MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION
(Autonomous)
(ISO/IEC - 27001 - 2005 Certified)

SUMMER – 16 EXAMINATIONS

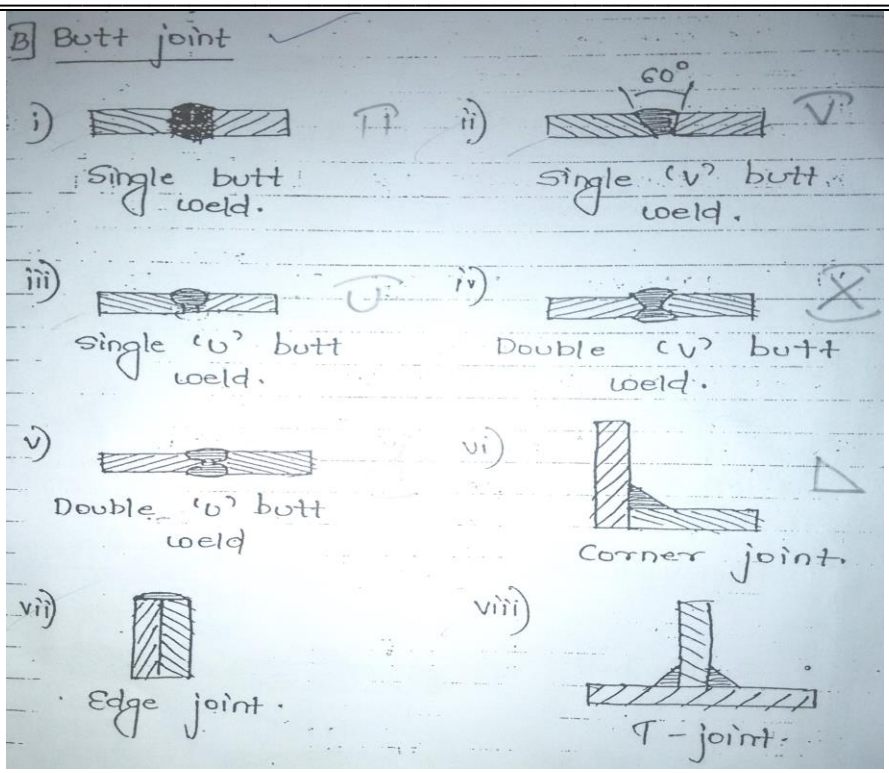
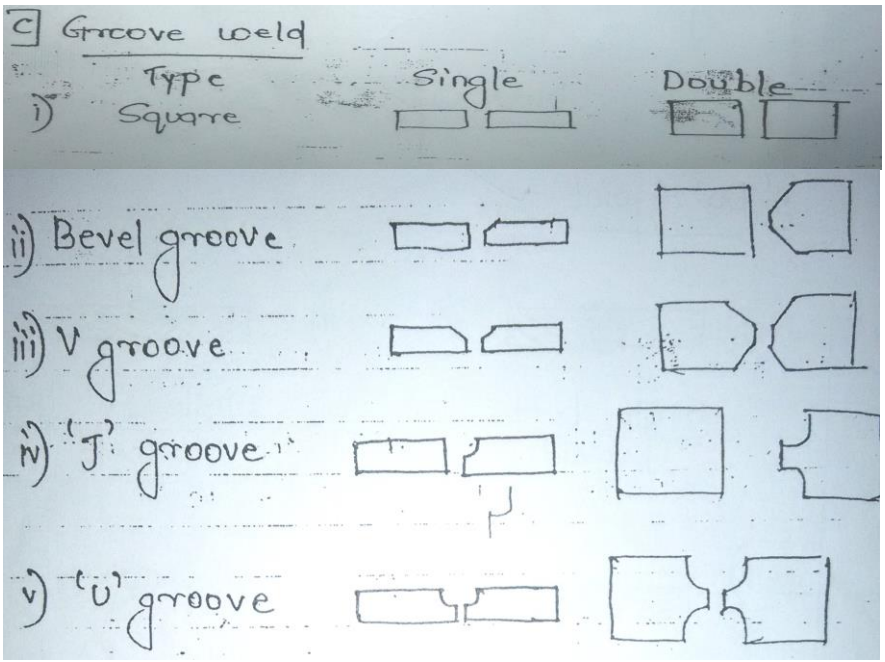
Subject Code: **17457** **Model Answer**

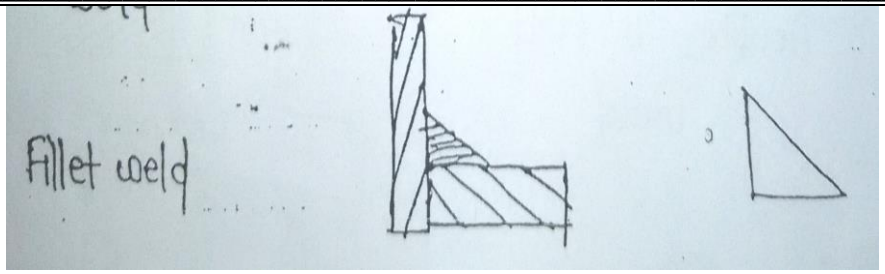
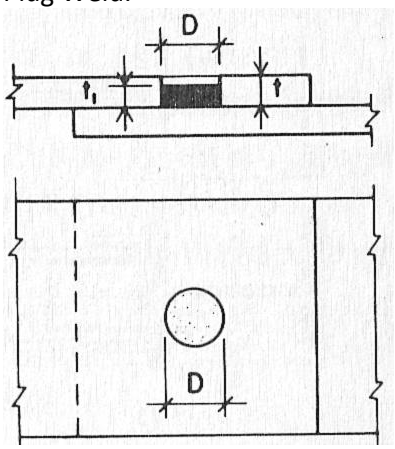
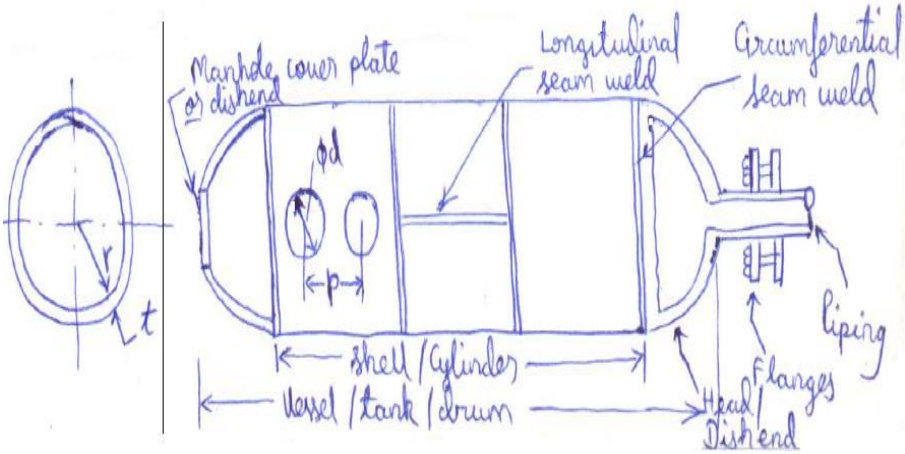
Important Instructions to examiners:

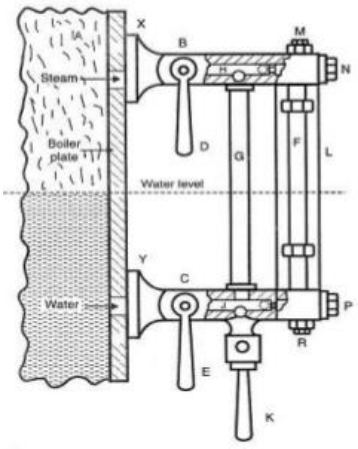
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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.

