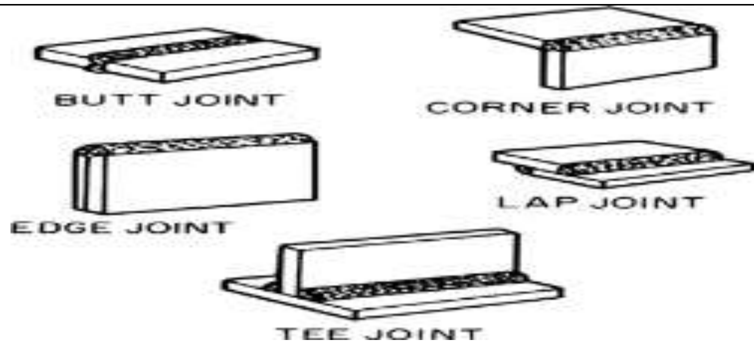
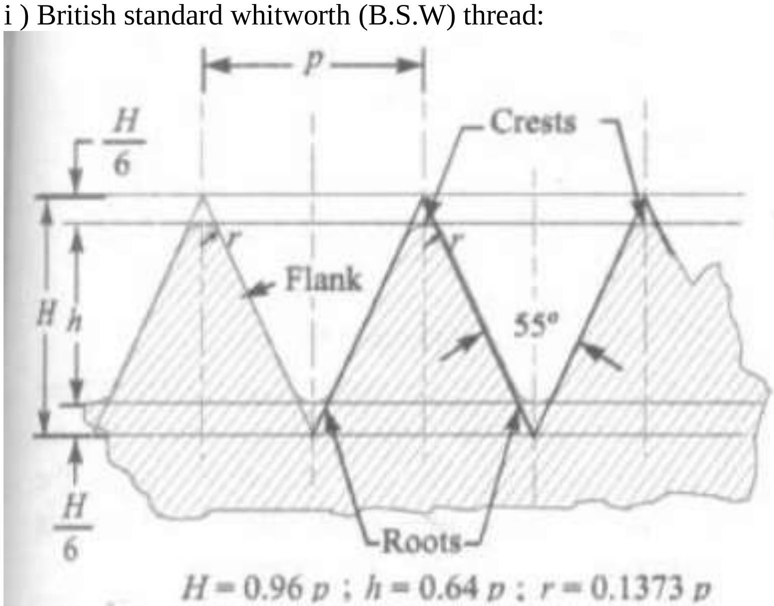
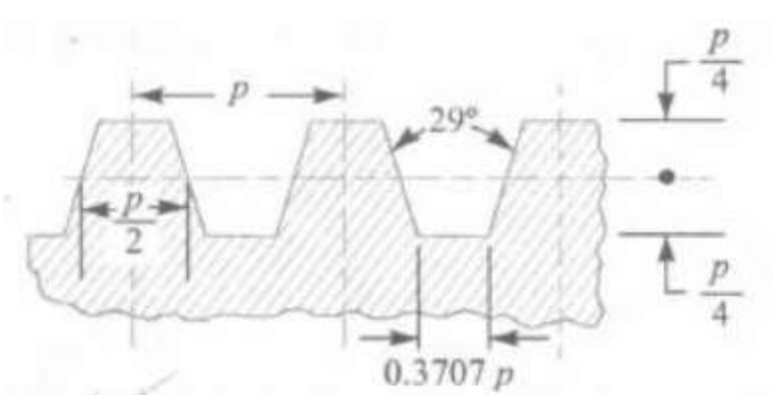
SUMMER – 17 EXAMINATIONS

Subject Code: **17553** **Model Answer** Page No: ____/ N

Important Instructions to examiners:

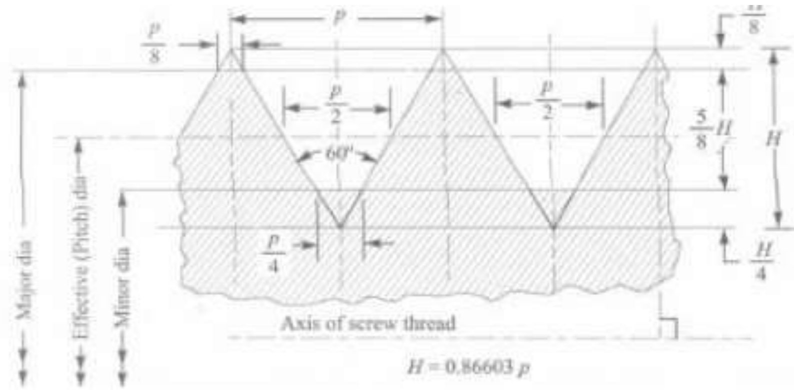
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more importance. (Not applicable for subject English and Communication Skills)
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q. NO.	MODEL ANSWER	MARKS	TOTAL MARKS
1	**Attempt any FIVE of the following:**		**5X4=20**
a	**The general procedure of machine design is as follows:** 1. Recognition of need: First of all, make a complete statement of the problem, indicating the need, aim or purpose for which the machine is to be designed. 2. Synthesis (Mechanisms): Select the possible mechanism or group of mechanisms which will give the desired motion. 3. Analysis of forces: Find the forces acting on each member of the machine and the energy transmitted by each member. 4. Material selection: Select the material best suited for each member of the machine. 5. Design of elements (Size and Stresses):Find the size of each member of the machine by considering the force acting on the member and the permissible stresses for the material used. It should be kept in mind that each member should not deflect or deform than the permissible limit. 6. Modification: Modify the size of the member to agree with the past experience and judgement to facilitate manufacture. The modification may also be necessary by consideration of manufacturing to reduce overall cost. 7. Detailed drawing: Draw the detailed drawing of each component and the assembly of the machine with complete specification for the manufacturing processes suggested. 8. Production: The component, as per the drawing, is manufactured in the workshop.	1/2 mark each for each step points.	**4M**
b	**Standard Sizes of Transmission Shafts** The standard sizes of transmission shafts are : 25 mm to 60 mm with 5 mm steps; 60 mm to 110 mm with 10 mm steps; 110 mm with 15 mm steps; and 140 mm to 500 mm with 20 mm steps. The standard length of the shafts are 5 m, 6 m and 7 m]	01 mark each for each size any 4	**04 marks**
c	Following are the types:- 1)Butt joint 2) Corner joint 3)edge joint 4)Lap joint 5) tee joint	2m Any 2 name	**4m**

