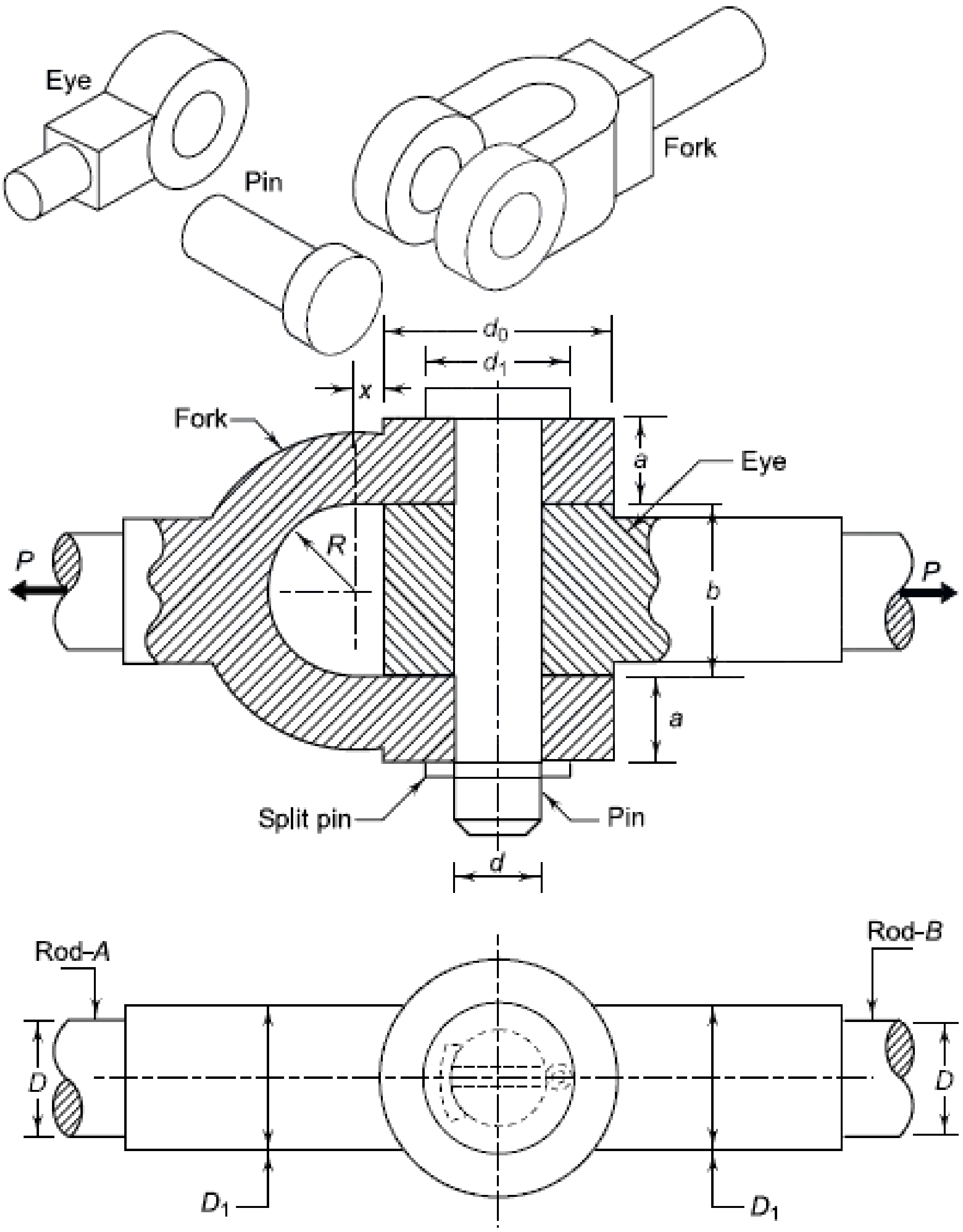


Figure.5.1

2. The force acting on a bolt consists of two components an axial pull of 12 kN and a transverse shear force of 6 kN. The bolt is made of steel FeE 310 ($S_{yt} = 310\ N/mm^2$) and the factor of safety is 2.5. Determine the diameter of the bolt using the maximum shear stress theory of failure.
3. A C-frame subjected to a force of 15 kN is shown in Fig.5.2 it is made of grey cast iron FG300 and the factor of safety is 2.5. Determine the dimensions of the cross-section of the frame.

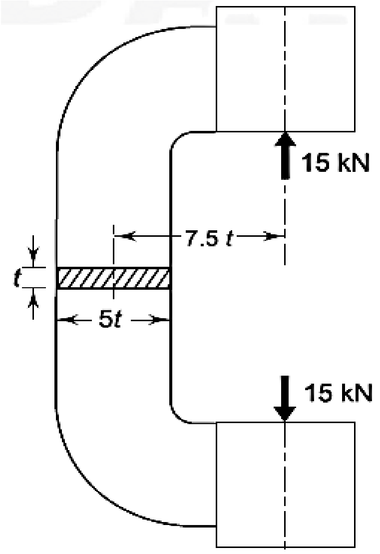


Figure.5.2

4. The principal stresses induced at a point in a machine component made of steel 50C4 ($S_{yt} = 460\ N/mm^2$) are as follows:
   $\sigma_1 = 200\ N/mm^2$, $\sigma_2 = 150\ N/mm^2$, $\sigma_3 = 0$
   Calculate the factor of safety by (i) the maximum shear stress theory and (ii) the distortion energy theory.
5. The stresses induced at a critical point in a machine component made of steel 45C8 ($S_{yt} = 380\ N/mm^2$) are as follows:
   $\sigma_x = 100\ N/mm^2$, $\sigma_y = 40\ N/mm^2$, $\tau_{xy} = 80\ N/mm^2$
   Calculate the factor of safety by (i) the maximum normal stress theory, (ii) the maximum shear stress theory and (iii) the distortion energy theory.
6. **6.** A link of S-shape made of a round steel bar is shown in Fig. 5.3 It is made of plain carbon steel 45C8 ($S_{yt} = 380\ N/mm^2$) and the factor of safety is 4.5. Calculate the dimensions of the link.

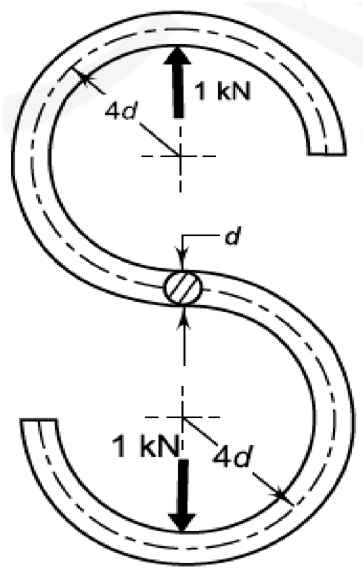


Figure. 5.3

7. A bracket, (Fig: 5.4) made of steel FeE 200 ($S_{yt} = 200\ N/mm^2$) and subjected to a force of 5 kN acting at an angle of 30^o to the vertical, is shown in Fig. The factor of safety is 4. Determine the dimensions of the cross-section of the bracket.

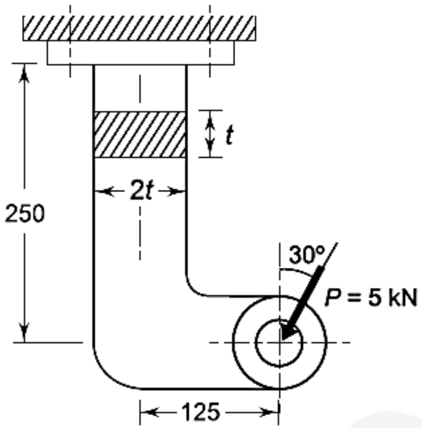


Figure: 5.4

8. Fig 5.5 shows a C-clamp, which carries a load P of 25 kN. The cross-section of the clamp is rectangular and the ratio of width to thickness (b/t) is 2:1. The clamp is made of cast steel of Grade 20-40 ($S_{ut} = 400\ N/mm^2$) and the factor of safety is 4. Determine the dimensions of the cross-section of the clamp.

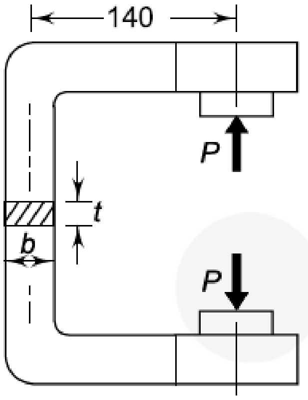


Figure: 5.5

9. A gib and cotter joint is used for strap-type big end of the connecting rod. The rod is subjected to a maximum pull of 70 kN. The rods, strap, gib and cotter are all made of plain carbon steel ($S_{yt} = 250\ N/mm^2$) and the factor of safety is 10. Assume thickness of cotter as 0.3 times the width of strap. Diameter of circular part of rod adjacent to the strap is 60 mm. Calculate:
   a. Width of strap
   b. Thickness of strap at the thinnest cross-section and at cross-section passing through the slot
   c. Thickness and widths of gib and cotter at midsection.
10. A bolt is subjected to an axial force of 10 kN with a transverse shear force of 5 kN. The permissible tensile stress at elastic limit is 100 MPa and the Poisson's ratio is 0.3 for the bolt material. Determine the diameter of the bolt required according to,
   (i) Maximum principal stress theory
   (ii) Maximum shear stress theory
   (iii) Maximum distortion energy theory
11. A bolt is subjected to an axial pull of 12 kN together with transverse shear force of 6 kN. Determine the diameter of bolt according to maximum shear stress theory if elastic limit in tension is 300 MPa. Factor of safety is 3.
12. A hollow wrought iron rod is subjected to a tensile load of 10 kN acting along its axis. If the outside diameter and inside diameter of the rod are 20 mm and 15 mm respectively. Calculate the following:
   a. Safe tensile stress in the rod
   b. Factor of safety if the ultimate tensile stress is 300 MPa.
13. A bolt is subjected to a tensile load of 25 kN and a shear load of 10 kN. Determine the diameter of the bolt according to (i) Maximum principal stress theory, (ii) Maximum stress

theory. Assume factor of safety as 2.5, yield point stress in simple tension = $300\ N/mm^2$, Poisson's ratio = 0.25.

14. Design a cotter joint to transmit a load of 100 kN in tension or compression. Assume the following stresses for socket, spigot and cotter:

    Allowable tensile stress = 90 MPa

    Allowable crushing stress = 170 MPa

    Allowable shear stress = 60 MPa

15. Design a cotter joint to transmit a load of 100 kN in tension or compression. Assume the following stresses for socket, spigot and cotter:

    Allowable tensile stress = 90 MPa

    Allowable crushing stress = 170 MPa

    Allowable shear stress = 60 MPa

16. Design and draw a cotter joint to support a load varying from 30 kN in compression to 30 kN in tension. The material used is carbon steel for which the following allowable stresses may be used. The load is applied statistically. Tensile stress = Compressive stress = 50 MPa, Shear stress = 35 MPa and Crushing stress = 90 MPa.
17. Design and draw a knuckle joint to connect two mild steel bars under a tensile load of 25 kN. The allowable stresses are 65 MPa in tension, 50 MPa in shear and 83 MPa in crushing.
18. Distinguish clearly between bending and bearing stress.
19. Explain the following terms with neat sketches:

    (1) Tensile stress (2) Compressive stress (3) Principle Stress (4) Bearing pressure
20. Differentiate between (with neat sketch):
    a. crushing and compressive stresses
    b. torsional and transverse shear stress

Rubric Wise Marks Obtained:

Rubrics	**1**	**2**	**3**	**4**	**Total**
Marks					

Faculty Sign

TUTORIAL NO: 06

Design of Machine Components Under Fluctuating Loading Condition

1. A rectangular plate, 15 mm thick, made of a brittle material is shown in Fig 6.1. Calculate the stresses at each of three holes of 3, 5 and 10 mm diameter.

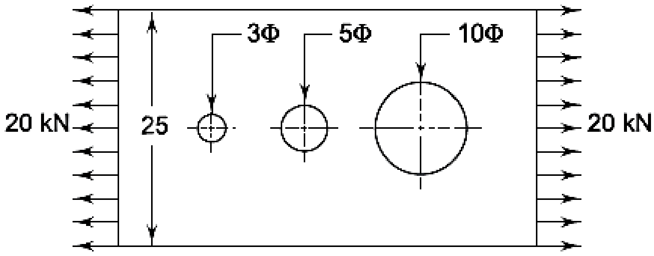


Figure 6.1

2. A round shaft made of a brittle material and subjected to a bending moment of 15 N-m is shown in Fig. 6.2 The stress concentration factor at the fillet is 1.5 and the ultimate tensile strength of the shaft material is $200\ N/mm^2$. Determine the diameter d, the magnitude of stress at the fillet and the factor of safety.