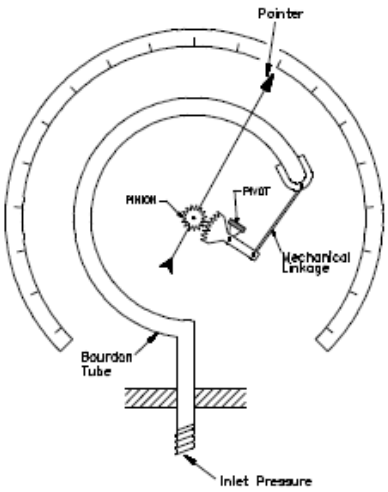
Q. NO.	MODEL ANSWER	MARKS	TOTAL
1.	**Attempt any FIVE of the following**	**5x4**	**20**
a)	Effect of pressure and temperature on Pressure vessel: 1) The effect of temperature on continuous deformation is in the form of creep. 2) With increase in temperature there is reduction in ultimate strength, modulus of elasticity and hardness. 3) Due to pressure and temperature dilation of the pressure vessel occurs. This is due to the expansion of material. 4) Due to internal pressure Hoop's stress, radial loading and longitudinal loading in pressure vessel occurs. 5) Stresses due to external pressure which may be caused by external pressure or vacuum, also occur.	**04 mark (any four point)**	**04**
b)	Many high temperature petroleum refining processes are carried out under high partial pressures of hydrogen. Therefore steps for material selection in vessel construction for such service so as to withstand hydrogen which causes deterioration of the material and subsequent failure depends upon identifying some factors like; • Temperature • Hydrogen pressure • Time, • Composition of materials, • etc.	**04 marks**	**04**
c)	Dilation: It is defined as the radial growth i.e. growth of the vessel along the radius in a pressure vessel due to internal pressure. Dilation of cylindrical vessel: $\delta = Pr^2(2-\mu)/2tE$ Dilation of pressure vessel occurs due to prolonged pressure and temperature forces acting radially. These effects occur due to fatigue in the pressure vessel material.	**02 marks** **02 mark**	**04**
d)	General consideration for material selection for Non- corrosive services: 1) Design pressure- pressure up to 3000kg\cm^2 2) Design temperature- temperature range of 200^{o}c to 600^{o}C 3) Corrosion resistance- corrosion effect due to fluids like acids or alkalies	**01mark each (any four)**	**04**

	4) Type of loads- steady or cyclic loads 5) Other mechanical properties of material 6)Cost and availability 7) Quality of maintenance 8) Life of product		
e)	Stress concentration Factor: In design under fatigue loading, stress concentration factor is used in modifying the values of endurance limit while in design under static loading it simply act as stress modifier. This means Actual stress = Kt X Calculated stress i.e Kt = Actual stress/ Calculated stress Stress concentration is due to- 1) Geometry of welded joints 2) Defects & imperfections in weld 3) Different metallurgical structure of the weld metal 4) Properties of base metal	**02 marks** **02 marks**	**04**
f)	Pressure vessels usually contain regions where abrupt changes in geometry, material, or loading occur. These regions are known as discontinuity areas, and the stresses associated with them are called discontinuity stresses. Because of dissimilar characteristics, each of the adjacent parts joining at a discontinuity area behaves differently to an applied load, such as internal pressure or temperature. The deformations of the disconnected free bodies are different from each other. Because these parts are joined together, they share a common displacement that is different from their free displacements. The difference between the free displacement and the actual joint displacement is a forced displacement, which produces forces and stresses. These additional stresses are referred to as discontinuity stresses. Calculation of discontinuity stresses is generally based on the behavior of the longitudinal strip of the cylindrical shell. The perfect example of discontinuity stress is the Bimetallic joint. Since these joints are at the nozzle joints where two different parts having different material a discontinuity stress occur.	**04 marks**	**04**

g)	 	01mark for any one butt weld 01mark for any one groove weld	04

	 Plug Weld:  	**01 for fillet weld** **01 mark for plug weld**	
2.	**Attempt any <u>TWO</u> of the following**	**8x2**	**16**
a)	 Pressure vessel consists of basic parts such as; Cylinders/shell:- it is the container which holds the fluid under pressure and temperature Rings: - these are used so that leakages at the joints in the pressure vessel are avoided.	**04 marks dia** **04marks expl.**	**08**

	Baffle plates: - these used to increase the pressure in boiler or pressure vessel. The position of these plates varies the pressure in vessel. Curved shape dish ends/ heads/ closure ends:- these are ends which provides closure to the vessel. The shape of the ends varies according to the use. Nozzles: - these are the outlets/inlet hole which is used for the supply of the fluid. Flanges: - these are used to connect the pipes with the vessel so that minimum loses are achieved. Piping: - these are used so that the fluid can be transferred from the vessel.		
b)	Pressure Vessel mountings: • Water level Indicator Water level indicator is located in front of boiler in such a position that the level of water can easily be seen by attendant. Two water level indicators are used on all boilers.  • Pressure Gauge A pressure gauge is fitted in front of boiler in such a position that the operator can conveniently read it. It reads the pressure of steam in the boiler and is connected to steam space by a siphon tube. Most commonly, the Bourdon pressure gauge is used.	**04 marks for mounting (any 02)**	**08**

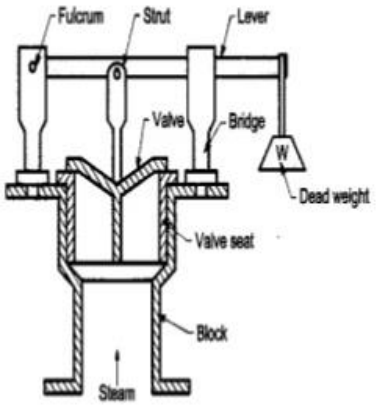


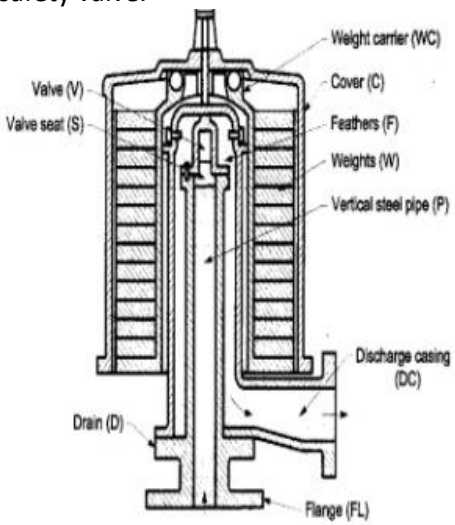
• Safety Valve

Safety valves are located on the top of the boiler. They guard the boiler against the excessive high pressure of steam inside the drum. If the pressure of steam in the boiler drum exceeds the working pressure then the safety valve allows blow-off the excess quantity of steam to atmosphere. Thus the pressure of steam in the drum falls. The escape of steam makes audible noise to warn the boiler attendant.