		2m Any 2 dia	
d	i) British standard whitworth (B.S.W) thread:  This is a British standard thread profile and has coarse pitches. It is a symmetrical V-thread in which the angle between the flankes, measured in an axial plane, is 550These threads are found on bolts and screwed fastenings for special purposes.The various proportions of B.S.W. threads are shown in Fig. ii)Acme thread 	4m Any 2	**4m**

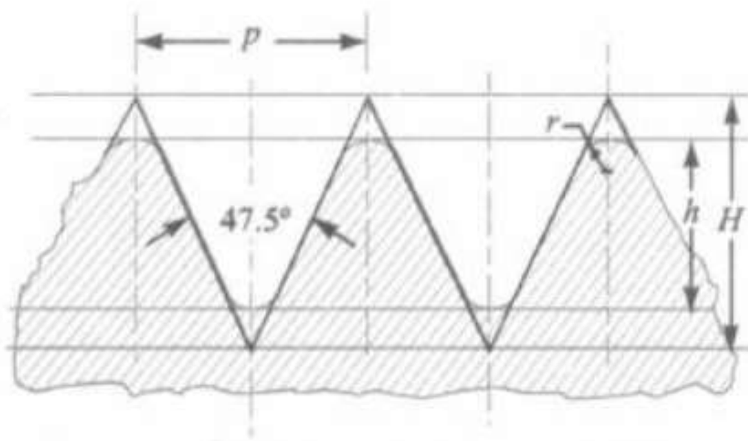
It is a modification of square thread. It is much stronger than square thread and can be easily produced. These threads are frequently used on screw cutting lathes, brass valves,cocks and bench vices.

iii) Metric Threads



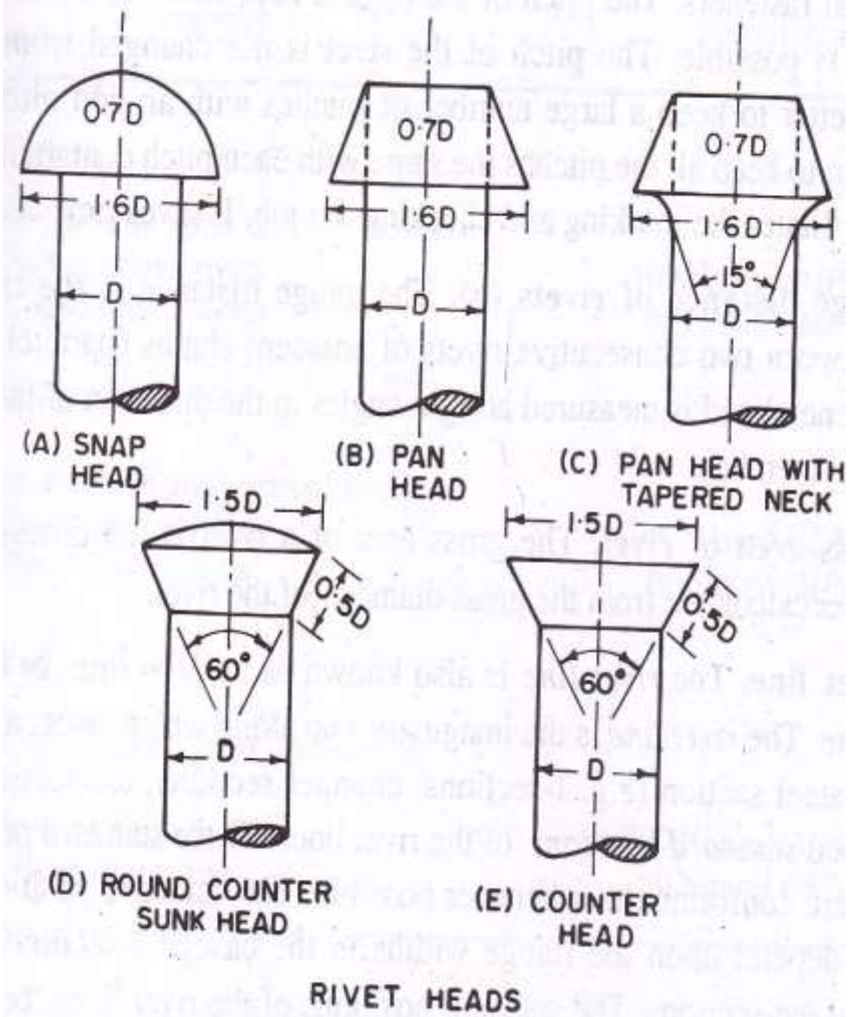
It is an Indian standard thread and is similar to B.S.W. threads. It has an included angle of 60° instead of 55°. The basic profile of the thread is shown in Fig.a and the design profIle of the nut and bolt is shown in Fig.