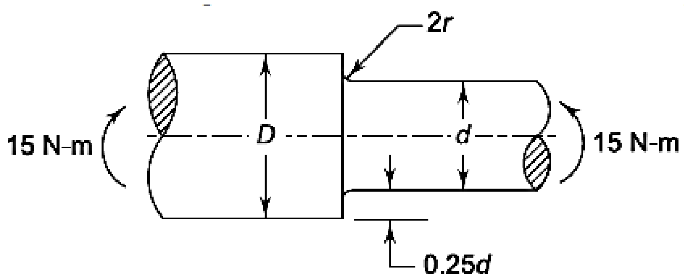


Figure 6.2

3. A shaft carrying a load of 5 kN midway between two bearings is shown in Fig. 6.3 Determine the maximum bending stress at the fillet section. Assume the shaft material to be brittle.

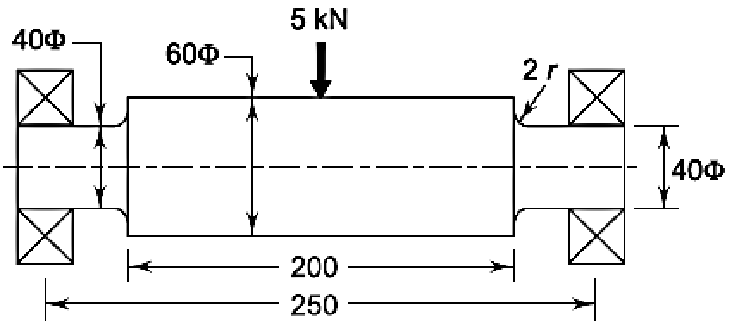


Figure 6.3

4. A plate, 10 mm thick, subjected to a tensile load of 20 kN is shown in Fig.6.4 The plate is made of cast iron ($S_{ut} = 350\ N/mm^2$) and the factor of safety is 2.5. Determine the fillet radius.

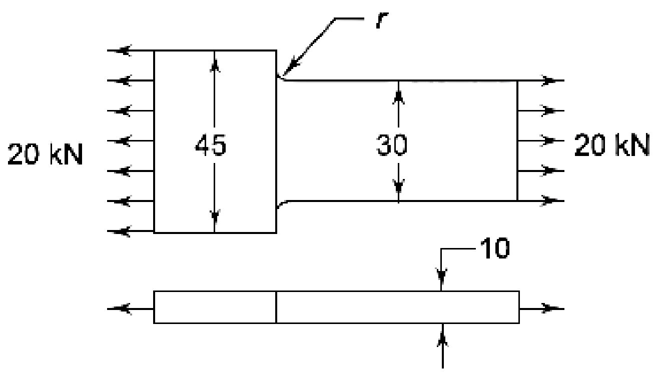


Figure 6.4

5. A 25 mm diameter shaft is made of forged steel 30C8 ($S_{ut} = 600\ N/mm^2$). There is a step in the shaft and the theoretical stress concentration factor at the step is 2.1. The notch sensitivity factor is 0.84. Determine the endurance limit of the shaft if it is subjected to a reversed bending moment.
6. A 40 mm diameter shaft is made of steel 50C4 ($S_{ut} = 660\ N/mm^2$) and has a machined surface. The expected reliability is 99%. The theoretical stress concentration factor for the shape of the shaft is 1.6 and the notch sensitivity factor is 0.9. Determine the endurance limit of the shaft.
7. A cantilever beam made of steel Fe 540 ($S_{ut} = 540\ N/mm^2$ and $S_{yt} = 320\ N/mm^2$) and subjected to a completely reversed load (P) of 5 kN is shown in Fig. 6.5. The beam is machined and the reliability is 50%. The factor of safety is 2 and the notch sensitivity factor is 0.9. Calculate: (i) endurance limit at the fillet section; and (ii) diameter d of the beam for infinite life.

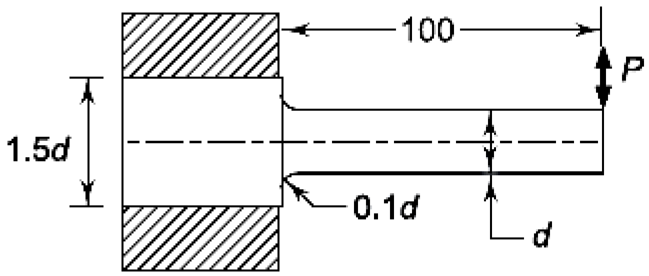


Figure 6.5

8. A solid circular shaft made of steel Fe 620 ($S_{ut} = 620\ N/mm^2$ and $S_{yt} = 380\ N/mm^2$) is subjected to an alternating torsional moment, which varies from -200 N-m to +400 N-m. The shaft is ground and the expected reliability is 90%. Neglecting stress concentration, calculate the shaft diameter for infinite life. The factor of safety is 2. Use the distortion-energy theory of failure.
9. A solid circular shaft, 15 mm in diameter, is subjected to torsional shear stress, which varies from 0 to 35 N/mm^2 and at the same time, is subjected to an axial stress that varies from -15 to

+30 N/mm^2. The frequency of variation of these stresses is equal to the shaft speed. The shaft is made of steel FeE 400 ($S_{ut} = 540\ N/mm^2$ and $S_{yt} = 400\ N/mm^2$) and the corrected endurance limit of the shaft is 200 N/mm^2. Determine the factor of safety.

10. A bar of steel has an ultimate tensile strength of 700 MPa, a yield point stress of 400 MPa and fully corrected endurance limit (S_e) of 220 MPa. The bar is subjected to a mean bending stress of 60 MPa and a stress amplitude of 80 MPa. Superimposed on it is a mean torsional stress and torsional stress amplitude of 70 and 35 MPa respectively. Find the factor of safety.

Rubric Wise Marks Obtained:

Rubrics	1	2	3	4	Total
Marks					

Faculty Sign

TUTORIAL NO: 07

DESIGN OF SHAFTS, KEY'S & COUPLING

SHAFT DESIGN

1. A centrifugal pump is driven by 10 kW power 1440 rpm electric motor. There is a reduction gearbox between the motor and the pump. The pump shaft rotates at 480 rpm. The design torque is 150% of the rated torque. The motor and pump shafts are made of plain carbon steel 40C8 ($S_{yt} = 380\ N/mm^2$) and the factor of safety is 4. Assume ($S_{sy} = 0.5\ S_{yt}$).

   Calculate:

   (i) Diameter of the motor shaft; and

   (ii) Diameter of the pump shaft.

2. A transmission shaft is supported between two bearings, which are 750 mm apart. Power is supplied to the shaft through coupling, which is located to the left of the left-hand bearing. Power is transmitted from the shaft by means of belt pulley, 450 mm in diameter, which is located at a distance of 200 mm to the right of the left-hand bearing. The weight of the pulley is 300 N and the ratio of the belt tension of tight and slack sides is 2:1. The belt tensions act in vertically downward direction. The shaft is made of steel FeE 300 $\left(S_{yt} = 300\ N/mm^2\right)$ and the factor of safety is 3. Determine the shaft diameter, if it transmits 12.5 kW power at 300 rpm from the coupling to the pulley. Assume ($S_{sy} = 0.5\ S_{yt}$).

3. A rotating shaft, 40 mm in diameter, is made of steel FeE 580 $\left(S_{yt} = 580\ N/mm^2\right)$. It is subjected to a steady torsional moment of 250 N-m and bending moment of 1250 N-m. Calculate the factor of safety based on,

   (i) Maximum principal stress theory; and

   (ii) Maximum shear stress theory.

4. A propeller shaft is required to transmit 50 kW power at 600 rpm. It is a hollow shaft, having and inside diameter 0.8 times of the outside diameter. It is made of steel $\left(S_{yt} = 380\ N/mm^2\right)$ and the factor of safety is 4. Calculate the inside and outside diameters of the shaft. Assume ($S_{sy} = 0.5\ S_{yt}$).

5. An intermediate shaft of a gearbox, supporting two spur gears A and B and mounted between two bearings C_1 and C_2, is shown in Fig.7.1 The pitch circle diameters of gears A and B are 500 and 250 mm respectively. The shaft is made of alloy steel 20MnCr5. $\left(S_{ut} = 620 \quad \& \quad S_{yt} = 480\ N/mm^2\right)$. The factors k_b and k_t of the ASME code are 2 and

1.5 respectively. The gears are keyed to the shaft. Determine the shaft diameter using the ASME code.

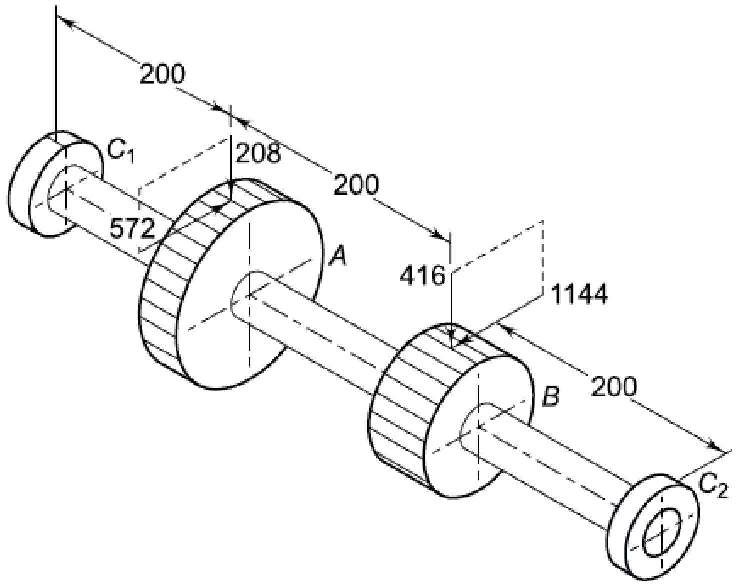


Figure 7.1

6. Assume the data of the intermediate shaft illustrated in the previous example. The permissible angle of twist for the shaft is 0.25° per meter length and the modulus of rigidity is 79300 N/mm^2. Determine the shaft diameter on the basis of torsional rigidity.
7. A transmission shaft, supporting two pulleys A and B and mounted between two bearings C_1 and C_2 is shown in Fig.7.2 Power is transmitted from the pulley A to B. The shaft is made of plain carbon steel 45C8 $\left(S_{ut} = 600\ N/mm^2 \&\ S_{yt} = 380\ N/mm^2\right)$. The pulleys are keyed to the shaft. Determine the shaft diameter using the ASME code if, $k_b = 1.5\ and\ k_t = 1.0$. Also, determine the shaft diameter on the basis of torsional rigidity, if the permissible angle of twist between the two pulleys is 0.5° and the modulus of rigidity is 79300 N/mm^2.

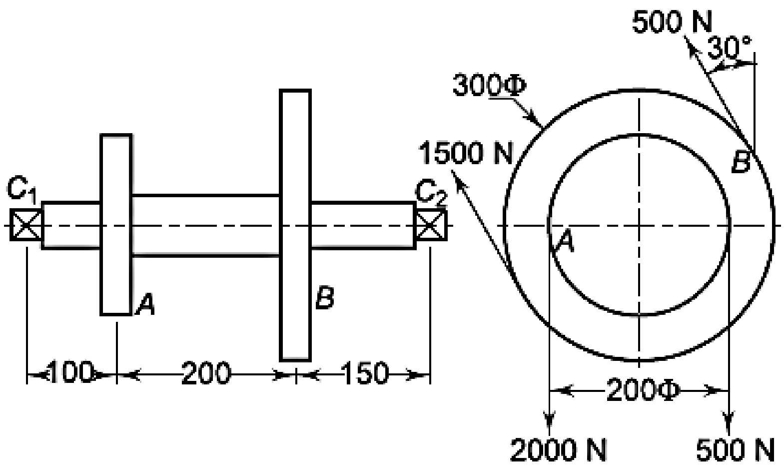


Figure 7.2

8. A steel shaft carrying two weights of 200 and 3500 N is shown in Fig.7.3 Neglect the weight of the shaft and estimate the first critical speed of the shaft. $(E = 207000\ N/mm^2)$.

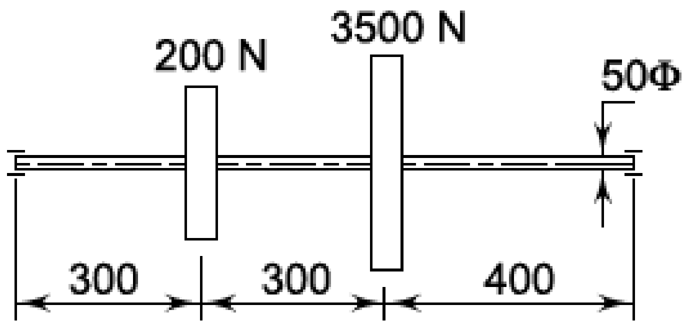


Figure 7.3

9. A hollow shaft is to transmit 200kW at 80 rpm if the shear stress is not to exceed 60MPa and internal diameter is 0.6 of the external diameters. Find the diameters of the shaft.
10. A solid shaft is subjected to a torque of 1.6kN-m. Find the necessary diameter of the shaft, if the allowable shear stress is 60MPa. The allowable twist is 1^o for every 20 diameter length of the shaft. Take C= 80GPa
11. A solid shaft of 60mm diameter is to be replaced by a hollow steel shaft of the same material with internal diameter equal to half of the external diameter. Find the diameter of hollow shaft and saving material, if the maximum allowable shear stress is same for both shafts.