There are four types of safety valve.

1. Dead weight safety valve.
2. Spring loaded safety valve
3. Lever loaded safety valve
4. High steam and low water safety valve.

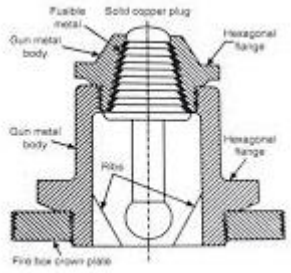




• Fusible Plug

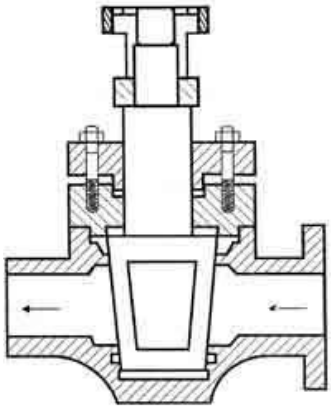
It is very important safety device, which protects the fire tube boiler against overheating. It is located just above the furnace in the boiler. It consists of gun metal plug fixed in a gun metal body with fusible molten metal.

During the normal boiler operation, the fusible plug is covered by water and its temperature does not rise to its melting state. But when the water level falls too low in the boiler, it uncovers the fusible plug. The furnace gases heat up the plug and fusible metal of plug melts, the inner plug falls down. The water and steam then rush through the hole and extinguish the fire before any major damage occurs to the boiler due to overheating.



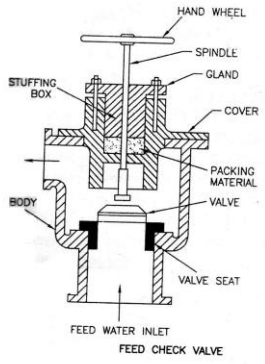
• Blow-Off Cock

The function of blow-off cock is to discharge mud and other sediments deposited in the bottom most part of the water space in the boiler, while boiler is in operation. It can also be used to drain-off boiler water. Hence it is mounted at the lowest part of the boiler. When it is open, water under the pressure rushes out, thus carrying sediments and mud



• Feed Check Valve

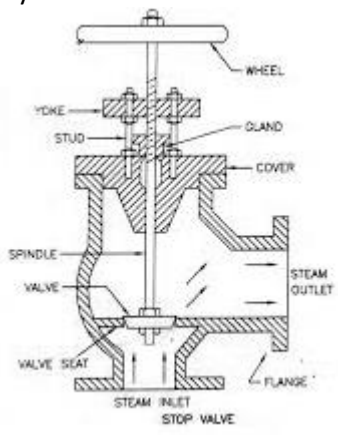
The feed check valve is fitted to the boiler, slightly below the working level in the boiler. It is used to supply high pressure feed water to boiler. It also prevents the returning of feed water from the boiler if feed pump fails to work.



FEED CHECK VALVE

• Steam Stop Valve

The steam stop valve is located on the highest part of the steam space. It regulates the steam supply to use. The steam stop valve can be operated manually or automatically.



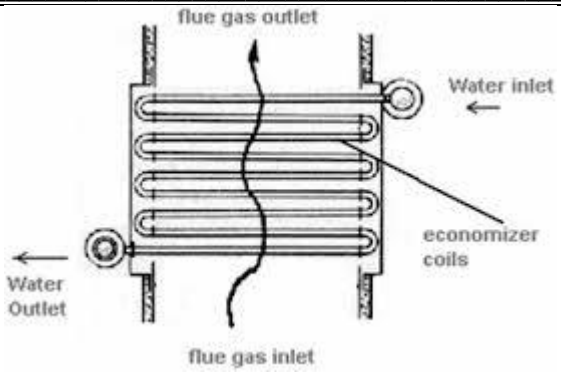
STOP VALVE

Pressure Vessel Accessories:

04 marks for accessories (any 02)

• Economizer

An economizer is a heat exchanger, used for heating the feed water before it enters the boiler. The economizer recovers some of waste heat of hot flue gases going to chimney. It helps in improving the boiler efficiency. It is placed in the path of flue gases at the rear end of the boiler just before air pre-heater.

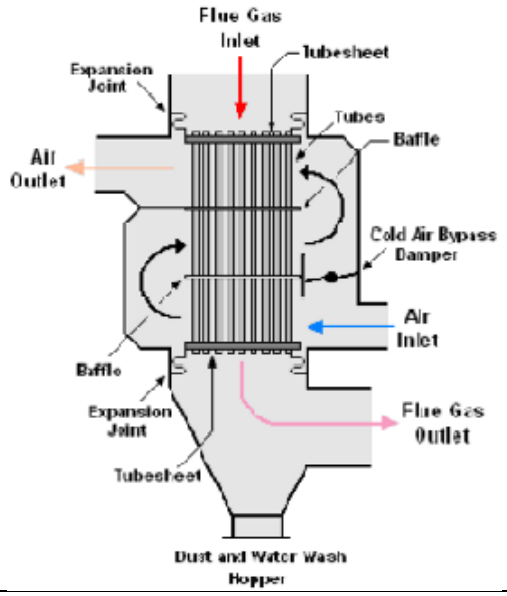


• Super heater

It is a heat exchanger in which heat of combustion products is used to dry the wet steam, pressure remains constant, its volume and temperature increase. Basically, a super heater consists of a set of small diameter U tubes in which steam flows and takes up the heat from hot flue gases.

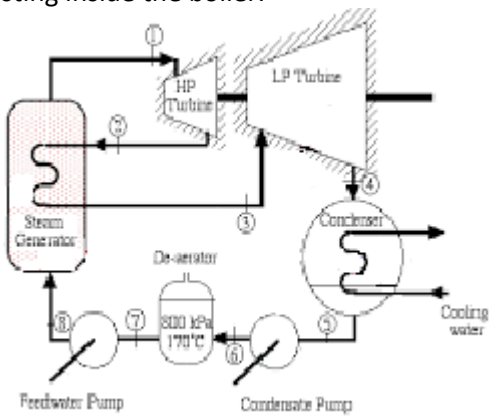
• Air Pre-heater

The function of an air pre-heater is similar to that of an economizer. It recovers some portion of the waste heat of hot flue gases going to chimney, and transfers same to the fresh air before it enters the combustion chamber. Due to preheating of air, the furnace temperature increases. It results in rapid combustion of fuel with less soot, smoke and ash. The high furnace temperature can permit low grade fuel with less atmospheric pollution. The air pre-heater is placed between economizer and chimney.



