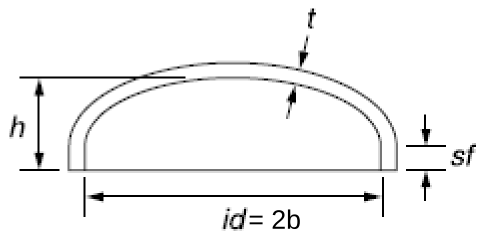
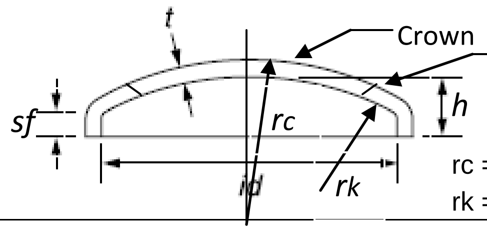
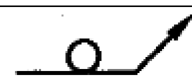
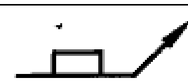
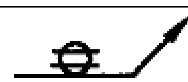
SUMMER – 14 EXAMINATIONS

Subject Code: **17457** **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
1	**Attempt any Five of the following**	------------------	**20**
a)	A pressure vessel is a closed container designed to hold gases or liquids at a pressure substantially different from the ambient pressure. Pressure vessels are leak proof containers. They may be of any size, shape and range. Pressure vessels are classified as; Function: Storage tank, Process vessel, Reactor, Heat Exchanger, etc. Geometry: Cylindrical, Spherical, Conical, Non circular, Horizontal, Vertical, etc. Construction: Monowall, Intersecting, Multishell, Cast, Forged, etc. Service: Cryogenic, Steam, Vacuum, Fired/Unfired, Stationery/Mobile, etc.	**02 marks** **02 mark for any two classification with 01 eg. each**	**04**
b)i)	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.	**02 marks**	**04**
b)ii)	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.	**02 marks**	
c)	General design criteria for pressure vessel: For cylinders under internal pressure, three principal stresses are generated, a) Hoop stress, b) Radial stress and c) Longitudinal stress The latter is due to the thrust of pressure on the heads of the cylinder. The value of the Hoop and Radial stresses are not constant through the cylinder walls, whereas longitudinal stresses are in fact constant. In the design phase it is therefore necessary to consider the stresses of the tri-axial state and to derive the ideal stress via. one of the theories of failure. Assuming that the ideal stress is equal to the basic allowable stress, we can then obtain an equation to compute the minimal required thickness for the pressure vessel.	**04 marks**	**04**

d)i)	 2b = major axis 2a = minor axis		**02 marks**	**04**
d)ii)	 rc = crown radius rk = knuckle radius		**02 marks**	
e)i)	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.		**02 marks**	**04**
e)ii)	Ligament efficiency: It is the ratio of Area of ligament to the Area of normal section expressed in %age.		**02 marks**	
f)	Stress concentration: Whenever in a part there is a change in the shape of its cross-section, then the stress distribution changes. This irregularity in the stress distribution caused by the abrupt changes of form is called as stress concentration. It occurs for all kinds of stresses in the presence of notches, fillets, holes, keyways, splines, surface roughness, shoulders, scratches, etc.		**02 marks** **02 mark for any two causes**	**04**
g)	**Arrow side**	**Other side**		
g)i)			**01 mark (any one)**	**04**
g)ii)			**01 mark (any one)**	
g)iii)			**01 mark (any one)**	
g)iv)		Not used	**01 mark (any one)**	
2	**Attempt any Two of the following**			**16**
a)	The boiler mountings are the part of the boiler and are required for proper functioning. In accordance with the Indian Boiler regulations, of the boiler mountings these are essential fittings for safe working of a boiler. Some of the important mountings are:		**01 marks** **02 marks for**	**08**

<table>
<tr><td></td><td colspan="2">Pressure Gauge, Safety Valve, Fusible Plug, Blow-Off Cock, etc.