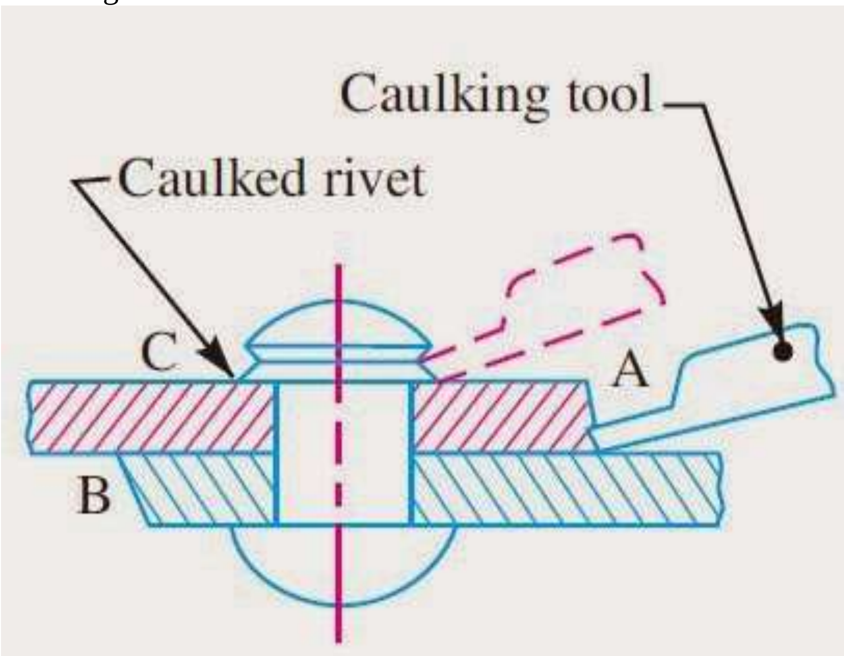
iv) British association (B.A.) thread.

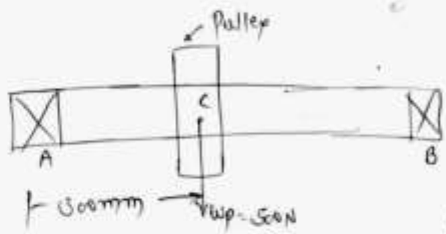
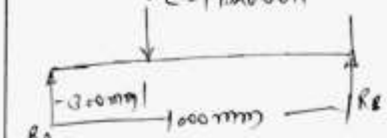


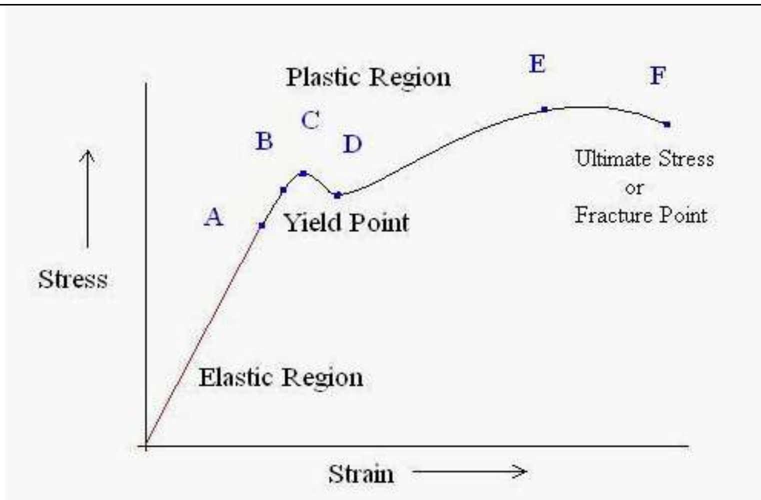
$H = 1.13634\,p$; $h = 0.6\,p$; $r = 0.18083\,p$

This is a B.S.W. thread with fine pitches. The proportions of the B.A. thread
are shown in Fig. These threads are used for instruments and other precision works.

e		04 m Any 4	**4m**
f	**Perfect frame :** A pin-jointed frame which has got just sufficient number of members to resist the loads without undergoing appreciable deformation in shape is called rigid or perfect frame. The perfect frame obeys the following condition viz. $n = 2j - 3$ where, n= no. of links and j= no. of joints **Ductility:-** It is the property ofmaterial by virtue of which it can be drawn into thin wires. Eg:- Alluminum, Copper etc.	2m 2m	**4m**
g	**Factor of Safety** It is defined, in general, as the ratio of the maximum stress to the working stress. Mathematically, Factor of safety = Maximum stress / Working or design stress In case of ductile materials e.g. mild steel, where the yield point is clearly defined, the factor of safety is based upon the yield point stress. In such cases,	2 marks	**4m**

	Factor of safety = Yield point stress / Working or design stress **Factors affecting selection of FOS:-** 1.The reliability of the properties of the material and change of these properties during service; 2. The reliability of test results and accuracy of application of these results to actual machine parts; 3. The reliability of applied load ; 4. The certainty as to exact mode of failure ; 5. The extent of simplifying assumptions; 6. The extent of localised stresses; 7. The extent of initial stresses set up during manufacture; 8. The extent of loss of life if failure occurs; and 9. The extent of loss of property if failure occurs.	2 marks. Any 2	
h.	Caulking:-  In order to make the joints leak proof or fluid tight in pressure vessels like steam boilers, air receivers and tanks etc. a process known as **caulking** is employed. In this process, a narrow bunt tool called caulking tool about 5 mm thick and 38 mm in breadth is used. The edge of the tool is ground to an angle of 80°.	2 marks dia 2 marks.	**4m**