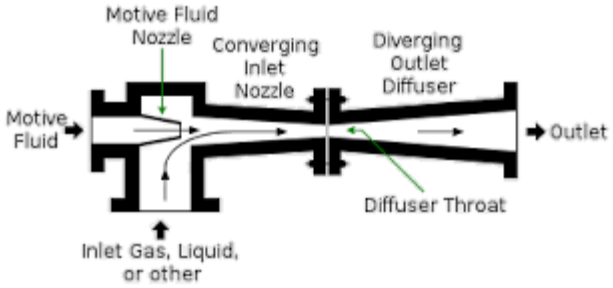
• Feed Water Pump

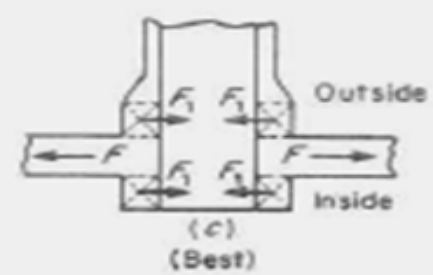
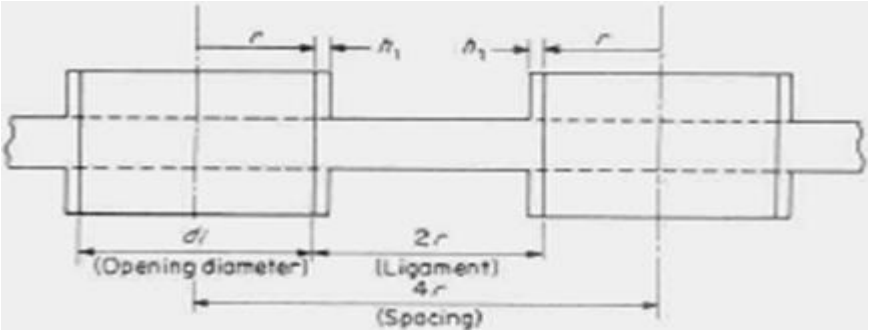
It is used to feed the water at a high pressure against the high pressure of steam already existing inside the boiler.

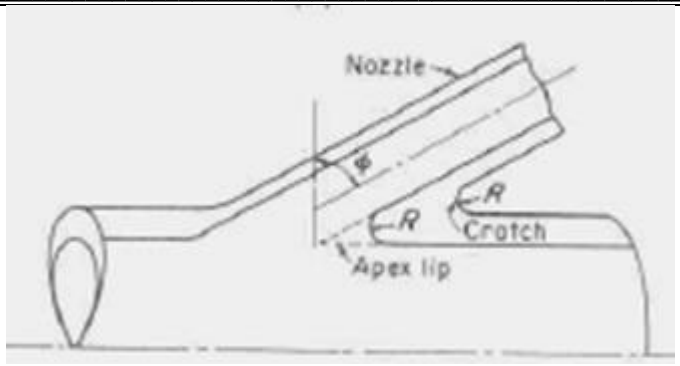
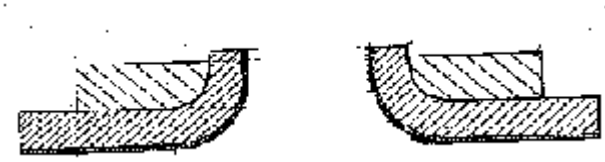
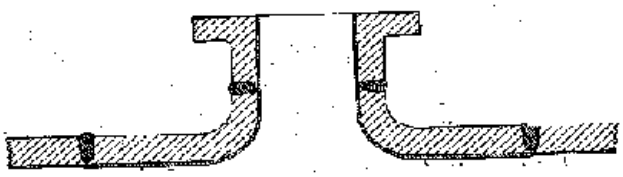


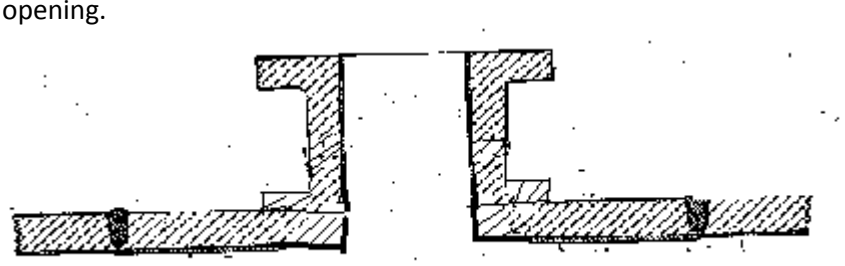
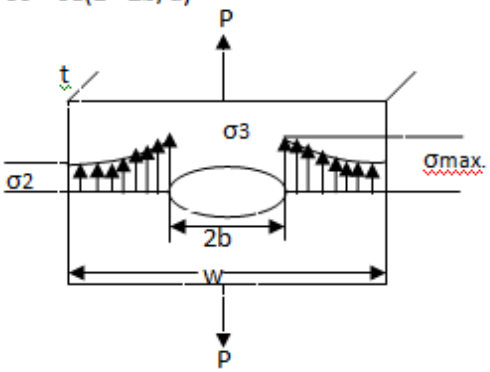
• Steam Injector

A steam injector lifts and forces the feed water into the boiler. It is usually used for vertical and locomotive boilers and can be accommodated in small space. It is less costly. It does not have any moving parts thus operation is salient.