The boiler accessories are mounted on the boiler to increase its efficiency. These units are optional on an efficient boiler. With addition of accessories on the boiler, the plant efficiency also increases. Some of the important accessories are:
Economizer, Super heater, Air pre heater, Feed water pump, Steam injector, etc.

Boiler may operate with/without accessories but should not operate without mountings.</td><td>any two

01 marks

02 marks for any two

02 marks</td><td></td></tr>
<tr><td>b)i)</td><td>Design by ASME Approach

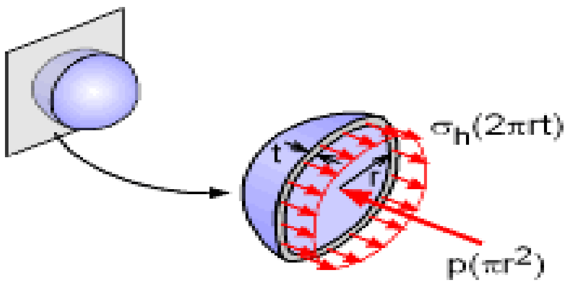
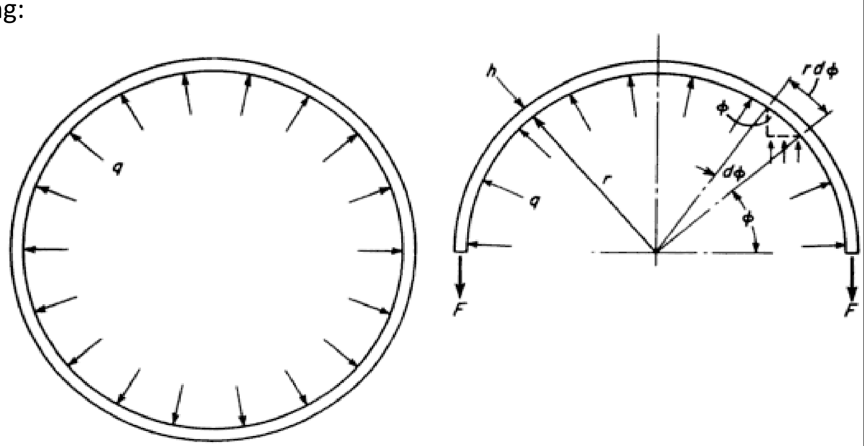
Datas:
1. Cast Steel cylinder
Inside diameter, D_i = 350mm
Design pressure, P = 13.5N/mm²
Maximum hoop stress, S = 55MPa
Assume, ε = 100%
$t = PR_i / (S\varepsilon - 0.6P)$
=</td><td>Design by Internal Pressure Approach
Datas:
1. Cast Steel cylinder
Inside diameter, D_i = 350mm
Design pressure, P = 13.5N/mm²
Maximum hoop stress, S = 55MPa
Assume, ε = 100%
$t = PD_i / (2S\varepsilon - P)$
=</td><td>04 marks (any one method)</td><td rowspan="2">08</td></tr>
<tr><td>b)ii)</td><td>Alloy Steel flat cover plate
Inside diameter, D = 350mm
Design pressure, P = 13.5N/mm²
Maximum working stress, S = 55MPa
Constant, C = 0.1 to 0.33
Assume, ε = 100%
$t = D\sqrt{CP/S\varepsilon}$
=</td><td>Alloy Steel flat cover plate
Inside diameter, D = 350mm
Design pressure, P = 13.5N/mm²
Maximum working stress, S = 55MPa
Constant, C = 0.4 to 0.7
$t = CD\sqrt{P/S}$
=</td><td>04 marks (any one method)</td></tr>
<tr><td>c)</td><td>Design by ASME Approach

Datas:
1. Steel cylinder
Inside diameter, D_i = 1m
Design pressure, P = 2N/mm²
Ult. tensile strength, S_{ult} = 420MPa
Factor of safety, FOS = 6
Permissible stress, S = S_{ult} / FOS
Assume, ε = 100%
$t = PR_i / (S\varepsilon - 0.6P)$
=