2.	**Attempt any TWO of the following:**		8X2=16
a	 Given $P = 15kw = 15\times10^3 W$ $N = 300 rpm$ $D_p = 200 mm$ $R_p = 100 mm$ $W_p = 500 N$ $\frac{T_1}{T_2} = \frac{2}{1}$, $\sigma_t = 70 N/mm^2$ $\tau = 56 N/mm^2$ 1) To Find Torque $P = \frac{2\pi N T}{60}$ $\therefore T = \frac{60\times P}{2\pi N}$ $= \frac{60\times15\times10^3}{2\times\pi\times300}$ $T = 477.71\times10^3 N.mm$ 2) To Find Total load acting at C (W_c) we know $T_1 = 2T_2$ & $T = (T_1 - T_2) R_p$ $= (2T_2 - T_2) R_p$ $477.77\times10^3 = 2T_2\times100$ $\therefore T_2 = 4777.10 N$ $\therefore T_1 = 2T_2$ $\therefore T_1 = 9554.10 N$ $\therefore W_c = T_1 + T_2 + W_p$ $W_c = 14826.30 N$ 3) To Find R_A, R_B & M_{max} $W_c = 14826.30N$  Taking $\Sigma f_y = 0$ $R_A + R_B = 14826.30 N$ Taking $\Sigma M_A = 0$ $(R_A\times0) + (14826.300) - (1000 R_B) = 0$ $\therefore R_B = 4447.89 N$ $R_A = 10378.41 N$ Therefore Maximum Moment will occur at C $M_c = R_A\times300$ $M_c = 3.11\times10^6 N.mm$	2m for each step	**8m**

b.	 A. Proportional limit: Hooke's law holds good up to point A and it is known as proportional limit. It is defined as that stress at which the stress-strain curve begins to deviate from the straight B. Elastic limit: The material has elastic properties up to the point B. This point is known as elastic limit. It is defined as the stress developed in the material without any permanent set C & D. Yeild Point: There are two yield points C and D. The points C and D are called the upper and lower yield points respectively. E. Ultimate stress: At E, the stress, which attains its maximum value is known as ultimate stress. F. Breaking strength: Failure is complete	4m Dia 4m	**8m**
c	**Advantages:-** 1. The welded structures are usually lighter than riveted structures. This is due to the reason that in welding, gussets or other connecting components are not used. 2. The welded joints provide maximum efficiency (may be 100%) which is not possible in case of riveted joints. 3. Alterations and additions can be easily made in the existing structures 4. As the welded structure is smooth in appearance, therefore it looks pleasing. 5. In welded connections, the tension members are not weakened as in the case of riveted joints. 6. A welded joint has a great strength. Often a welded joint has the strength of the parent metal itself. 7. Sometimes, the members are of such a shape (i.e. circular steel pipe) that they afford difficulty for riveting. But they can be easily welded. 8. The welding provides very rigid joints. This is in line with the modern trend of providing rigid frames. 9. It is possible to weld any part of a structure at any point. But	4m (any4)	**08 marks**

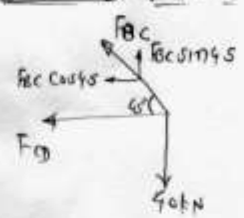
	riveting requires enough clearance. 10. The process of welding takes less time than the riveting. **Disadvantages:-** 1.Since there is an uneven heating and cooling during fabrication, therefore the member may get distorted or additional stresses may develop. 2. It requires a highly skilled labour and supervision. 3. Since no provision is kept for expansion and contraction in the frame, therefore there is a possibility of cracks developing in it. 4. The inspection of welding work is more difficult than riveting work.	4m (any4)	
3.	**Attempt any TWO of the following:**		**2X8=16**
a	(handwritten solution below)	2m for each isolating joint and 2 m for table	**08m**

Q. 3. a

By Geometry of the figure :