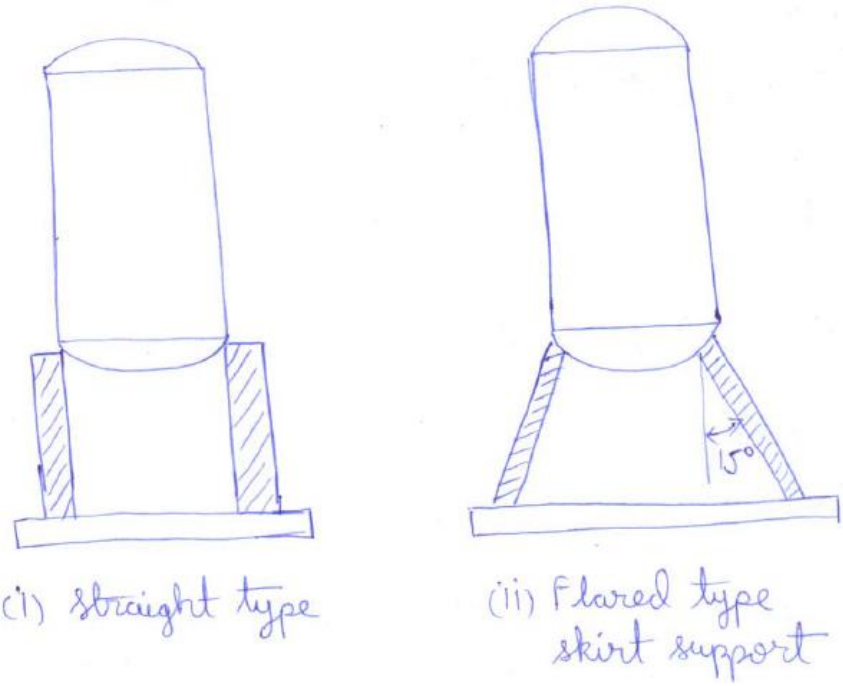


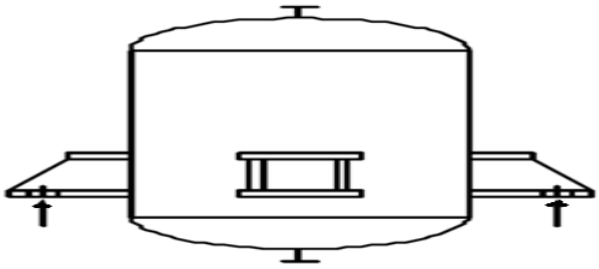
c)	Nozzle reinforcement is a means to provide compensation for weakening due to the hole made on the shell by providing sufficient additional materials. The reinforcing material being placed adjacent to the hole such that it should not introduce any stress concentration. Nozzle placement: 1. Single nozzles Minimum stress concentration factor is obtained with balanced reinforcement explainable by the fact that reinforcing material evenly disposed both inside and outside of the vessel surface introduces no eccentricity or unbalance to create local bending moments and stresses.  2. Multiple nozzle arrangements Multiple reinforced nozzle arrangements require special consideration when they are very closely spaced because their individual effects become overlapping and the average membrane stress in the vessel wall is not increased by the presence of reinforced nozzles.  3. Non radial nozzles A non-radial nozzle may be installed for a functional purpose and not commonly used. A non-radial circular nozzle makes an elliptical opening in the vessel and just as an elliptical hole in a plate gives rise to a higher stress concentration factor than does a circular hole, so does a non-radial nozzle have higher stress concentration factor than its comparable radial one.	**02marks** **02marks** **02marks** **02marks**	**08**

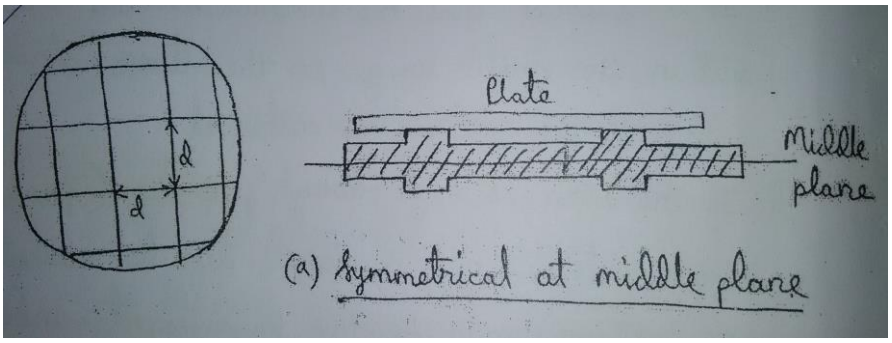
			
3.	**Attempt any TWO of the following**	**2x8 marks**	**16**
a)	Openings in vessels (nozzles) are made by making holes in the wall of the vessel. Nozzles are then formed and welded around these holes. Holes cause discontinuity in the vessel wall. Due to the pressure, a stress concentration is created near the holes, the maximum value of the stress being at the edge of the holes. To reduce this stress concentration and chances of failure at the hole edge reinforcement of nozzle is done. Types/Shapes of nozzles: • Integral nozzle: These are fabricated from a part of the shell and/head by cutting and shaping the material to obtain the contour of a nozzle.  • Fabricated nozzle: These are short pieces of pipes, tubes or plates cut to a specific length from standard fittings and welded to the vessel wall opening.  • Formed nozzle: These are fabricated to a specific shape/size preferably	**04 mark** **04 mark**	**08**

	with flanges by rolling/forging methods and welded to the vessel wall opening. 		
b)	Fatigue concentration: Stress concentrations produced by irregularities are damaging in case of fluctuating stresses. All failures as a result of fatigue are in the areas of high localized stresses. Hence all stresses including localized stresses should be taken into account when designing the pressure vessel. Stress concentration for circular and elliptical holes: $K_t = \sigma_3 / \sigma_{av}$; where $\sigma_{av} = P/t(w-2b)$ $\sigma_1 = P/tw$ $\sigma_3 = \sigma_1(1+ 2b/a)$  Where, b/a = 1 refers to circular opening b/a = 1/2 refers to vertical ellipse with least stress concentration, Kt	**04 marks** **04 marks**	**08**

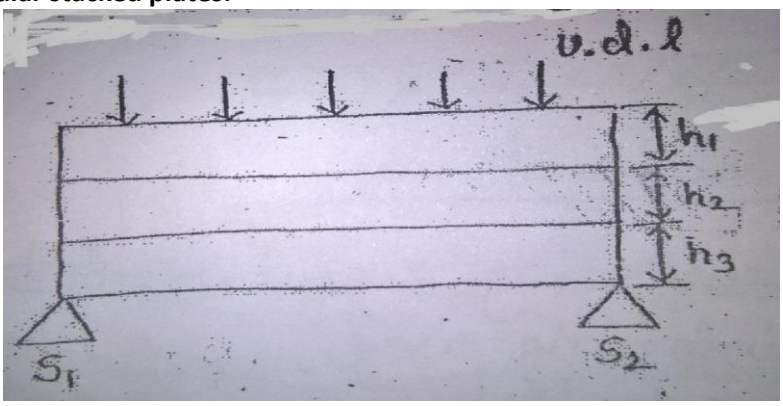
b/a	Kt
1	2.5
2	4.5
3	6.5
1/2	1.5
1/3	2.5
1/4	3.5
1/5	4.5

c)	 Support skirt: Tall vertical vessels are supported by cylindrical shell called as skirt. The skirt is a suitable supporting structure for tall vessels which are subjected to wind load, seismic load and other load. The skirt is welded to the bottom dish end from the outside of the shell. A bearing plate/ base plate/ support plate is attached to the bottom of the skirt. The plate is made to rest on a concrete foundation and is securely anchored to foundation by means of anchor bolts embedded in concrete to prevent overturning due to wind load or earthquake load. The commonly used materials for skirt supports are carbon steels. 1) Straight type skirt support is used for tall vessels. The centre line of cylindrical skirt and shell are coincident. This type is more difficult to fabricate and is used mainly for high external loads, high design temperatures or cyclic operating temperatures. A good fit between the outside diameter of the shell and inside diameter of skirt is a must. 2) Flared type skirt support is used for very high columns with high external moments. The angle of skirt is maximum 15^{o}.	**04 marks for skirt**	**08**