KEY DESIGN

12. The cross-section of a flat key for a 40 mm diameter shaft is $22 \times 14\ mm$. The power transmitted by the shaft to the hub is 25 kW at 300 rpm. The key is made of steel $\left(S_{yc} = S_{yt} = 300\ N/mm^2\right)$ and the factor of safety is 2.8. Determine the length of the key. Assume$\left(S_{sy} = 0.577 \times S_{yt}\right)$.
13. It is required to design a square key for fixing a pulley on the shaft, which is 50 mm in diameter. The pulley transmits 10 kW power at 200 rpm to the shaft. The key is made of steel 45C8 $\left(S_{yc} = S_{yt} = 380\ N/mm^2\right)$ and the factor of safety is 3. Determine the dimensions of the key. Assume$\left(S_{sy} = 0.577 \times S_{yt}\right)$.
14. A flat key is used to connect a pulley to a 45 mm diameter shaft. The standard cross section of the key is 14×9 mm. The key is made of commercial steel $\left(S_{yt} = S_{yc} = 230\ N/mm^2\right)$ and the factor of safety is 3. Determine the length of the key on the basis

of shear and compression considerations, if 15 kW power at 360 rpm is transmitted through the keyed joint. Assume $(S_{sy} = 0.5 \times S_{yt})$.

15. A standard splined connection $8 \times 36 \times 40$ is used for a gear and shaft assembly rotating at 700 rpm. The dimensions of the splines are as follows:

    Major diameter = 40 mm

    Minor diameter = 36 mm

    Number of splines = 8

The length of the gear hub is 50 mm and the normal pressure on the splines is limited to 6.5 N/mm^2. Calculate the power that can be transmitted from the gear to the shaft.

Rubric Wise Marks Obtained:

Rubrics	1	2	3	4	Total
Marks					

Faculty Sign

TUTORIAL NO: 08

DESIGN AND DRAWING OF POWER SCREW.

1. A double-threaded power screw, used for lifting a load, has a nominal diameter of 30 mm and a pitch of 6 mm. The coefficient of friction at the screw threads is 0.1. Neglecting collar friction, calculate: (i) efficiency of the screw with square threads; and (ii) efficiency with ACME threads (2θ=29°).
2. A sluice valve, used in a water-pipeline, consists of a gate raised by the spindle, which is rotated by the hand wheel. The spindle has single-start square threads. The nominal diameter is 36 mm and the pitch is 6 mm. The inner and outer diameters of the friction collar are 30 mm and 50 mm respectively. The coefficients of friction at the threads and the collar are 0.15 and 0.20 respectively. The weight of the gate is 7.5 kN and the frictional resistance to open the valve due to water pressure is 2.5 kN. Using the uniform wear theory for collar friction, calculate: (i) the torque required to raise the gate; and (ii) the overall efficiency of the mechanism.
3. A double-threaded power screw is used to raise a load of 5 kN. The nominal diameter is 60 mm and the pitch is 9 mm. The threads are ACME type (2θ=29°) and the coefficient of friction at the screw threads is 0.15. Neglecting collar friction, calculate: (i) the torque required to raise the load; (ii) the torque required to lower the load; and (iii) the efficiency of the screw for lifting load.
4. A 50 kN capacity screw jack consists of a square-threaded steel screw meshing with a bronze nut. The nominal diameter is 60 mm and the pitch is 9 mm. The permissible bearing pressure at the threads is 10 N/mm^2. Calculate: (i) the length of the nut; and (ii) the transverse shear stress in the nut.
5. Plot a graph of efficiency v/s helix angle, which varies from 0 to 60°, for a square-threaded screw. The coefficient of friction at the threads is 0.15 and the collar friction is negligible.

α(°)	5	10	15	20	25	30	35	40	45	50	55	60
η(%)	36.35	52.60	61.53	66.95	70.37	72.50	73.71	74.16	73.49	72.94	71.11	68.12

The following data is given for a machinist's clamp:

Type of thread=single-start square

Nominal diameter=20 mm

Pitch=5 mm

Collar friction radius=8 mm

6. The coefficient of friction at the threads and the collar is 0.15. The operator exerts a force of 50 N on the handle at a distance of 150 mm from the axis of the screw. Determine the maximum clamping force that can be developed.
7. Write down the step by step design procedure of the screw jack.
8. Design a screw jack to lift load of 300 KN and having a maximum lift of 300 mm. select proper material and draw a proportional sketch.

Rubric Wise Marks Obtained:

Rubrics	**1**	**2**	**3**	**4**	**Total**
Marks					

Faculty Sign

TUTORIAL NO: 09

CASE STUDY FOR 2D/3D DRAWING OF MACHINE COMPONENTS USING COMPUTER SOFTWARE.

The 2D/ 3D modelling software tools are used for a number of projects, from simulation to manufacturing. A 2D/ 3D modelling software with great visualization options can help you get a better overview of your project. A precise overview allows you to adjust and improve your parts efficiently. It is also a good method to correct the last errors.

Activity to be perform (Any one)

1. Based on the exercise provided (Annexure-1), students, working in groups of 2 to 3, are required to create 2D or 3D drawings using any suitable drawing software.
2. Prepare the Assembly and Detail drawing to the scale and show limit, fits & Surface finish symbols according to the given List (Annexure-1),
3. Drawing / Calculation (If any)
4. Case Study Results /Closure
5. Presentation in Laboratory session.
6. Take Print / Plot and attached here

The Details and Assembly Drawing of all above machines and machine components are provided in **Annexure: 1** at the end of this manual.

You can use as a reference. You may also choose another mechanical machine drawing with the approval of your faculty.

Rubric Wise Marks Obtained:

Rubrics	1	2	3	4	Total
Marks					

Faculty Sign

ANNEXURE: 1 Drawing of Machine Components

1. Piston and Connecting Road of Petrol Engine

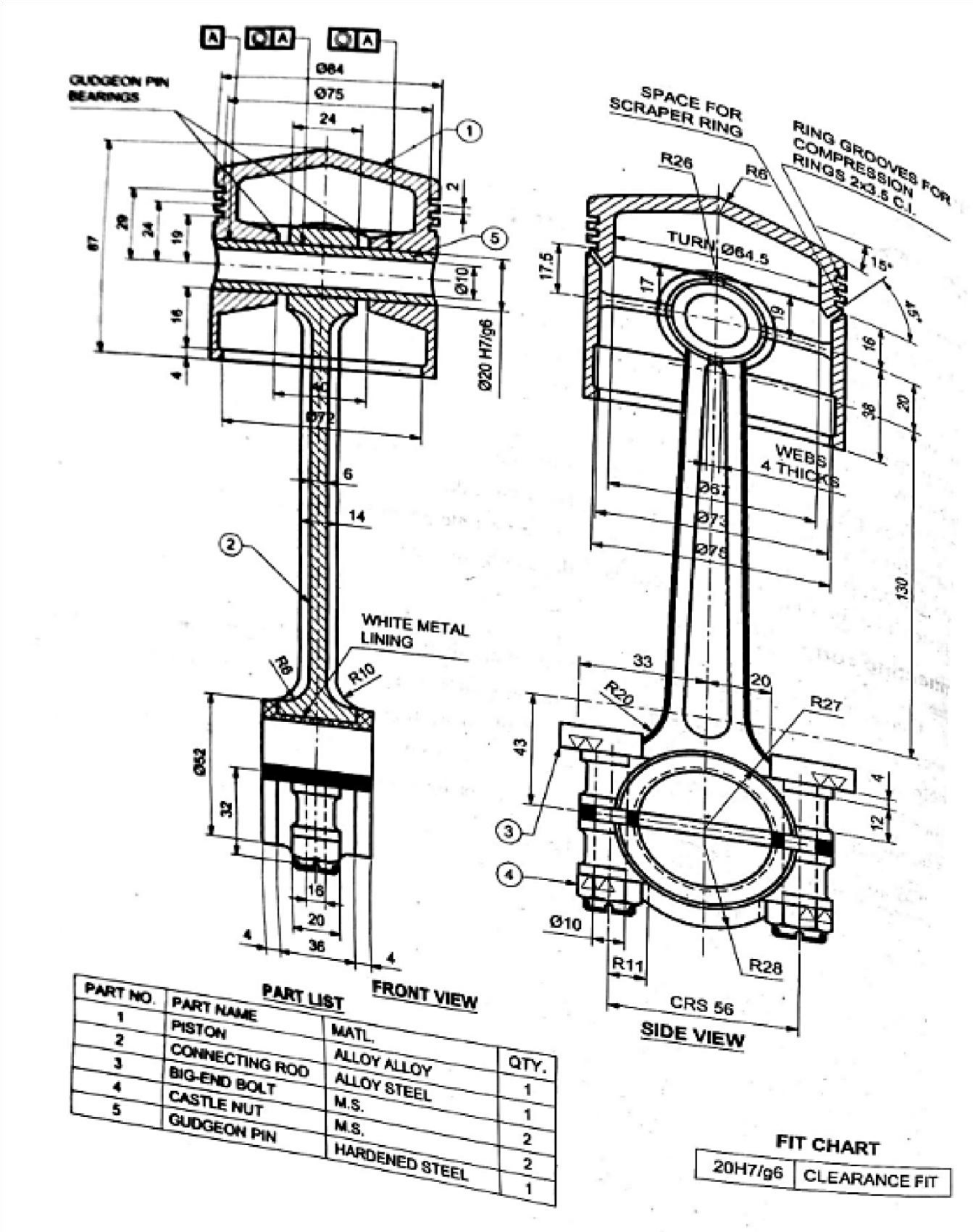


Fig: Assembly: Piston and Connecting Road of Petrol Engine

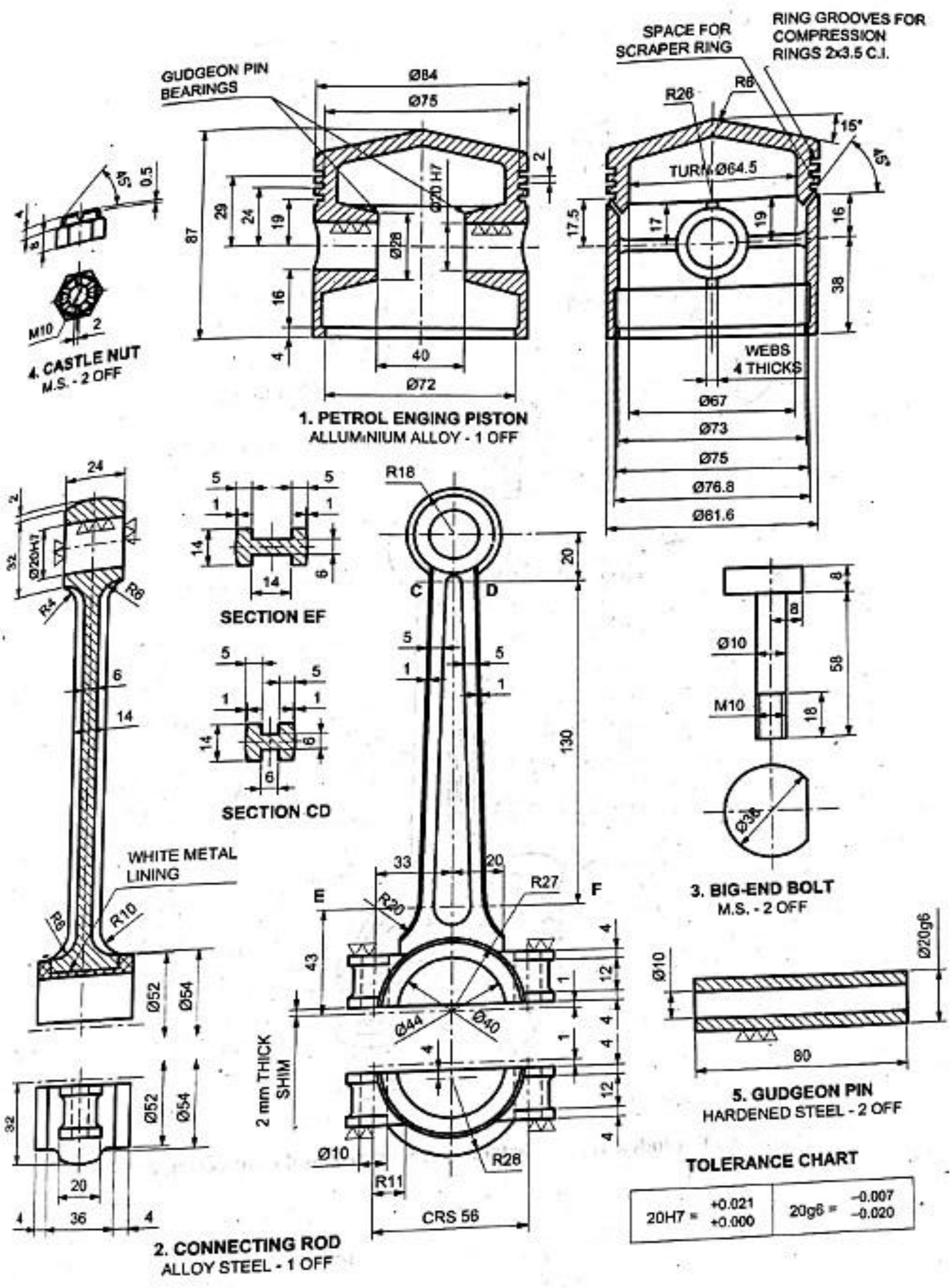


Fig: Details: Piston and Connecting Road of Petrol Engine

2. Spring Loaded Safety Valve

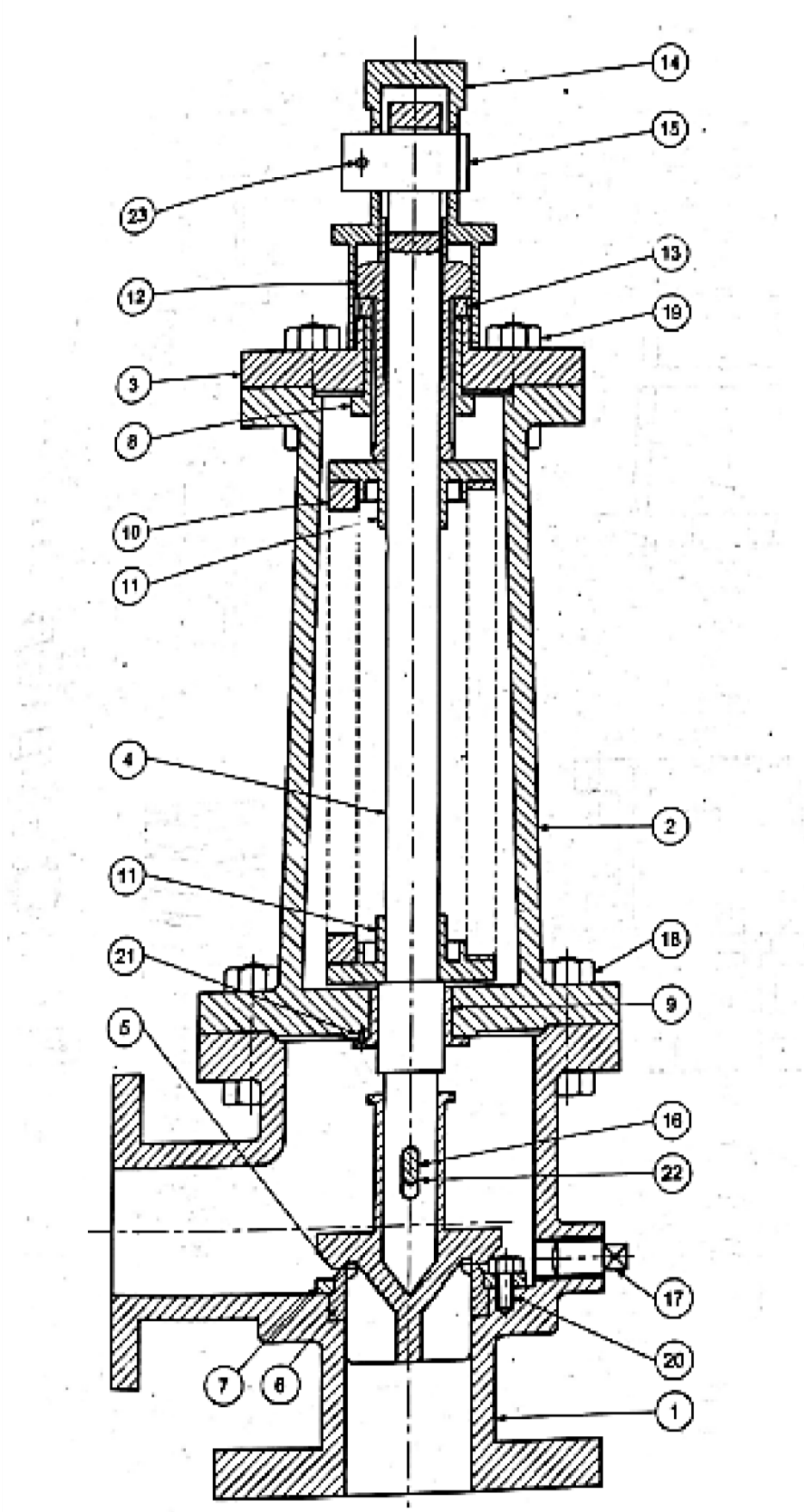


Fig: Assembly of Spring Loaded Safety Valve

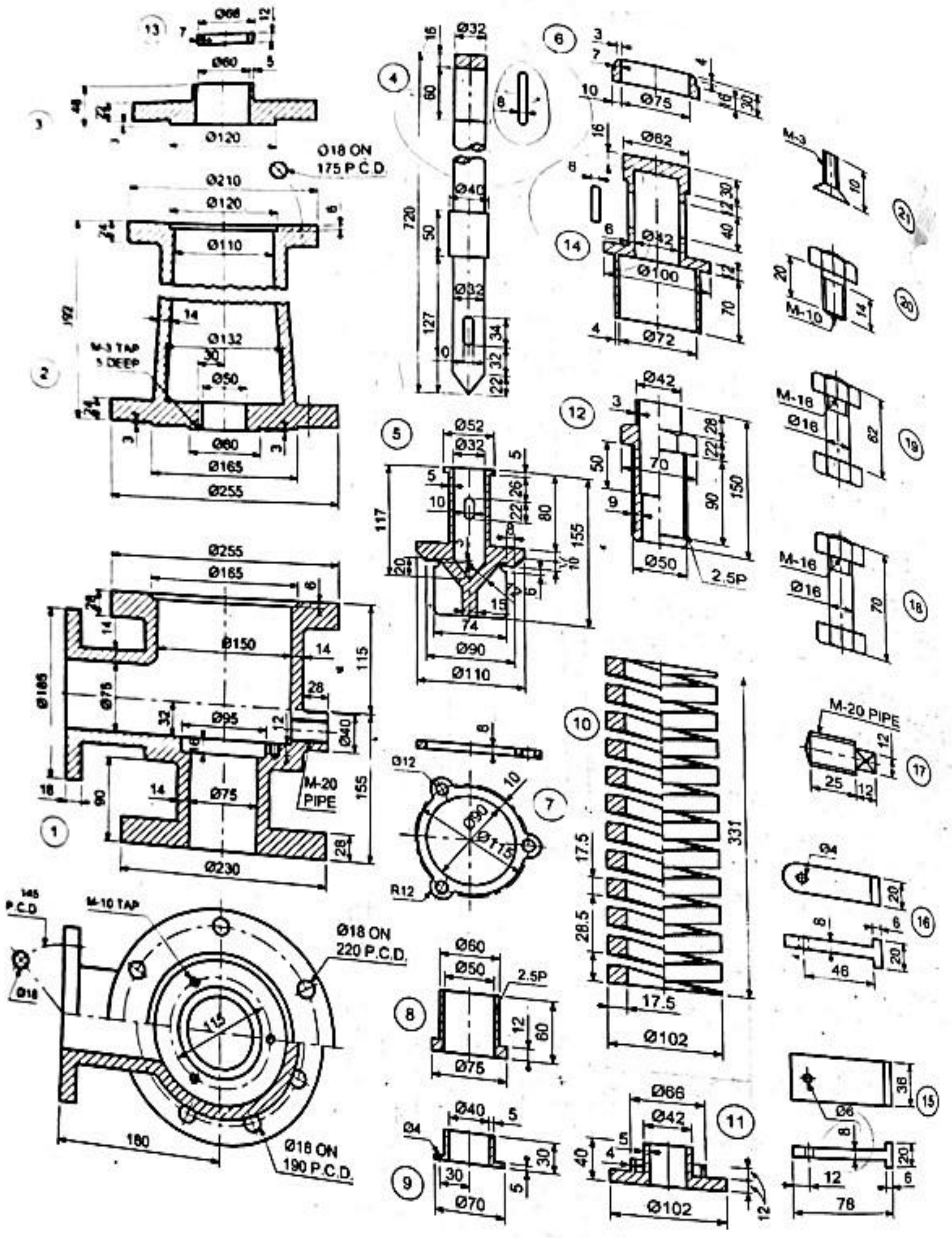


Fig: Detail of Spring Loaded Safety Valve

3. Steam Stop Valve

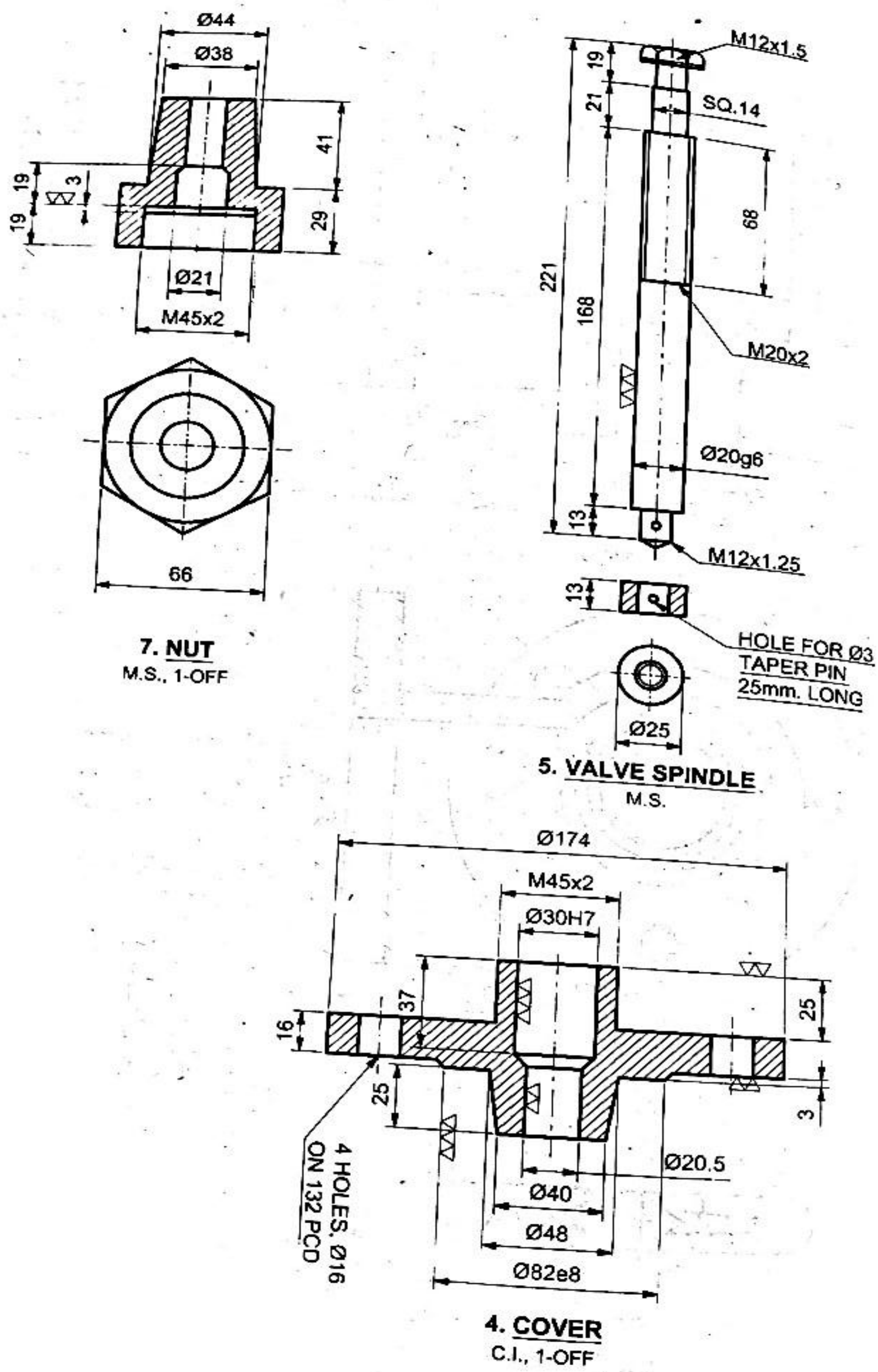


Fig: Assembly of Steam Stop Valve

TOLERANCE CHART

10H7 = +0.018 / +0.000	30H7 = +0.011 / +0.000
10e8 = -0.032 / -0.059	30e6 = +0.033 / +0.017
82H7 = +0.035 / +0.000	82e8 = -0.072 / -0.126
20H7 = +0.021 / +0.000	20g6 = -0.007 / -0.020

FIT CHART

10H7/e8 = CLEARANCE FIT
82H7/e8 = CLEARANCE FIT
30H7/n6 = TRANSITION FIT
20H7/g6 = CLEARANCE FIT

PART LIST

PART NO.	PART NAME	METL.	QTY.
1	BODY	C.I	1
2	VALVE SEAT	G.M.	1
3	VALVE	G.M	1
4	COVER	C.I.	1
5	SPINDLE	M.S.	1
6	GLAND	G.M	:
5	NUT	M.S.	1
6	HAND WHEEL	C.I.	1