∠ BCD = ∠ BED = ∠ ABE = 45°

Isolating Joint C



Taking $\Sigma F_y = 0$

$F_{BC} \sin 45 - 40 = 0$

$0.71 F_{BC} = 40$

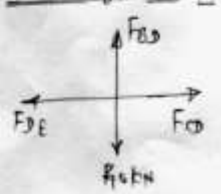
$F_{BC} = 56.56 kN$ T

Taking $\Sigma F_x = 0$

$-F_{BC} \cos 45 = F_{CD}$

$F_{CD} = -39.39 kN$ C

Isolating Joint D



Taking $\Sigma F_y = 0$

$F_{BD} - 40 = 0$

$F_{BD} = 40 kN$ T

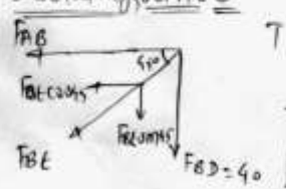
Taking $\Sigma F_x = 0$

$F_{CD} - F_{DE} = 0$

$\therefore F_{CD} = F_{DE}$

$\therefore F_{DE} = -39.39 kN$ C

Isolating Joint B



Taking $\Sigma F_y = 0$

$-40 - F_{BE} \sin 45 = 0$

$-40 = F_{BE} \sin 45$

$F_{BE} = -56.56 kN$ C

Taking $\Sigma F_x = 0$

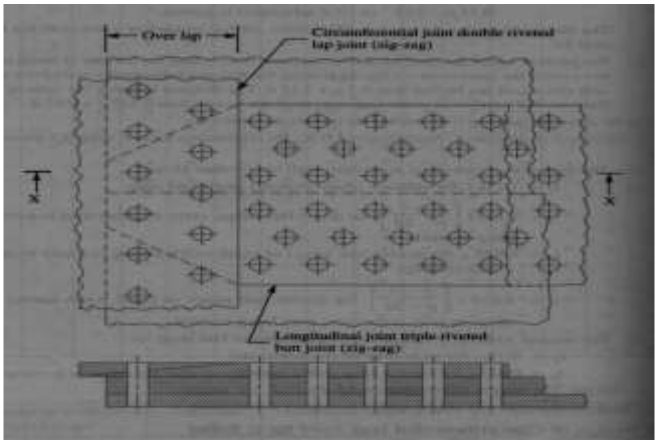
$-F_{AB} - F_{BE} \cos 45 = 0$

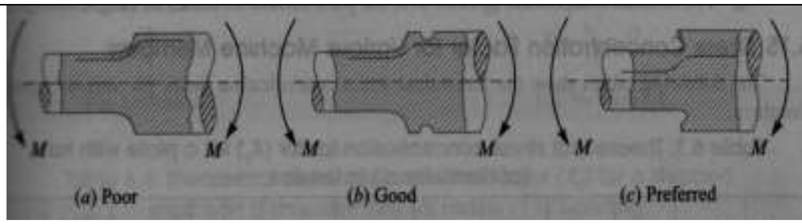
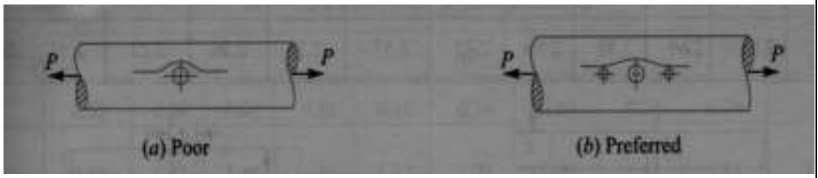
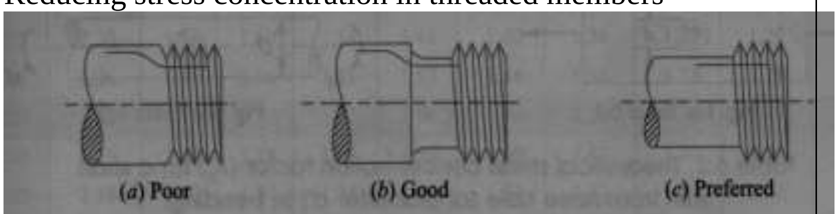
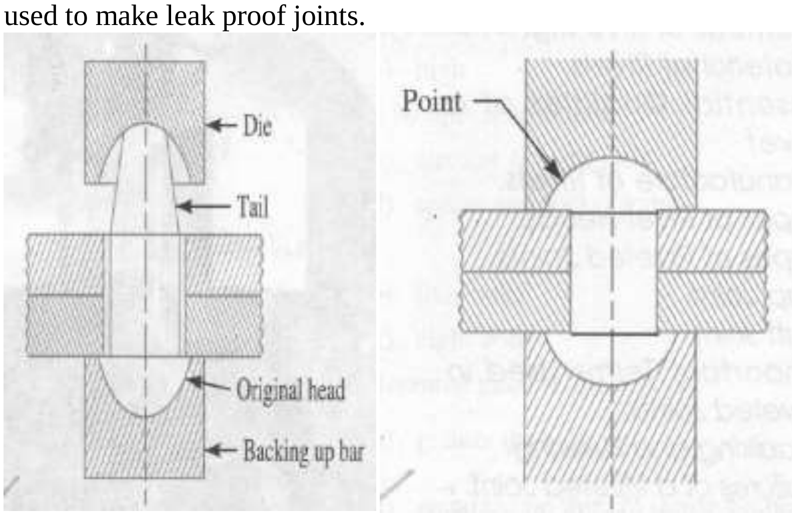
$-F_{AB} = F_{BE} \cos 45$

$= -56.56 \cos 45$

$F_{AB} = 39.39 kN$ T

Sr No	Member	Magnitude	Nature
1	BC	56.56 kN	T
2	BD	40 kN	T
3	CD	-39.39 kN	C
4	DE	-39.39 kN	C
5	BE	-56.56 kN	C
6	AB	39.39 kN	T

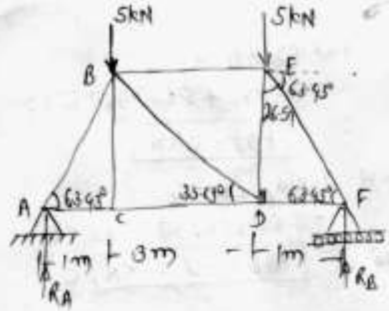
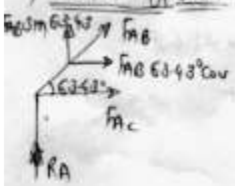
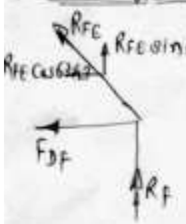
b	The following procedure is adopted for the design of circumferential lap joint for a boiler. 1. Thickness of the shell and diameter of rivets: The thickness of the boiler shell and the diameter of the river will be same as for longitudinal joint. 2. Number of rivets:	01 mark 01 mark	**8m**
	 	01 mark for figure	
	Since it is a lap joint, therefore the rivets will be in single shear. Shearing resistance of the rivets, $P_s = n \times \pi/4 \times d^2 \times T$ ……..(i) Where n = Total number of rivets. Knowing the inner diameter of the boiler shell (D), and the pressure of steam (P) the total shearing load acting on the circumferential joint, $W_s = \pi/4 \times D^2 \times P$ ………..(ii) From equations (i) and (ii), we get $n \times \pi/4 \times d^2 \times T == \pi/4 \times D^2 \times P$ $n = (D/d)^2 \times (P/T)$ 3. Pitch of rivets: If the efficiency of the longitudinal joint is known, then the efficiency of the circumferential joint may be obtained. It is generally taken as 50% of tearing efficiency in longitudinal joint, but if more than one circumferential joint is used, then it is 62% for the intermediate joints. Knowing the efficiency of the circumferential lap joint (η_c),the pitch of the rivets for the lap joint (P_1) may be obtained by using the relation: $\eta_c = (P_1 - d)/ P_1$ 5.Number of rows: The number of rows of rivets for the circumferential joint may be obtained from the following relation: Number of rows = Total number of rivets/Number of rivets in one row and the number of rivets in one row $=\pi(D + t)/ P_1$ where D = Inner diameter of shell.	01 mark 01 mark 01 mark 01 mark 01 mark	
C **i)**	Stress Concentration. Whenever a machine component changes the shape of its cross-section, the simple stress distribution no longer holds good and the neighbourhood of the discontinuity is different. This irregularity in the stress distribution caused by abrupt changes of form is called stress concentration. It occurs for all kinds of stresses in the presence of fillets, notches, holes, keyways, splines, surface roughness etc. **Remedies:-** 1) By fillets, undercutting & notches	2m	