	 Support lug: Brackets are fabricated from plates and are attached to the vessel wall. They are made to rest on small columns or beams of structure depending on the elevation required. They can be easily leveled. Due to the eccentricity of these supports, compressive, tensile and shear stresses are induced in the vessel wall. Bracket supports are suitable for vessels with thick walls. The main loads on the bracket supports are the dead weight of the vessel with its content and the wind load. The wind load tends to overturn the vessel when it is empty. Use of bracket or lug support is limited to vertical pressure vessels with diameter Ø ranging from 1' to 10' (0.3m to 3.0m) and a moderate height to diameter ratio as h / d = 5 / 2.	**04 marks for laug**	
4.	**Attempt any <u>TWO</u> of the following**	**2x08 marks**	**16**
a)	Piping load: It is that compressive/tensile load on the pressure vessel consisting of the weight of pipe sections supported by nozzles into the vessel shells and the load due to thermal expansion of pipes. Wind load: A highly turbulent flow of air sweeping over the earth surface with a variable velocity and resisted by an obstacle in this case a pressure vessel is termed as wind load (moment load) on the vessel. Effect of loads on pressure vessel: 1) Wind has a rolling effect on the horizontal vessel, thus creating a twisting force on the vessel. 2) Wind load creates a bending force on the slender vertical vessel. 3) Turbulence of fluid flowing through the pipes creates vibration and affects the joints of the pipes and makes it lose. For this purpose gaskets or bellows can be used to reduce the pipe load. 4) Piping may also create unnecessary load on the vessel.	**02 mark** **02 mark** **04 mark for effect (01 mark each)**	**08**

b)	**Circular reinforcement Plate:**  1. Orthogonal grillage plates: Plates may be reinforced by equidistance, orthogonal system of ribs to form a grillage type of reinforcement. If the reinforcing ribs are symmetrical about the middle plane of the plate, the composite structure may be treated as a solid circular plate. Orthogonal ribs reinforcing system is used to support internal loads within pressure vessels such as nuclear core in reactor vessel.  2. Concentric ring plate: Another way reinforcing circular plates by use of concentric reinforcing ring. Reinforced plate consists of an inner plate, a ring and an outer plate. This method of reinforcement is used for flat plate which forms an integral part of a pressure vessel such as the end closure of a cylinder.	**02 mark**	**08**

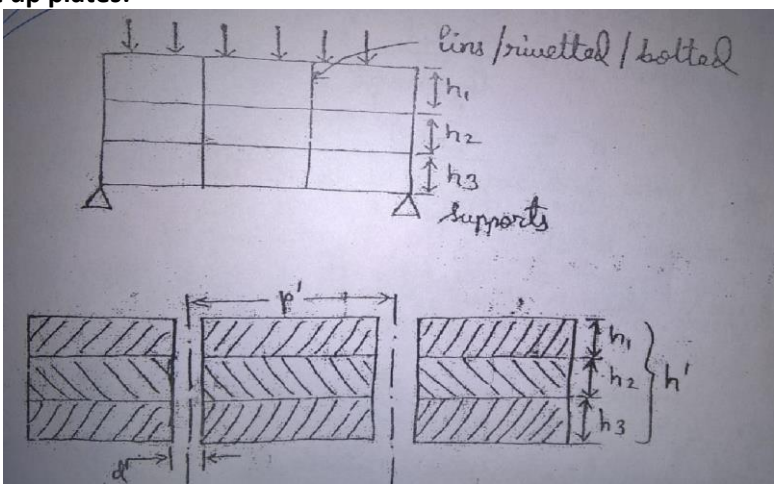
Circular stacked plates:



Flat pates are stacked one on the other and are frequently used to support loads. This may be done because the construction arrangement does not permit a single plate of equivalent thickness to be used or because a single plate of required thickness is not available.

02marks

Built up plates:



It sliding of one stacked plate on the other is to be prevented through the use of pins, rivets, bolts or keys to take shear at the plate interfaces, this arrangement is called as built up plates which is stiffer and stronger than the same stack weld. The shear pins, rivets, bolts or keys used in the built up plate should have a tight for in order to prevent high local deformation and initial deflection.

02marks

Application:

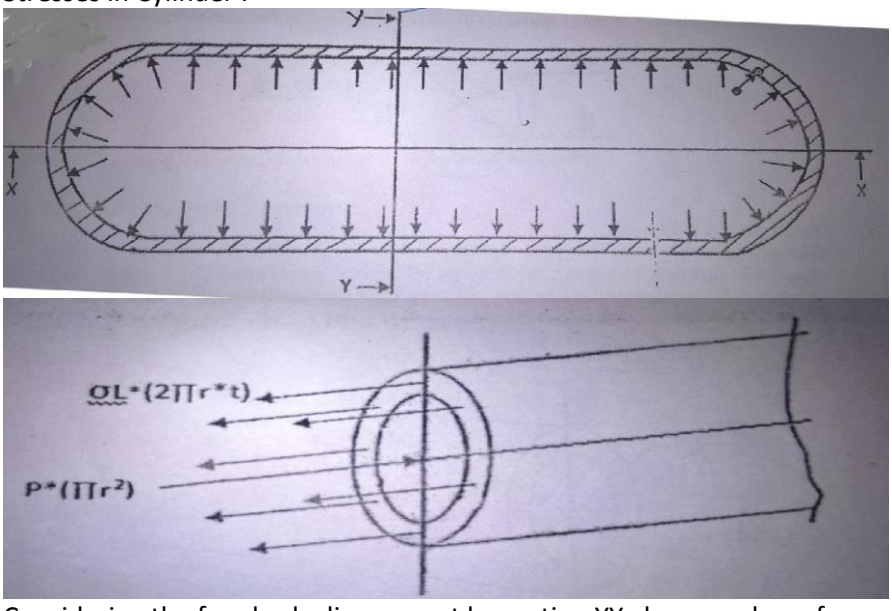
1) These plates are used in construction of boiler feed water heater.
2) They are used in nuclear steam generators.
3) They are used in heat exchangers.
4) They are used in feed (fuel) in boilers.

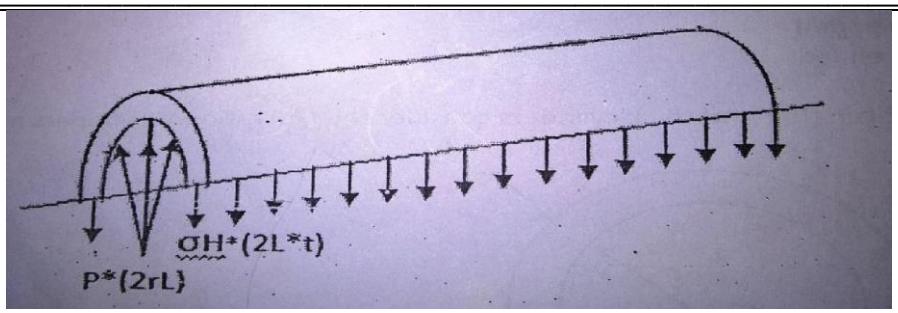
02marks

c)	Weld Defects are: **Undercut** Undercutting is when the weld reduces the cross-sectional thickness of the base metal, which reduces the strength of the weld and work pieces. One reason for this type of defect is excessive current, causing the edges of the joint to melt and drain into the weld; this leaves a drain-like impression along the length of the weld. Another reason is if a poor technique is used that does not deposit enough filler metal along the edges of the weld. A third reason is using an incorrect filler metal, because it will create greater temperature gradients between the center of the weld and the edges. Other causes include too small of an electrode angle, a dampened electrode, excessive arc length, and slow speed. **Cracks** Cracks are the most dangerous amongst all types of defects as it reduce the performance of a welded joint drastically and can also cause catastrophic failure. Depending on the position, location and orientation these can be categorized as longitudinal cracks, transverse cracks, crater cracks, under-bead cracks, and toe cracks. **Inclusions** There are two types of inclusions: linear inclusions and rounded inclusions. Inclusions can be either isolated or cumulative. Linear inclusions occur when there is slag or flux in the weld. It can also occur if the previous weld left an undercut or an uneven surface profile. NDT usefulness for weld: 1) NDT is nondestructive testing, hence less wastage of material. 2) It is capable of testing varied types of material. 3) It is a very sensitive method, capable of finding extremely fine flaws 4) Small objects, with awkward shapes, can be inspected 5) A power supply is not needed for some methods of penetrant testing 6) The method requires no great skill and is easy to understand 7) Lots of small articles, in batches, can be examined using automated systems **Note:** Relevant defect can also be considered	**04 mark for defect (write any two)** **04 marks for NDT (any four points)**	**08**