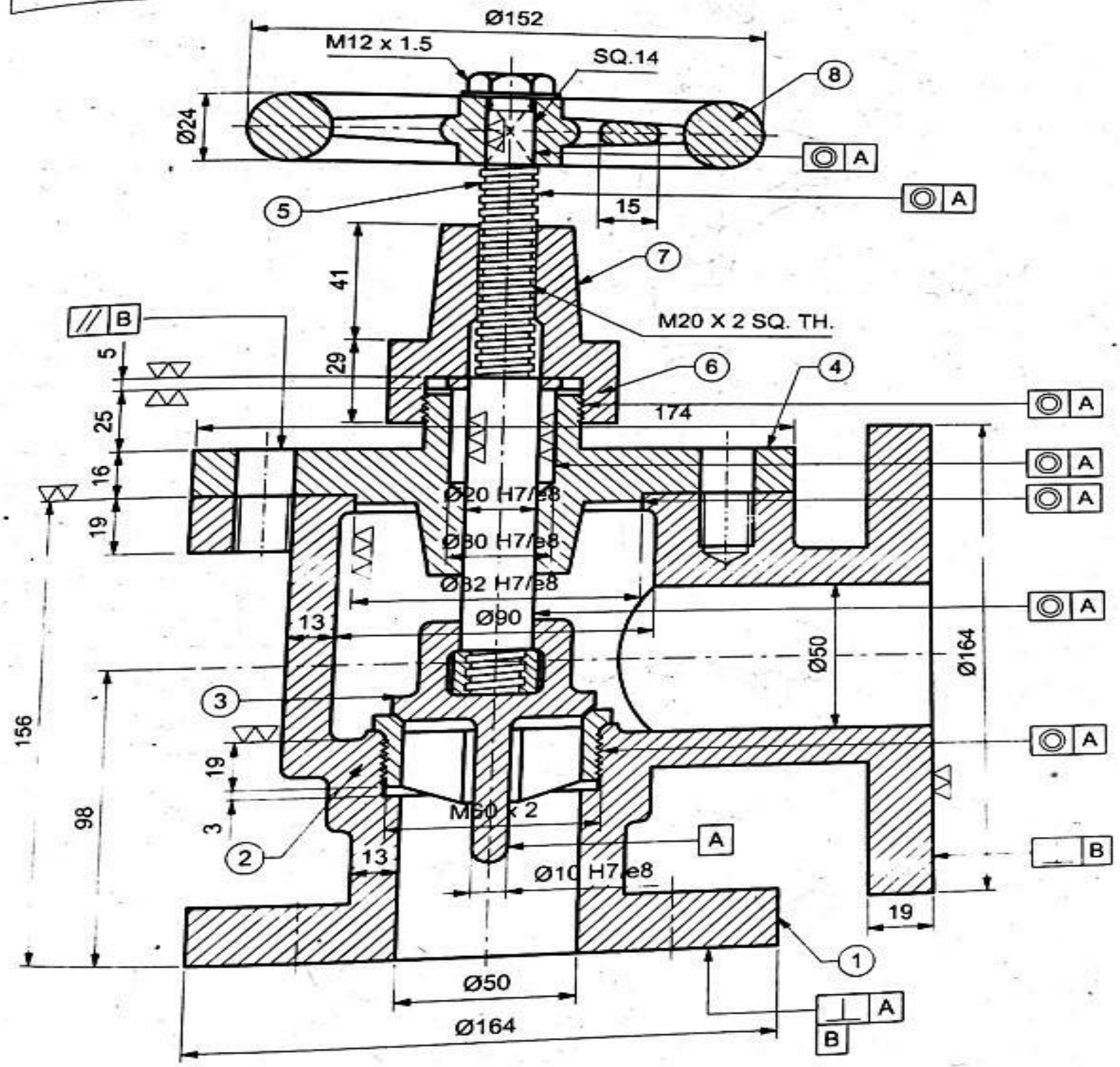
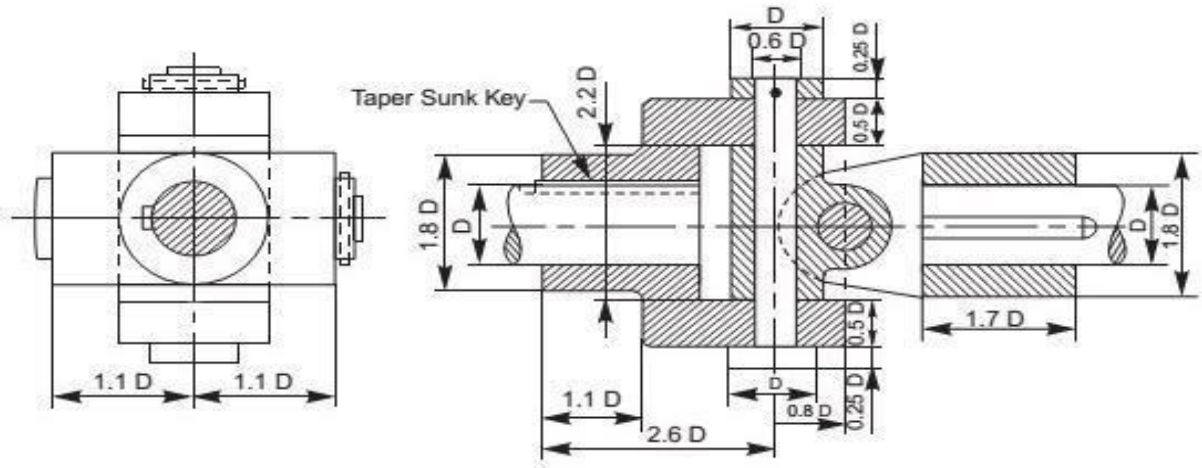
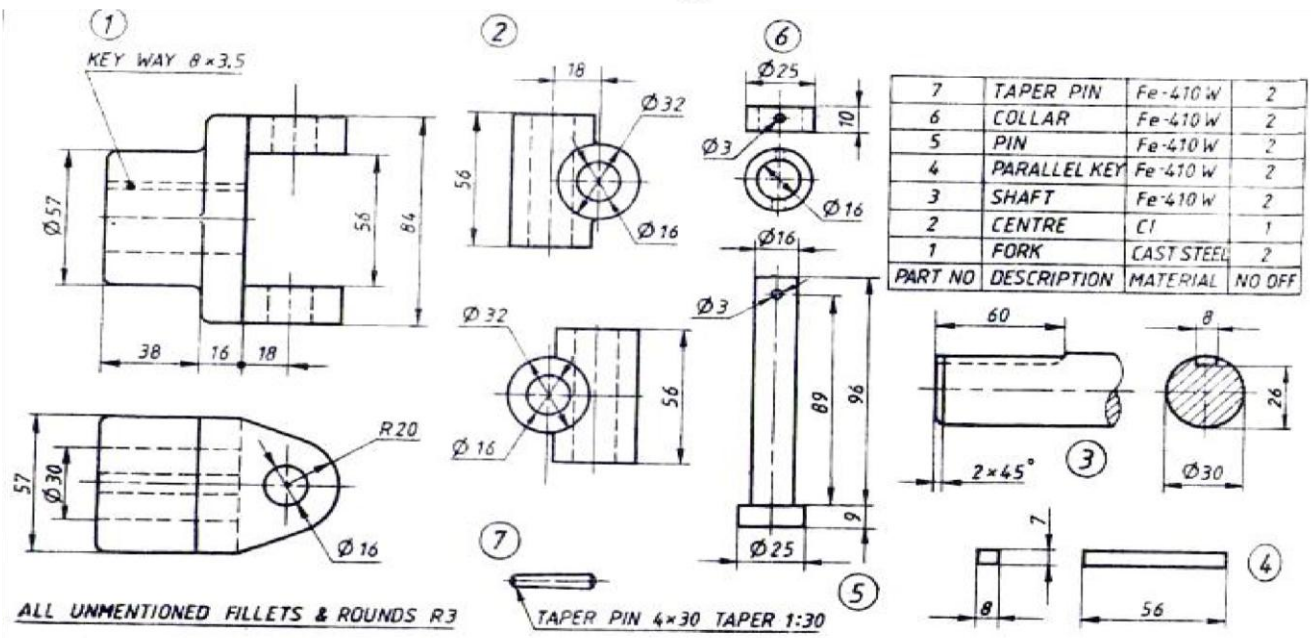


Fig: Detail of Steam Stop Valve

4. Universal Coupling



(b)



PART NO	DESCRIPTION	MATERIAL	NO OFF
7	TAPER PIN	Fe-410 W	2
6	COLLAR	Fe-410 W	2
5	PIN	Fe-410 W	2
4	PARALLEL KEY	Fe-410 W	2
3	SHAFT	Fe-410 W	2
2	CENTRE	CI	1
1	FORK	CAST STEEL	2