	 2) Additional notches & holes  3) Reducing stress concentration in threaded members 	2m Any 2	
C **ii)**	The plates are drilled together and then separated to remove any burrs or chips so as to have a tight flush joint between the plates. A cold rivet or a red hot rivet is introduced into the plates and thepoint (i.e. second head) is then formed, When a cold rivet is used, the process is known as cold riveting and when a hot rivet is used, the process is known as hot riveting. The cold riveting process is used for structural joints while hot riveting is used to make leak proof joints.  (a) Initial position. (b) Final position.	2m 2m For dia	

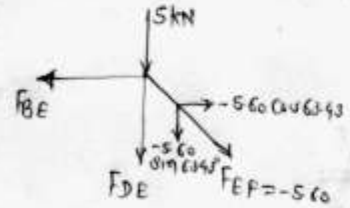
4.	**Attempt any TWO of the following:**		2X8=16
a	Method of section is preferred over method of joints when only fewer member of the entire truss are required to be determined. **The Method of Sections:-** In the method of sections, a frame is divided into two parts by taking an imaginary "cut" (shown here as a-a) through the frame. Since frame members are subjected to only tensile or compressive forces along their length, the internal forces at the cut member will also be either tensile or compressive with the same magnitude. This result is based on the equilibrium principle and Newton's third law. **Steps for Analysis** 1. Decide how you need to "cut" the frame. This is based on: a) where you need to determine forces, and, b) where the total number of unknowns does not exceed three (in general). 2. Decide which side of the cut frame will be easier to work with(minimize the number of forces you have to find). 3. If required, determine the necessary support reactions by drawing the FBD of the entire frame and applying the E-of-E. 4.Draw the FBD of the selected part of the cut truss. You need to indicate the unknown forces at the cut members. Initially we assume all the members are in tension, as we did when using the method of joints. Upon solving, if the answer is positive, the member is in tension as per your assumption. If the answer is negative, the member must be in compression. (Please note that you can also assume forces to be either in tension or compression by inspection as was done in the figures above.) 5. Apply the E-of-E to the selected cut section of the truss to solve for the unknown member forces. Note that in most cases it is possible to write one equation to solve for one unknown directly.	2m 2m 4m	**8m**

b	Q.4.b Let, T = Torque transmitted by shaft F = Tangential force acting at the circumference of shaft d = diameter of shaft l = length of key w = width of key t = thickness of key τ & σ_{ck} = Permissible shear & crushing stress for key Considering shear failure of key Torque transmitted $T = F \times \frac{d}{2}$ $\therefore T = l \times w \times \tau \times \frac{d}{2}$ From this equation of the length of key l can be determined. Considering crushing failure of key here Tangential crushing force $F = l \times \frac{t}{2} \times \sigma_{ck}$ $\therefore$ Torque transmitted $T = F \times \frac{d}{2}$ $\therefore T = l \times \frac{t}{2} \times \sigma_{ck} \times \frac{d}{2}$ From this equation the length of key l can be determined After this select the larger value of key as l	3m 2m 2m 1m	**8m**

c	In designing such joints, it is assumed that the fluid pressure acts in between the flanges and tends to separate them with a pressure existing at the point of leaking. The bolts are required to take up tensile stress in order to keep the flanges together. 1) The effective diameter on which the fluid pressure acts, just at the point of leaking, is the diameter of a circle touching the bolt holes. Let this diameter be D 1. If d1 is the diameter of bolt holeandDp is the pitch circle diameter, then D1 = Dp-d1 2) Force trying to separate the two flanges, Pipes and PJpe Joints F= π/4(D1)2 x P …………………….(i) Let n = Number of bolts, dc = Core diameter of the bolts, and σt = Permissible stress for the material of the bolts. .. Resistance to tearing of bolts = π/4 x (dc)2x n ...(ii) 3) Assuming the value of dc the value of n may be obtained from equations (i) and (ii). The number of bolts should be even because of the symmetry of the section. 4) The circumferential pitch of the bolts is given by P =(πDp)/n 5) In order to make the joint leakproof, the value of Pc, should be between 20 √d1 to 30 √d1:, where d1 is the diameter of the bolt hole. Also a bolt of less than 16 mm diameter should never be used	02 marks For each step	**8m**

5.	Attempt any TWO of the following:		2X8=16
a	 1) To Find Support Reactions From the Symmetry of Truss $R_A = R_B = 5kN$ 2) Isolating Joint A  Taking $\Sigma F_y = 0$ $R_A + F_{AB} \sin 63.43 = 0$ $5 = -F_{AB} \sin 63.43$ $F_{AB} = -5.60 kN$ C Taking $\Sigma F_x = 0$ $F_{AC} + F_{AB} \cos 63.43 = 0$ $F_{AC} = -F_{AB} \cos 63.43$ $F_{AC} = +2.50 kN$ T 3) Isolating Joint F  Taking $\Sigma F_y = 0$ $R_F + R_{FE} \sin 63.43 = 0$ $5 = -R_{FE} \sin 63.43$ $R_{FE} = -5.60 kN$ C Taking $\Sigma F_x = 0$ $-F_{DF} - R_{FE} \cos 63.43 = 0$ $-F_{DF} = R_{FE} \cos 63.43$ $F_{DF} = +2.50 kN$ T	1m each for finding magnitude of each member	**8m**