5.	Attempt any TWO of the following	02x 08 marks	16
a) i	Methods of attaching protective coatings: 1. Integral cladding Low carbon steels or low alloy steels (base plates) also called as backing plates and corrosion resistant steel (liners) are welded at the edges. This is then passed through steel mills for hot rolling operations. The high temperature and high pressure creates a solid bond between the plates. Thickness of the liners is about 2mm to 4mm or 8% to 20% thickness of base metals. 2. Sheet lining The corrosion resistant layer is attached to a vessel shell by welding. Thickness of sheet is 2mm to 4mm. Types are; i) Strip type lining of 3' to 5' *3" to 6" wide strips are welded on base material by spot welding. ii) Sheet type lining of several feet in length and width are welded on base materials by spot, plug or seam welding. The linings are attached to the vessel after the vessel is entirely completed. Sometimes sheets are attached to the base plates before rolling or forming. Carbon steel surfaces (base plates) are ground to provide suitable surface for application of the liner. 3. Protective coatings Coatings should be applied only on clean surfaces free from grease, oil, dirt, scale, etc. i) Metallic coatings – Common methods are electroplating, mechanical cladding (most important), metal spraying, cementation, hot dipping, and condensation of metal vapors. ii) Inorganic coatings – Chemical dipped methods are used to create protective oxide films on iron, steel, stainless steel, copper, aluminum and some of their alloys. Such films are very thin and colored. e.g. Electrolytic coating iii) Organic coating – Different synthetic resins, pigments, oils and solvents are used in coating formulations. A continuous adherent inert film is formed between the metal and environment. They change the appearance of the metal e.g. paint enamel, lacquer.	**02 mark** **03 mark** **03 mark**	**08**

a)ii	Uses of stainless steel: 1) For high corrosion and high temperature resistance application of pressure vessel. 2) In vessels such as storage tanks, reactors, absorption columns, distillation columns, heat exchangers. 3) As cladding of pressure vessel having thickness varied usually 8% to 20% of thickness of base metal. 4) Material handling equipment's such as pipes, conveyors, tankers. 5) machinery such as pumps, fans centrifugal compressors, dryers, filters, etc.	**08 mark (02 mark each any 4 points)**	**08**
b)	Design procedure for thickness of shell: 1) Shell: Cylinder is developed by rotating a straight line parallel to the the axis of rotation. The stresses in the closed end cylindrical shell under internal pressure 'p' is given by; $\sigma_c = \frac{pr}{t}$, $\sigma_l = \frac{pr}{2t}$ where, σ_c= circumferential stress σ_l= longitudinal stress p= Internal pressure r= internal radius t= thickness Thickness of the cylindrical shell: $t = \frac{pr}{SE - 0.6p}$ where, t= thickness of the shell E= Joint efficiency S= Design stress/ Permissible stress If Sult (ultimate strength) or Syield (Yield strength) is given, then F.O.S= $\frac{S_{ult}}{S}$ or $\frac{S_{yield}}{S}$	**04 mark for shell**	**08**

	2) Dish Ends: To close either ends of the cylindrical shell, closure or dish ends or heads are essential. These can be attached to the shell by welded or riveted or bolted joints. Following are the types of Dish ends. ● Flat head: t= CD $\sqrt{p/S}$ ● Conical heads: t= $\frac{pr}{SE- 0.6 p} \times \frac{1}{\cos\alpha}$ ● Torispherical dish ends: t= $\frac{prM}{2SE- 0.2p}$ ● Elliptical heads: t= $\frac{prV}{SE}$ ● Hemispherical heads: t= $\frac{pr}{2SE}$	**04 mark for dish end (any two formula)**	
c)	Stresses in Cylinder :  Considering the free body diagram cut by section YY above we have for the cylinder material; applied force due to internal pressure P = Resistive force due to longitudinal stress σ_L $P(\pi r^2)= \sigma_L*(2\pi r*t)$ $\sigma_L= Pr / 2t$	**04 marks for cylinder**	**08**



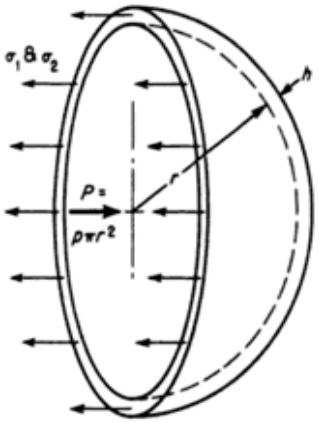
Considering the free body diagram cut by section XX above we have for cylinder material; applied force due to internal pressure P= Resistive force due to Hoop/Circumferential stress σ_H

$P*(2rL)= \sigma_H*(2L*t)$

$\sigma_H=Pr/t$

$\sigma_H=2* \sigma L$

Stresses in Sphere:



A spherical pressure vessel is really just a special case of a cylindrical vessel. No matter how the sphere is cut in half, the pressure load perpendicular to the cut must equal the shell stress load. This is the same situation with the axial direction in a cylindrical vessel. Equating the two loads gives;

$p(\pi r^2) = \sigma_h (2\pi rt)$

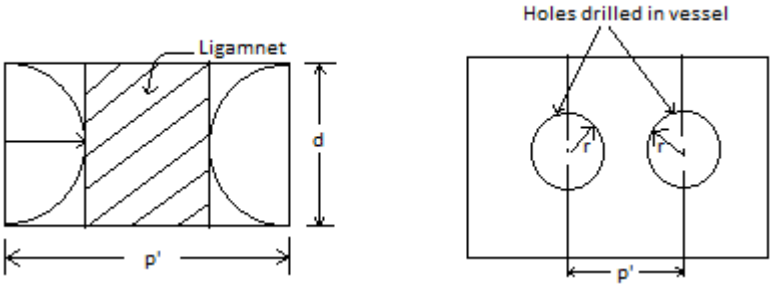
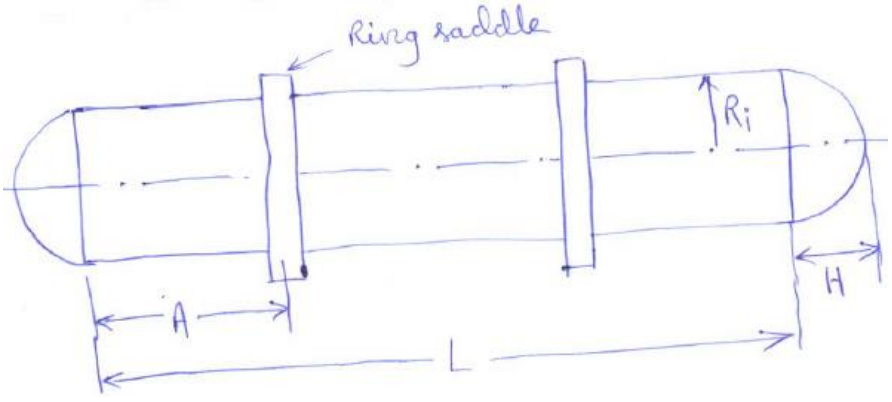
This can be simplified to:

$\sigma_h= \sigma_a = pr / 2t$

(Notice, the hoop and axial stress are the same due to symmetry)

04 marks for sphere

6.	Attempt any FOUR of the following	4x4 marks	16
a)	Ultra high pressure vessels: Hydraulic and extrusion presses utilize very high fluid pressures to large forces, which in turn required extremely thick walled cylinders. In such cylinders hoop stress at the outside of the inside surface; hence the wall material is not used uniformly to its fullest stress and economic potential. Several design principles that have been successfully used to overcome this situation follow; 1) Wedge principle 2) Segment principle 3) Cascade principle 4) Yoke principle	**02 marks** **02 marks**	**04**
b)	Earthquake load: Intensity and duration of earthquake motion damages the structure of the pressure vessel and hence it is to be taken in to account while designing the pressure vessel. Effects of earthquake on pressure vessel: 1) Due to the vibration caused earthquake the supports of the pressure vessel may get weak. 2) The land on which the pressure is placed, it may get lose and may affect the vessel.	**02 marks** **02 marks effect**	**04**

c)	Ligament Efficiency :  Minimum material remaining between the holes (nozzle) is called as ligament. Area in normal section= p'xd Area of ligament= (p'-2r)xd = (p'-d)xd Ligament efficiency is defined as the ratio of area of ligament to the area of normal section. Ligament Efficiency= $\frac{\text{Area of ligament}}{\text{Area of normal section}}$ x 100 = $\frac{(p'-d)xd}{p'xd}$ x 100 = $\frac{p'-d}{p'}$ x 100	**02 mark** **02 mark**	**04**
d)	Saddle Support:  	**02 mark for saddle**	**04**

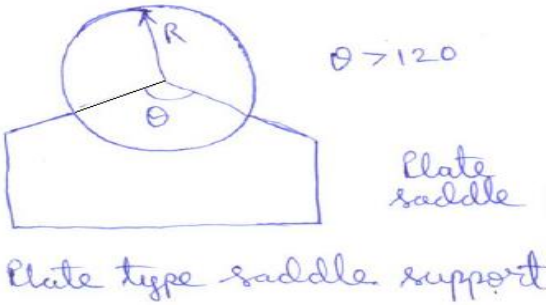
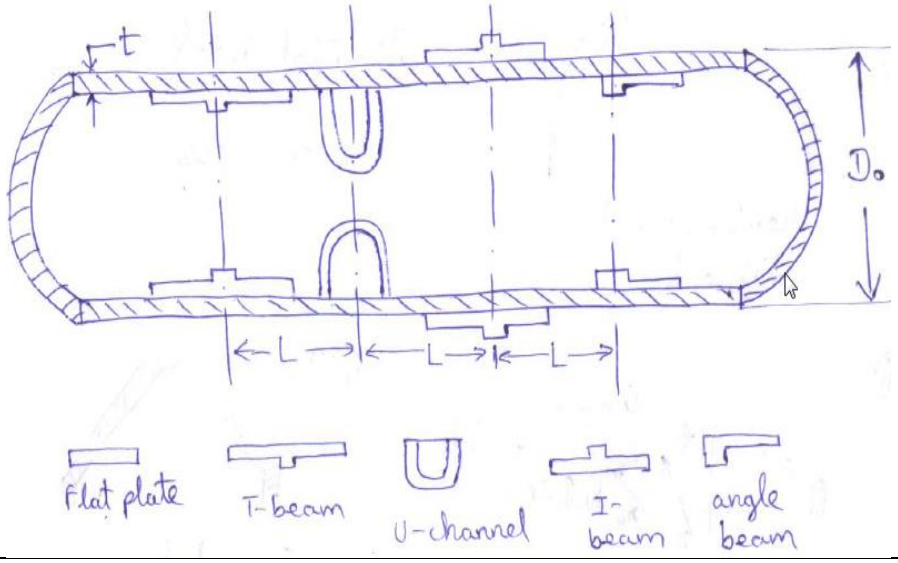
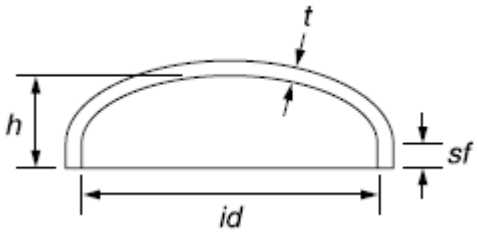


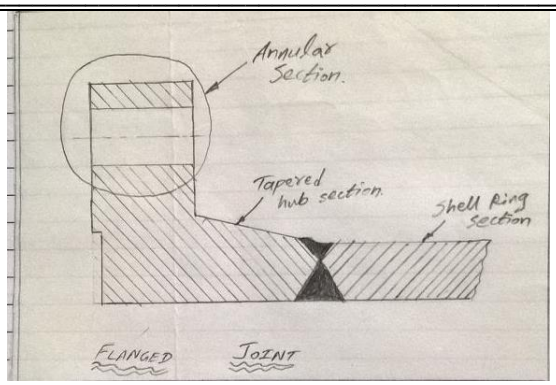
Plate type saddle support

Stiffeners:



02 mark for stiffeners

e)	Membrane stress analysis of Semi ellipsoidal head  These heads are developed by rotation of a semi-ellipse. Heads with a 2:1 ratio of major axis to minor axis are most frequently used end closures in vessel design, particularly for internal pressure above 150 psi and for bottom head of tall, slender column. Thickness of head: $t = \frac{pr}{SE - 0.1p} \times K$ where, K= constant = 1 for 2:1 ratio i.e. 1 for a/b = 2 i.e. 1 for a=2b	**01 mark** **01 mark** **02 mark**	**04**
f)	Stresses in flanges and flanged joints: Correct assembly of the flanged joint requires the flanged joint requires the flange to be analyzed and the correct bolt load established to seat joint. Criterion, adopted for flange design and stress analysis, is carried out according to ASME code, in which following assumption have been adopted. 1. For hub and shell sections of flange local pressure acting on surfaces is neglected. 2. The effect of the external moment applied to the flange, equal to the product of the bolt load and the lever are independent of the location of the bolt- loading circle and of the forces balancing the bolt load. 3. Creep and plastic yield do not occur.	**02 marks**	**04**

	 Consider the Flange as divided into three sections viz. • Annular ring section: 1. Overturning moment , acting on the ring, due to non-concentricity of the bolt load and gasket reaction load is replaced by two equal and opposite forces. 2. Internal hydrostatic pressure • Tapered hub section 1. Shear force and bending moment 2. Internal hydrostatic pressure • Shell ring section 1. Discontinuity shear force and bending moment	**02 marks**	