5. Flexible Coupling

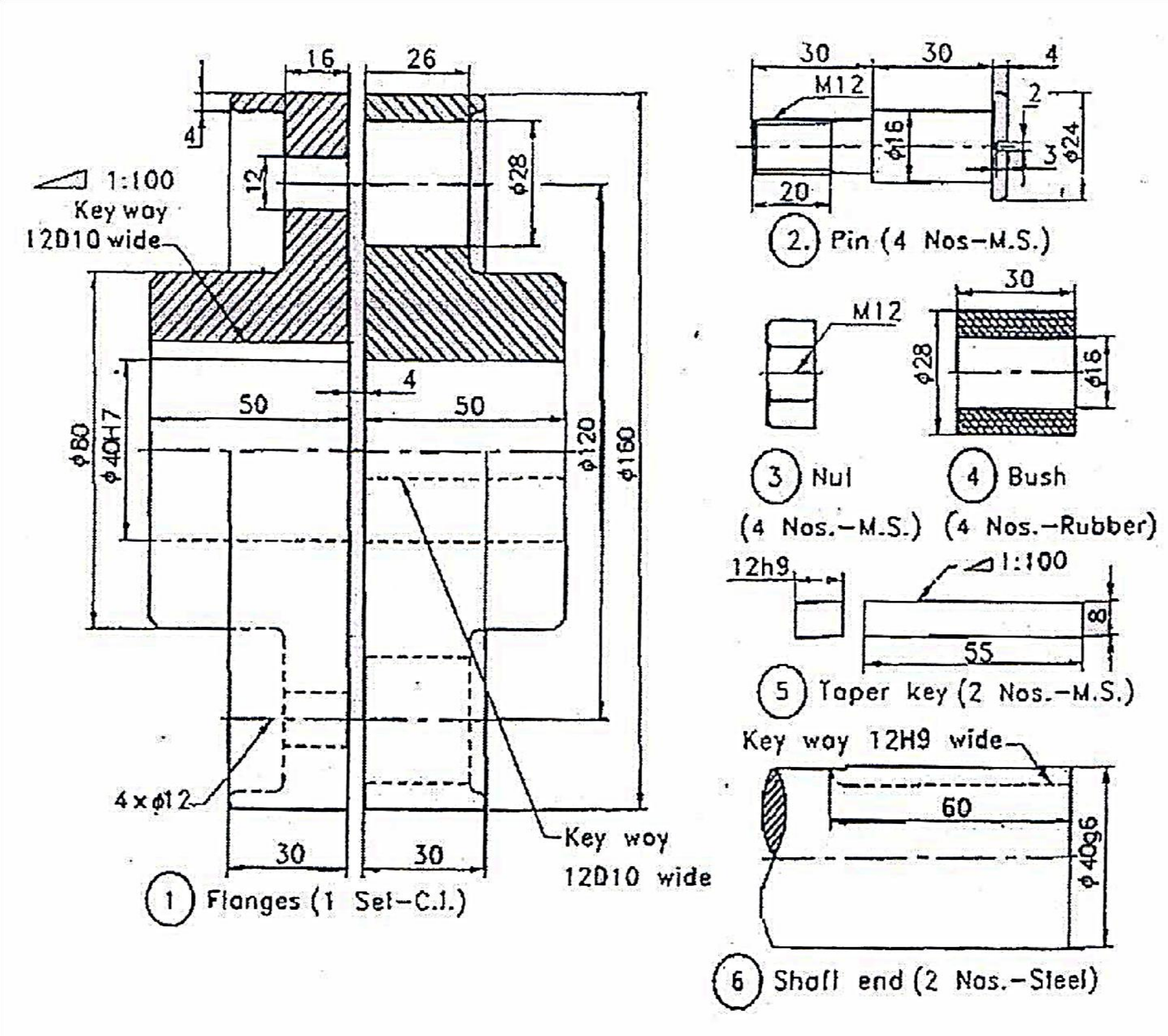


Fig. Detail & Assembly of Flexible Coupling

6. Caster

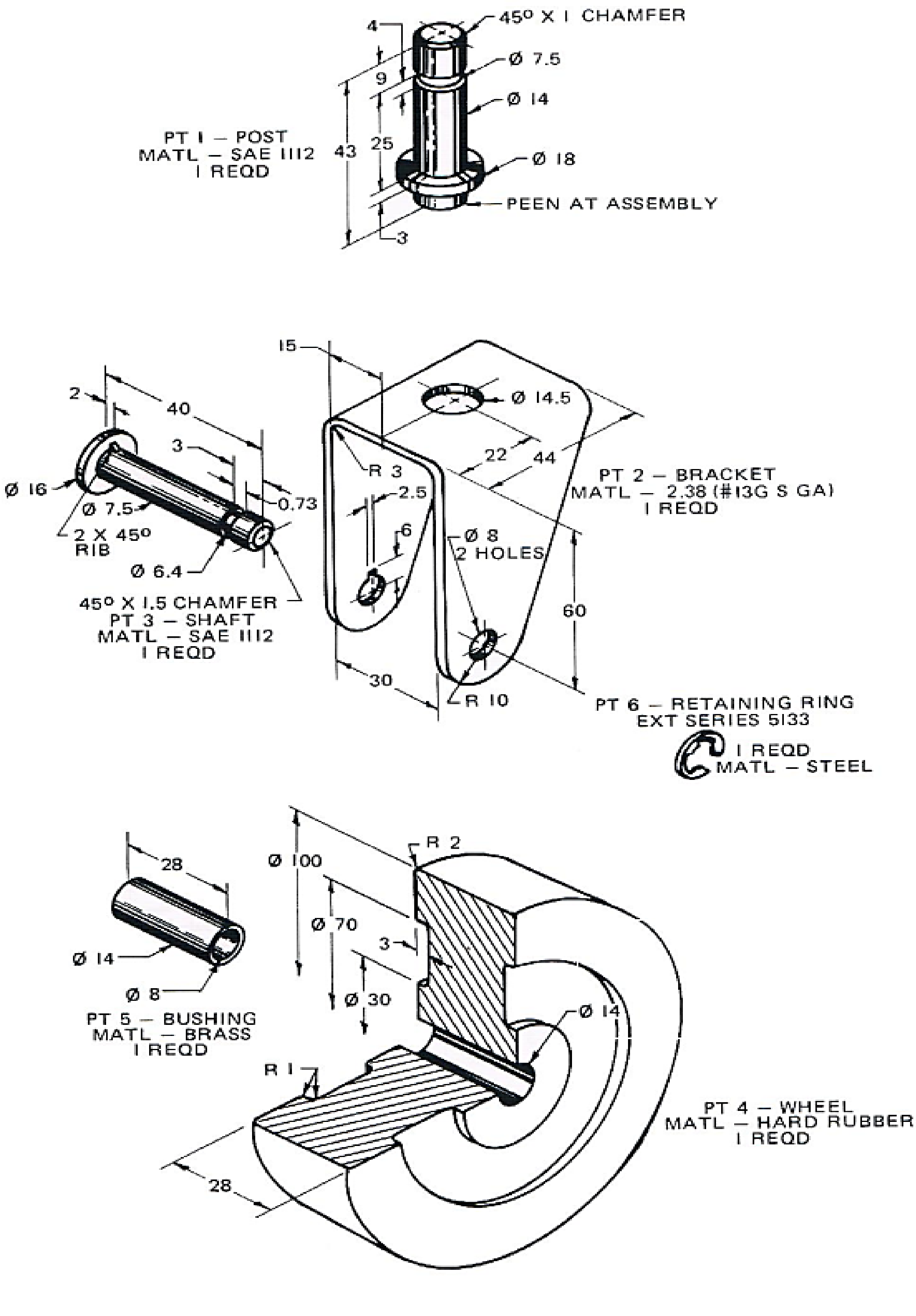


Fig. Detail & Assembly of **Caster**

7. C-clamp

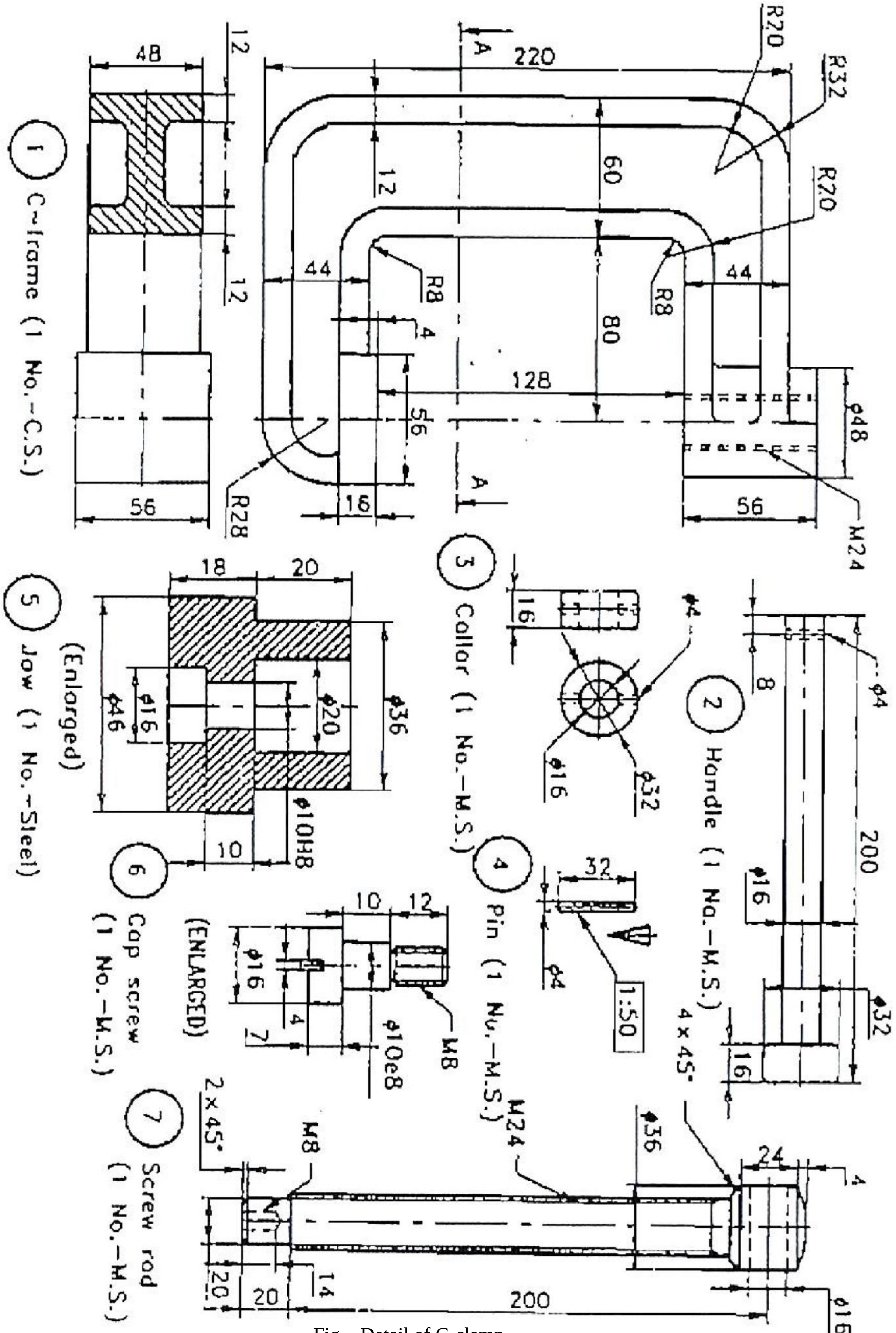


Fig. Detail of C-clamp

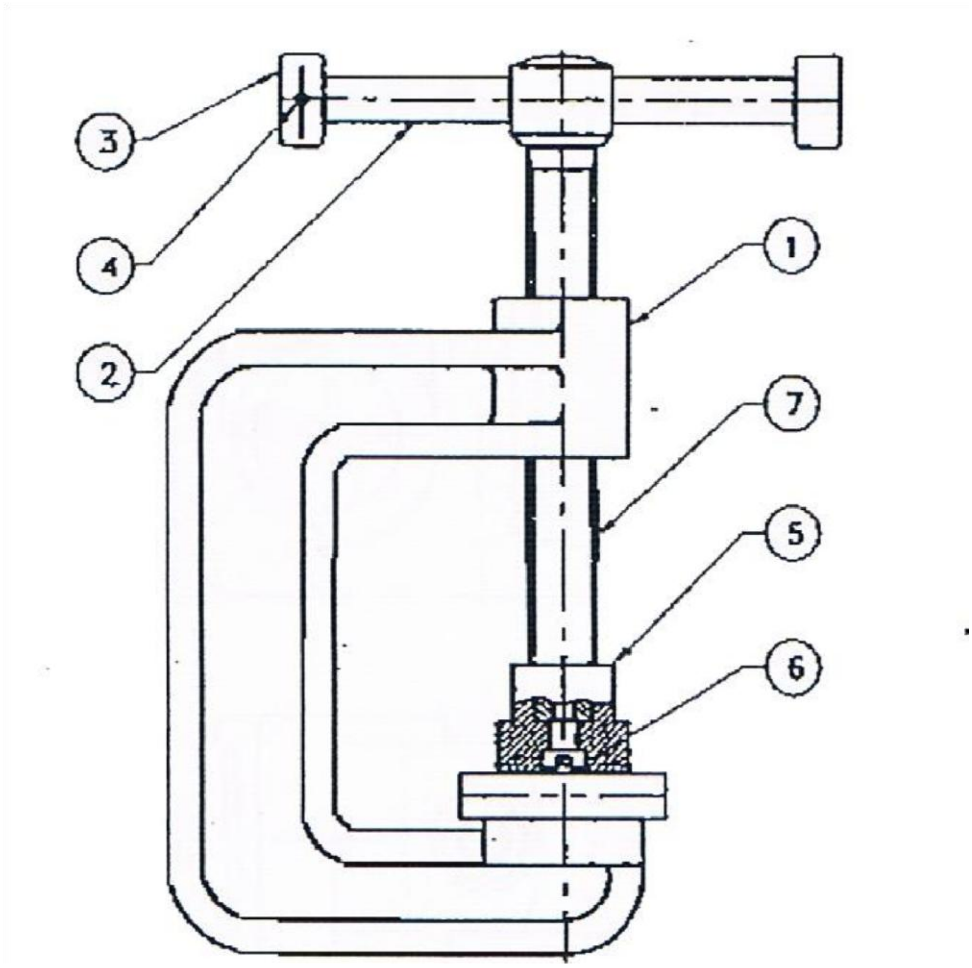


Fig. Assembly of C-clamp

7	**Screw rode**	**M.S.**		**1**
6	**Cap screw**	**M.S.**		**1**
5	**Jaw**	**Steel**		**1**
4	**Pin**	**M.S.**		**1**
3	**Collar**	**M.S.**		**1**
2	**Handle**	**M.S.**		**1**
1	**C-frame**	**C.S.**		**1**
No.	**Name of part**	**Material**	**Notes**	**Q**