Isolating Joint E



Taking $\Sigma F_y = 0$

$-5 - F_{DE} + 5.60\sin 63.43 = 0$

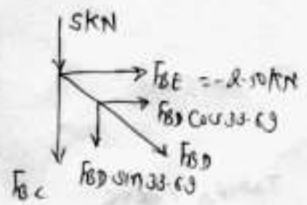
$\boxed{F_{DE} = 0 kN}$

Taking $\Sigma F_x = 0$

$-5.60\cos 63.43 - F_{BE} = 0$

$\boxed{F_{BE} = -2.50 kN}$ C

Isolating Joint B



Taking $\Sigma F_y = 0$

$-5 - F_{BC} - F_{BD}\sin 33.69 = 0$ --- ①

Taking $\Sigma F_x = 0$

$+F_{BE} + F_{BD}\cos 33.69 = 0$

$-2.50 = -F_{BD}\cos 33.69$

$\boxed{F_{BD} = 3 kN}$ T

Taking $\Sigma F_y = 0$

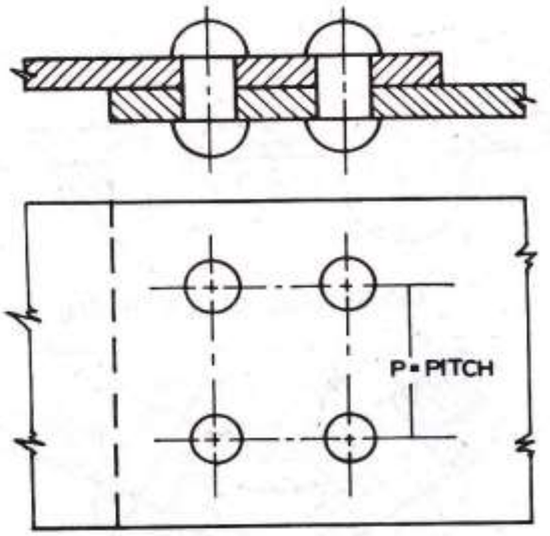
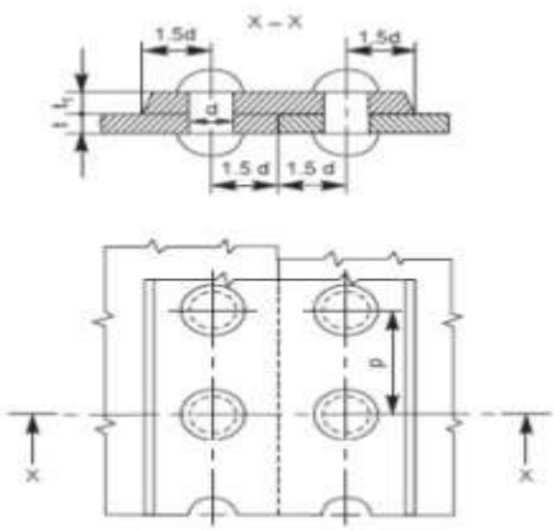
$-5 - F_{BC} - F_{BD}\sin 33.69 = 0$

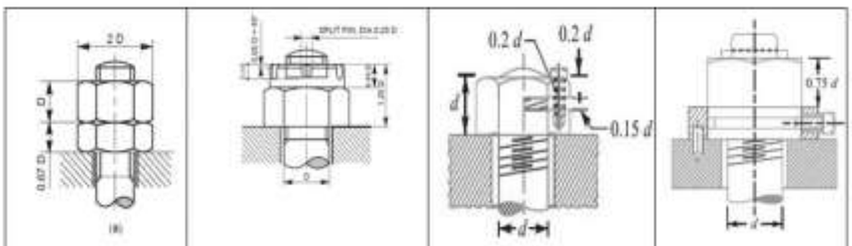
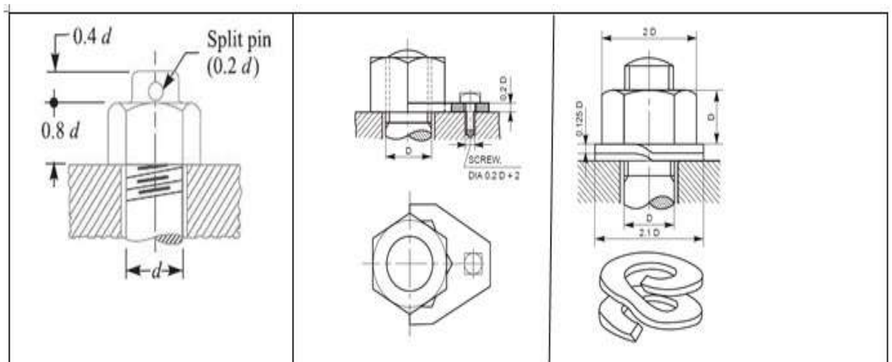
$-5 - F_{BC} - 1.67 = 0$

$-6.67 = F_{BC}$

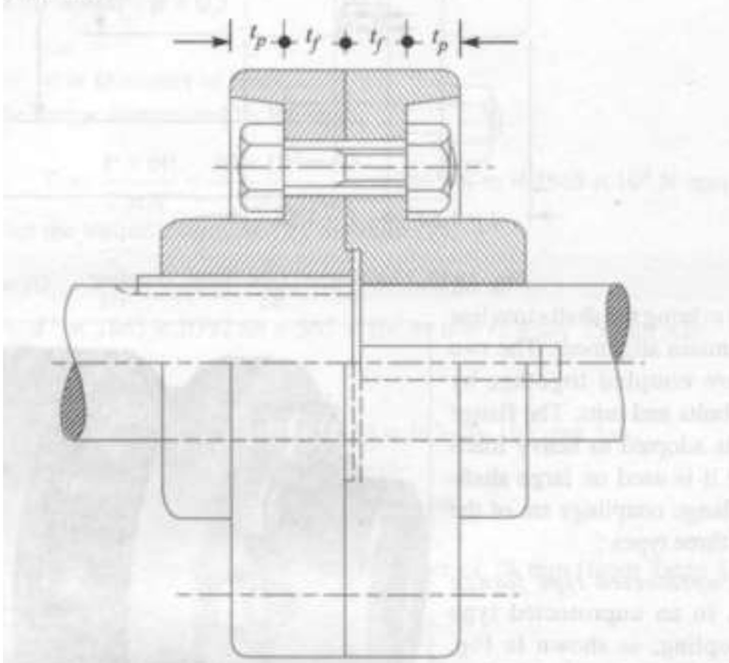
$\boxed{F_{BC} = -6.67 kN}$ C

b	Q. 5 b) Given $w = 75\ mm$, $t = 10\ mm$ $s = 10\ mm$ $\sigma_t = 70\ N/mm^2$ $\tau = 50\ N/mm^2$ $W = 55kN = 55 \times 10^3 N$ 1) To Find effective length of weld $l_1 = \text{width} - 12.5$ $= 75 - 12.5$ $l_1 = 62.5\ mm$ 2) Load Carried by single transverse weld $W_1 = 0.707 \times s \times l_1 \times \sigma_t$ $= 0.707 \times 10 \times 62.5 \times 70$ $W_1 = 30.93 \times 10^3\ N$ 3) Load Carried by Double Parallel weld $W_2 = 2 \times 0.707 \times s \times l_2 \times \tau$ $= 2 \times 0.707 \times 10 \times l_2 \times 50$ $W_2 = 707\ l_2$ N 4) We know that $W = W_1 + W_2$ $55 \times 10^3 = 30.93 \times 10^3 + 707\ l_2$ $\therefore 55 \times 10^3 - 30.93 \times 10^3 = 707\ l_2$ $l_2 = 34.04\ mm$ For Starting & Stopping of weld run 12.5 mm is added $\therefore l_2 = 34.04 + 12.5$ $l_2 = 46.54\ mm$	2m for each step	**8m**
C i)	•Keyway is a slot machined either on the shaft or in the hub to accommodate the key. • It is cut by vertical or horizontal milling cutter. • The keyway cut into the shaft reduces the load carrying capacity of shaft. • This is due to stress concentration near the comers of the keyway and reduction in the crosssectionalarea of shaft. • In other words, the torsional strength of shaft is reduced. • The following relation of reduction factor is used to analyze the weakening effect of keyway is given by H. F. Moore. e = 1 - 0.2 (w/d) - 1.1(h/d) Where, e = shaft strength factor = Strength of shaft with keyway/Strength Of shaft WIithout keyway	04 marks	

	w = Width of keyway, d = Diameter of shaft h = Depth of keyway = 112 x thickness of key = 1/2 x t • It is usually assumed that strength of keyed shaft is 75% of solid shaft. • Thus, after finding out dimensions of key, the reduction factor 'e' is calculated and for safe design, its value should be less than 0.75.		
c ii	**Double Riveted lap joint:-**  (A) CHAIN RIVETED LAP JOINT **Single Riveted single strap butt joint:-**  ıgle strap butt joint	2m 2m	

6.	Attempt any FOUR of the following:		4X4=16
a	Stresses in Pipes:The stresses in pipes due to the internal fluid pressure are determined by Lame's equation. 1)According to Lame's equation, tangential stress at any radius x $\sigma t = \{[p\ (ri)^2] / [(ro)^2 - (ri)^2]\} / \{1 + [(ro)^2 / x^2]\}$ 2)And Radial stress at any radius x $\sigma r = \{[p\ (ri)^2] / [(ro)^2 - (ri)^2]\} / \{1 - [(ro)^2 / x^2]\}$ where p = Internal fluid pressure in the pipe, ri = Inner radius of the pipe, and ro = Outer radius of the pipe	4m (any2)	4m
b	 Lock Nut Castle nut Sawn Nut Ring Nut  Locking with Pin Locking with Plate Spring lock Washer **1)Jam Nut or lock nut.** This is about one half or two third thickness of standard nut. 2) **Castle nut.** It is a hexagonal nut with cylindrical upper part. This part is slotted in line with the centre of each face. A split pin is inserted through two slots in the nut and a hole in the bolt. This used in automobile industry. **3)Sawn nut.** It has a slot sawn half way through. After the nut is tightened, the small screw is screwed which produces more friction between the nut and the bolt preventing the loosening of the nut. **4)Penn, ring or grooved nut.** It has a upper hexagonal part and a	2m for any two dia 2m for expalination of that	4m

	lower cylindrical part. The bottom cylindrical portion is recessed to receive the tip of locking set screw. **5)Locking with pin.** The nuts are locked by means of taper pin or cotter pin. **6)Locking with plate.** A plate or locking plate is used to lock the bolt. **7)Spring lock washer.** As the nut is tightened, one edge of the washer will be digging itself in the that piece thus increasing the resistance so that the nut will not be loosened.		
c	Key is a machine element which is used to connect the transmission shaft to the rotating machine element like pulleys, gear, sprocket or flywheel. **Functions of key:-** 1) The primary function of the key is to transmit the torque from the shaft to the hub of mating element and viceversa. 2) The second function of the key is to prevent relative rotational motion between the shaft and the joined machine element like gearor pulley. 3) Sometimes key also prevents axial motion between two elements.	2m 2m	**4m**
d	1) The load is distributed uniformly along the entire length of the weld. 2) The stresses is spread over the effective section uniformly. 3) Proper type of welded joints is used. 4) Suitable stress concentration factors and factors of safety are employed for unknown factors.	4m any 4	**4m**
e	Following are the general considerations in designing a machine component: 1. Type of load and stresses caused by the load 2. Motion of the parts or kinematics of the machine. 3. Selection of materials 4. Form and size of the parts 5. Frictional resistance and lubrication. 6. Convenient and economical features 7. Use of standard parts 8. Safety of operation 9. Workshop facilities 10. Number of machines to be manufactured 11. Cost of construction. 12. Assembling.	4m Any 4	**4m**

f	workman.  [redacted] Protective type flange coupling.	4m	**4m**