8 Knuckle joint

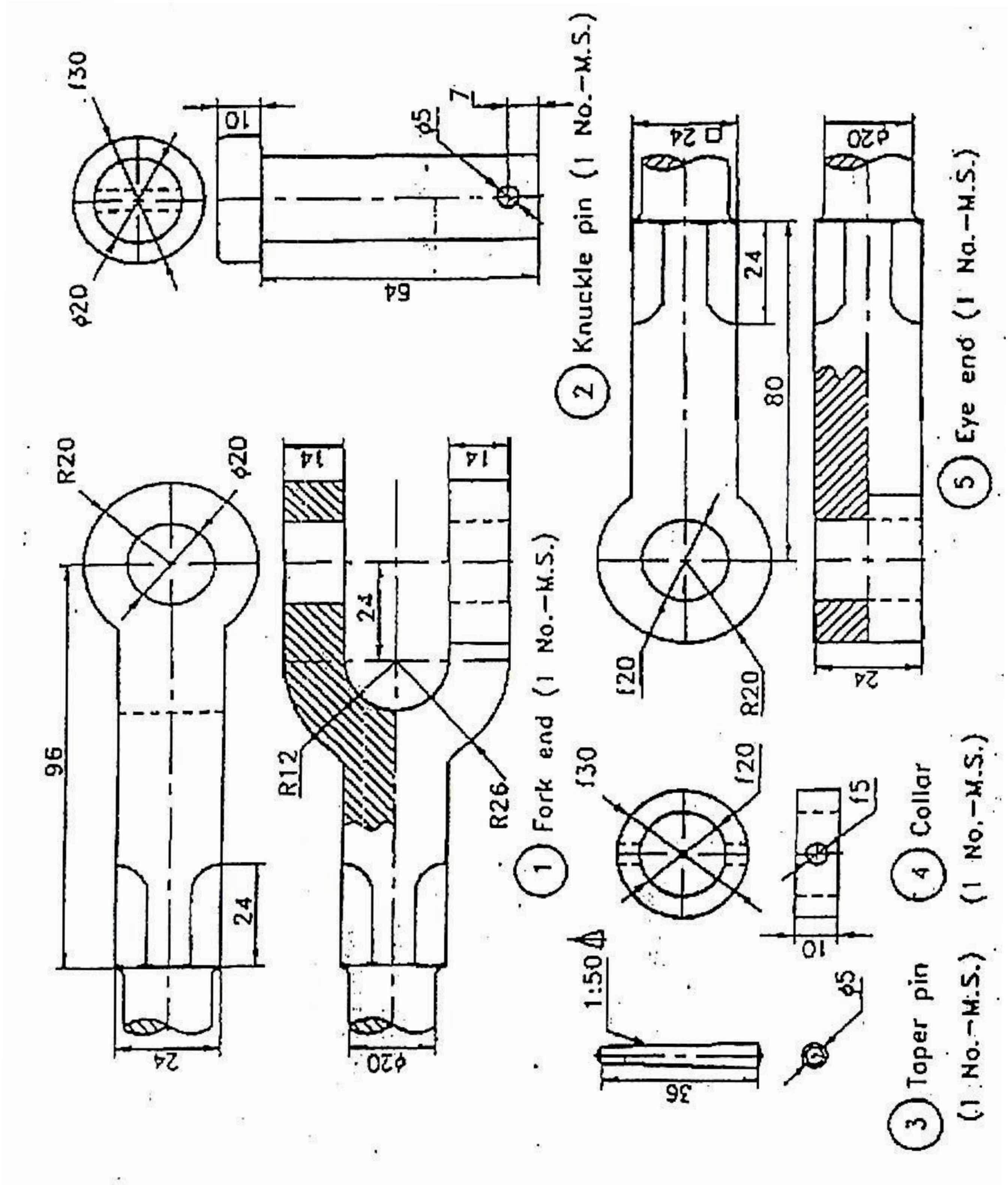


Fig. Detail and Assembly of Knuckle joint

9. Die Sets

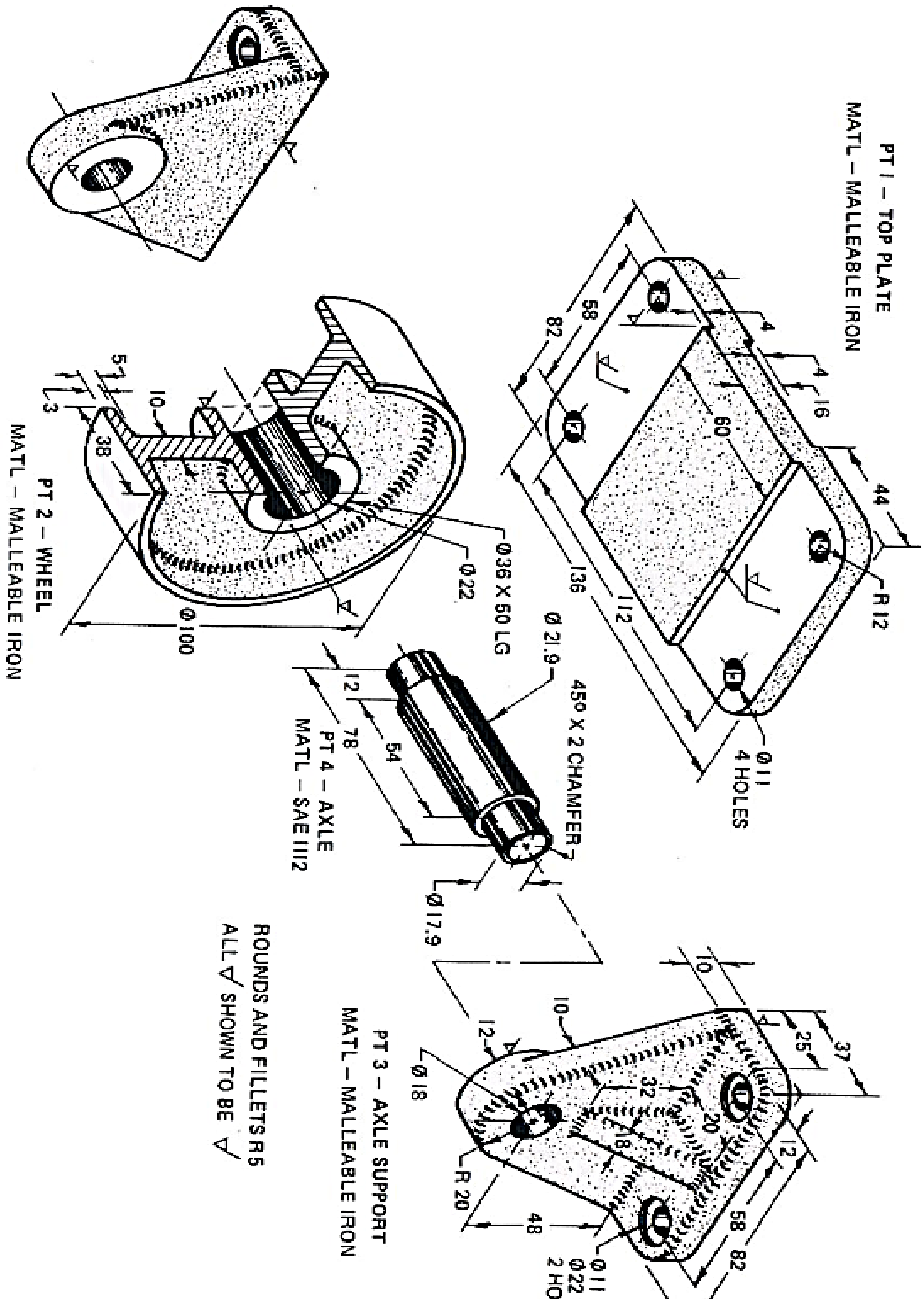
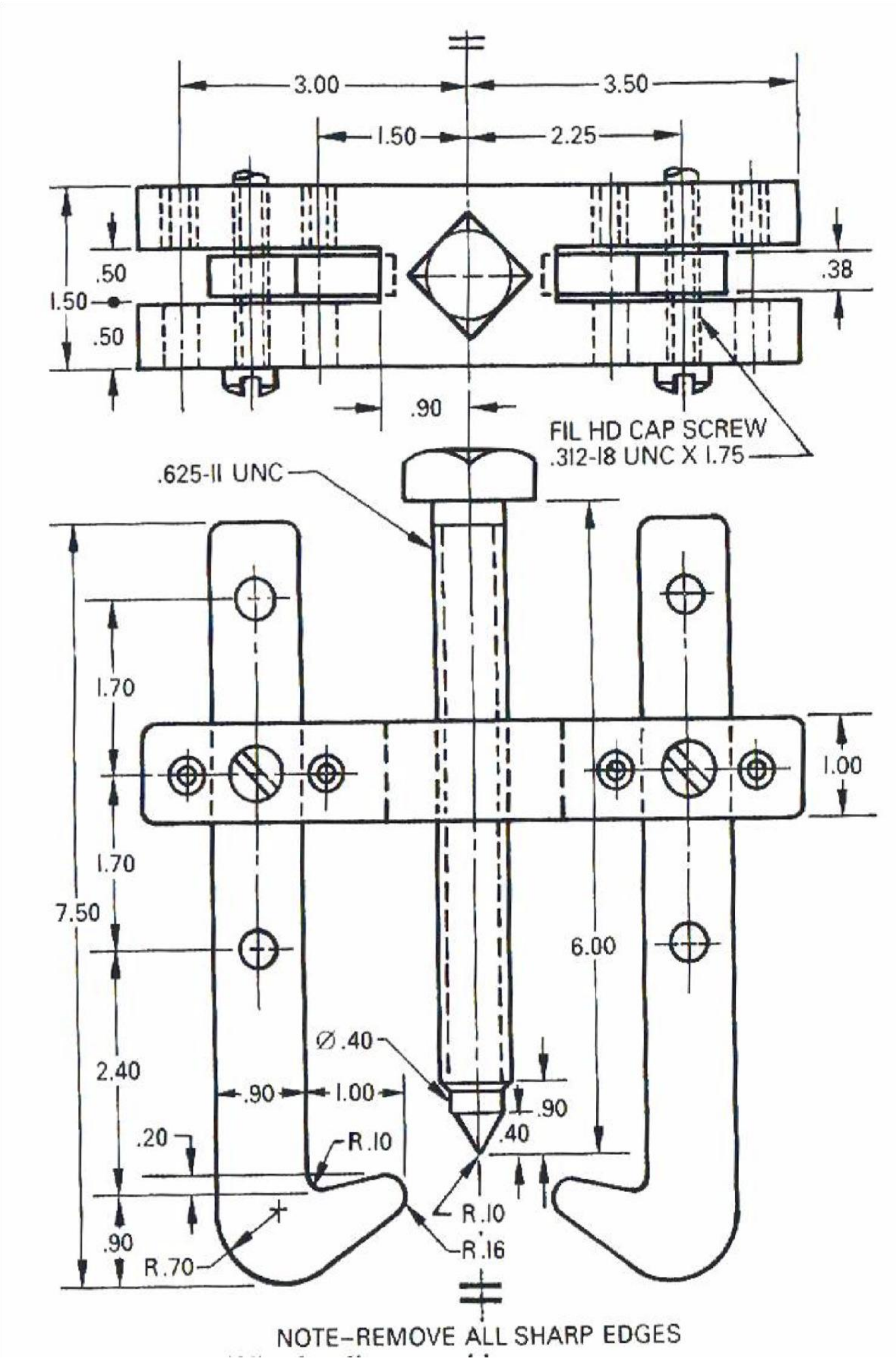
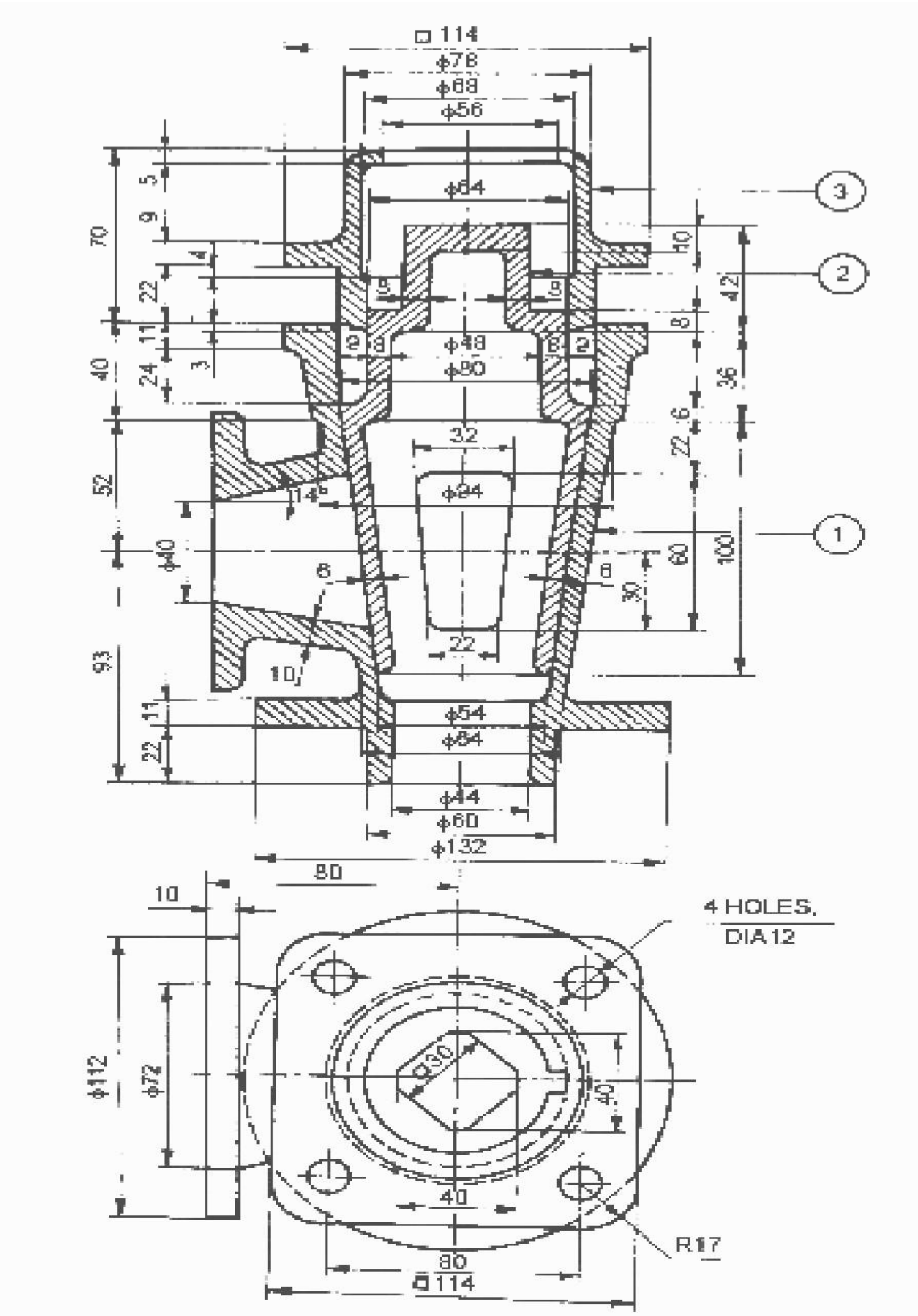


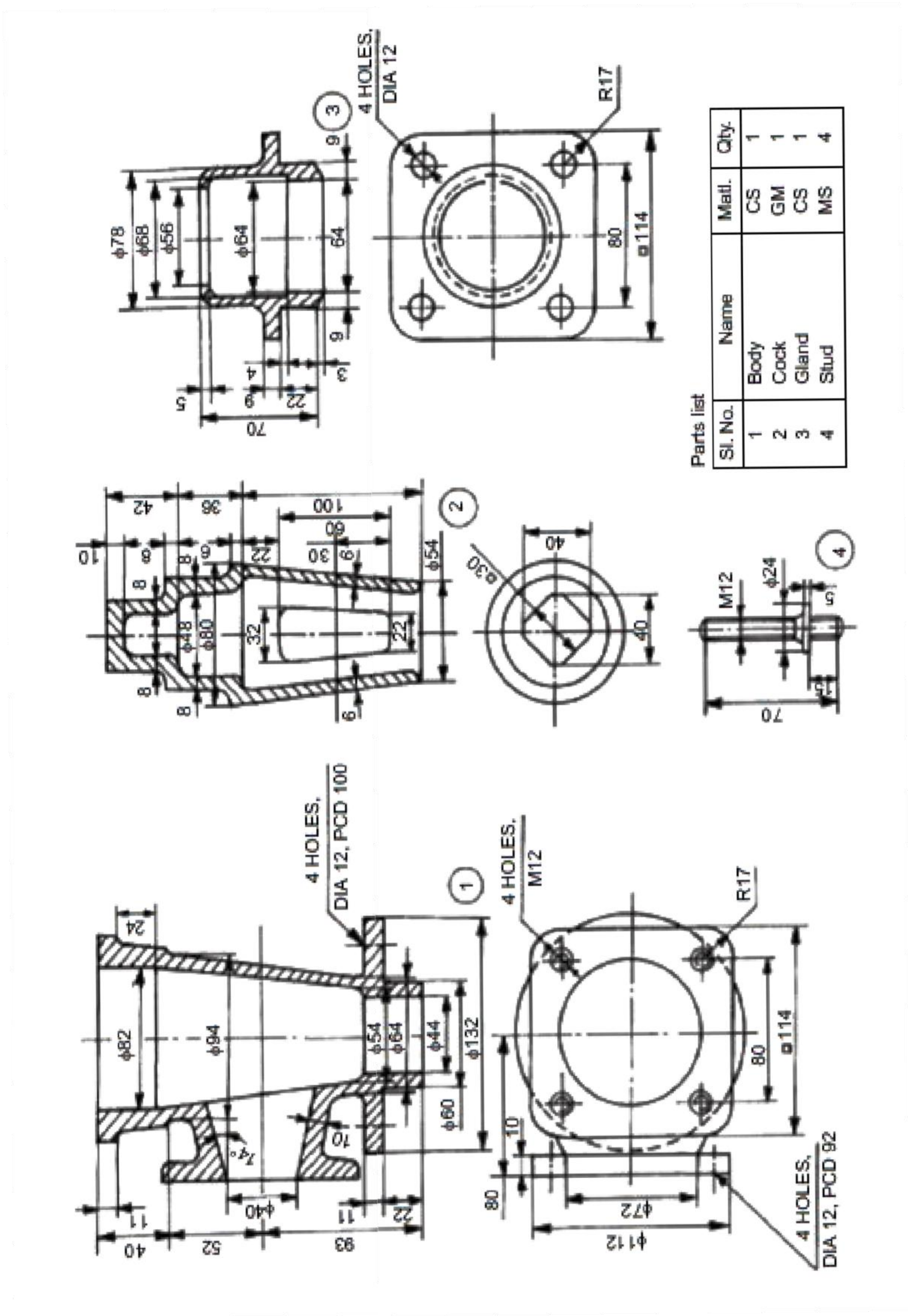
Fig. Detail and Assembly if Die sets

10 Wheel puller



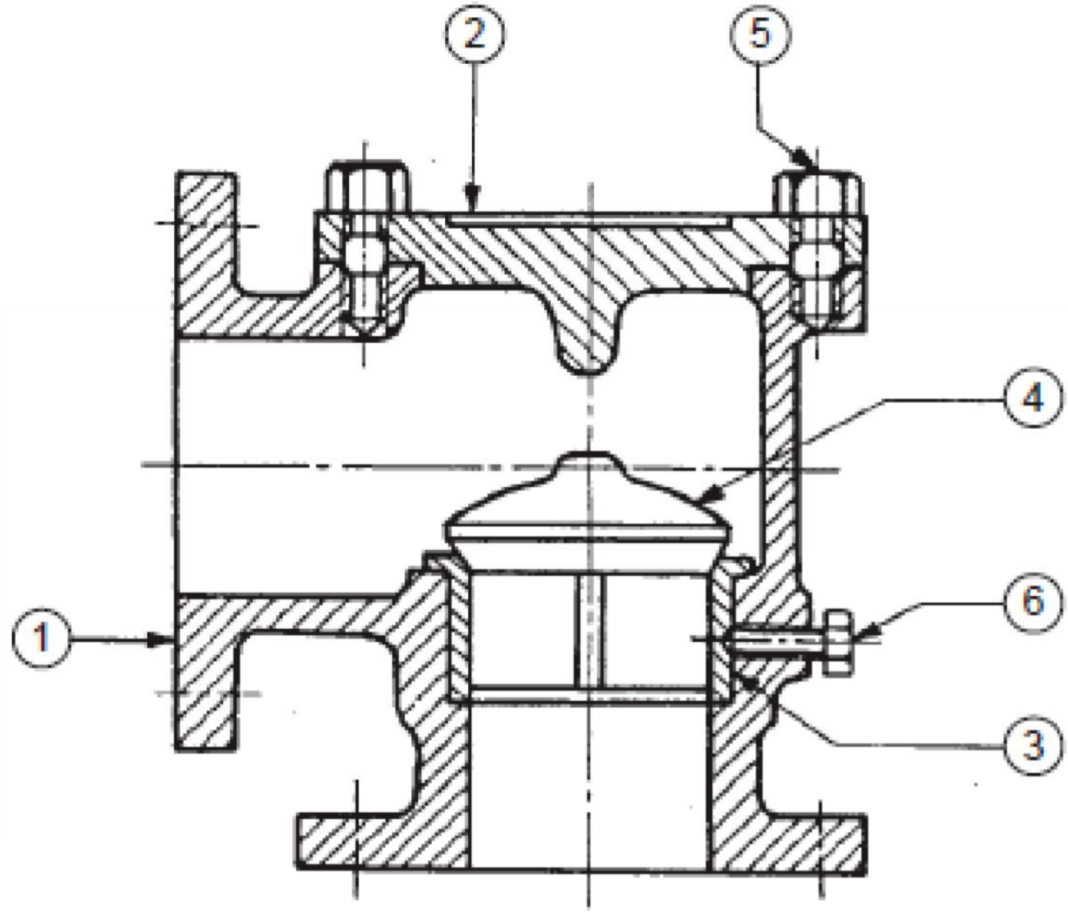
11 Blow off Cock

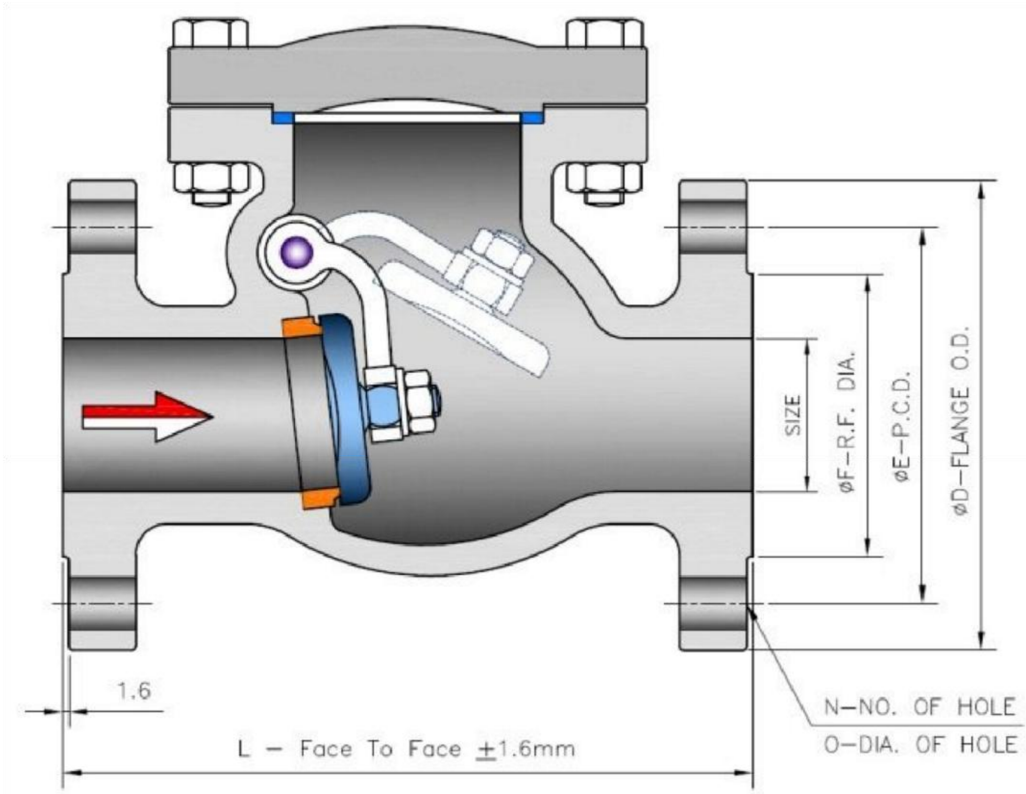


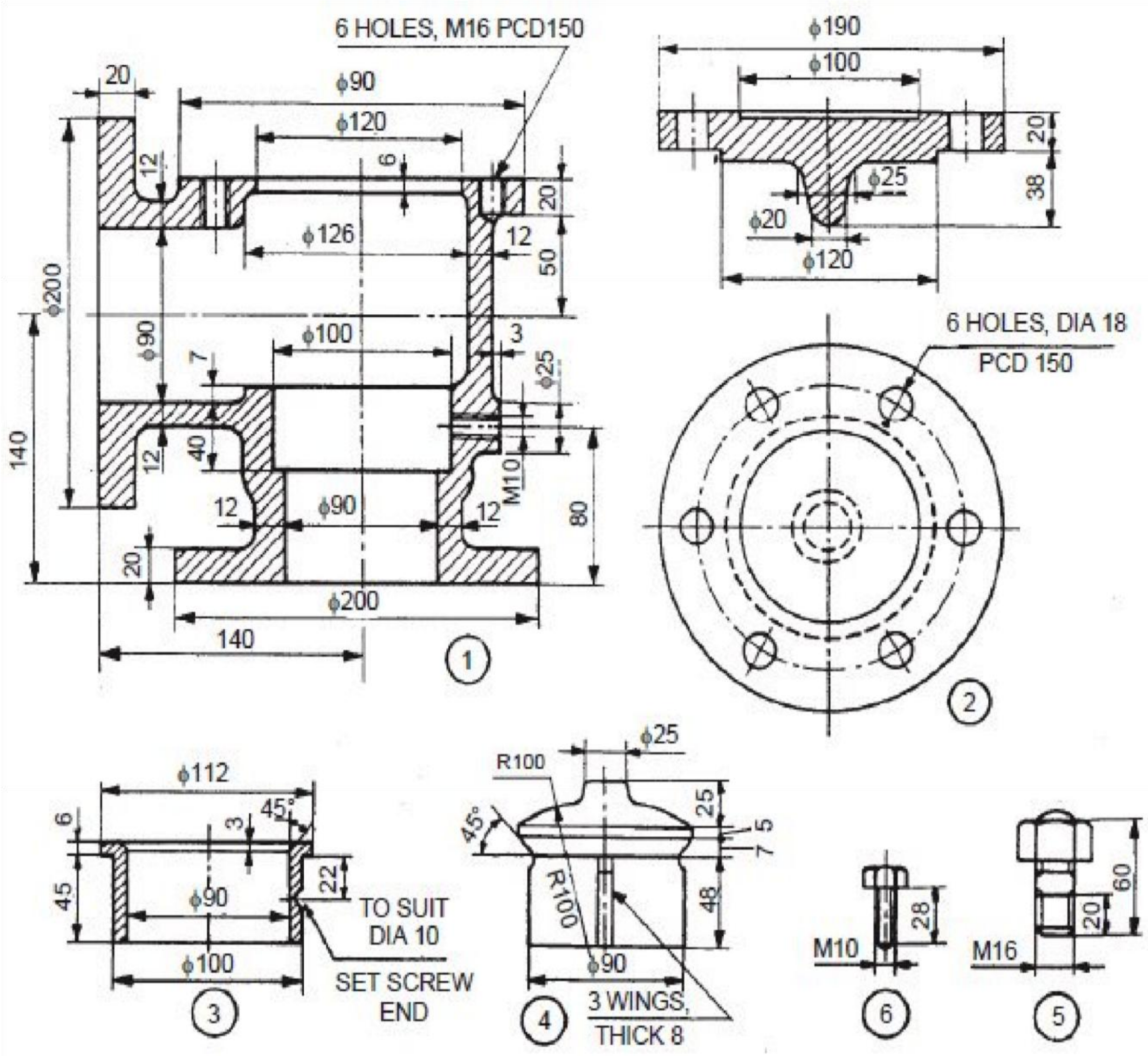


Detail of Blow off Cock

12 Non Return Valve







Parts list

No.	Name	Matl	Qty
1	Body	Brass	1
2	Cover	Brass	1
3	Valve seat	Bronze	1
4	Valve	Brass	1
5	Stud with nut	MS	6
6	Set screw	MS	1

Assignment

Machine Drawing and Elements of Machine Design

Subject Code: BE03000231

Bachelor of Engineering:

Mechanical Engineering/ Automobile Engineering /

Mechatronics / Manufacturing Engineering & Allied Branch

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