2. Hemispherical end
Inside diameter, D = 1m
Design pressure, P = 2N/mm²</td><td>Design by Internal Pressure Approach
Datas:
1. Steel cylinder
Inside diameter, D_i = 1m
Design pressure, P = 2N/mm²
Ult. tensile strength, S_{ult}= 420MPa
Factor of safety = 6
Permissible stress, S = S_{ult} / FOS
Assume, ε = 100%
$t = PD_i / (2S\varepsilon - P)$
=

2. Hemispherical end
Inside diameter, D = 1m
Design pressure, P = 2N/mm²</td><td>04 marks (any one method)

04 marks (any one</td><td>08</td></tr>
</table>

	Ult. tensile strength, Sult = 420MPa Factor of safety, FOS = 6 Permissible stress, S = Sult / FOS Assume, Ɛ = 100% t = PR / (2SƐ – 0.2P) =	Ult. tensile strength, Sult = 420MPa Factor of safety, FOS = 6 Permissible stress, S = Sult / FOS Assume, Ɛ = 100% t = PD / 4SƐ =	**method)**	
3	**Attempt any <u>Two</u> of the following**			**16**
a)	Sphere:  Spherical Pressure Vessel Cut in Half 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) Ring:  **Radial and Hoop Stresses in a Thin Ring**		**02 marks** **02 marks** **02 marks**	**08**

	If a thin circular ring is subjected to the action of radial forces uniformly distributed along its circumference, hoop forces will be produced throughout its thickness which act in a tangential direction. A uniform enlargement of the ring will take place if the acting forces are radial outward, or contraction will occur if the acting forces are radial inward. The magnitude of the force F in the ring can be found by cutting the ring at a horizontal diametrical section giving the free body shown in Figure. If the force per unit length of circumference is q, and r is the radius of the ring, the force acting on an element of the ring is $qrd\phi$. Taking the sum of the vertical components of all the forces acting on the semicircular ring gives the equilibrium equation: $$2F = 2\int_0^{\pi/2} qr\sin\phi d\phi = 2qr$$ $$F = qr$$ The unit stress in the ring can be obtained by dividing the force F by the cross-sectional area A of the ring. $$\sigma_2 = \frac{qr}{A}$$ Now, $r\sin\phi d\phi$ is the projection of a circumferential element on a diameter; hence the right side of Equatn. is merely the unit force times the projected length of the contact surface. If the ring is considered a section of unit length of a cylindrical vessel of thickness h subjected to internal pressure p, so that in Equatn. $q = p$ and $A = h$, the hoop stress in a cylindrical vessel becomes $$\sigma_2 = \frac{pr}{h}$$	**02 marks**	
b)	Design of nozzles: Design of nozzle has to be done based on "area compensation" criterion. In this criterion, nozzle is designed such that area available for reinforcement with in "certain limits" at the junction must be compensated to area removed from shell/head to make that opening. Also according to ASME, strength of nozzle material must not be given additional importance compared to corresponding counter-joint (with whom nozzle is joined i.e. shell or head) material strength. t = PR / (Sε + 0.4P) + CA where, t = thickness of nozzle P = Pressure in nozzle (Assume same as pressure in vessel, if not given) R = Internal radius of nozzle S = Permissible stress of nozzle material ε = Joint efficiency CA = Corrosion allowance	**02 marks** **02 marks**	**08**

Design of flange: **02 marks**

Criterion, adopted for flange design and stress analysis, is carried out according to ASME code, in which following assumptions have been adopted.

1. For hub and shell sections of the flange, local pressure acting on their 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 arm, is 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.

Stresses in flanges and flanged joints: **02 marks**

For understanding of design and stress analysis of flange, integral weld neck flange has been taken in to consideration. In which, flange is divided into three sections with various loads and moments on each viz.

i. Annular ring section:
   Overturning moment
   Internal hydrostatic pressure
ii. Tapered hub section
   Shear force and bending moment
   Internal hydrostatic pressure
iii. Shell ring section
   Discontinuity shear force and bending moment

c) Fatigue concentration: **02 marks** **08**

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 localised stresses. Hence all stresses including localised stresses should be taken into account when designing the pressure vessel.

Stress concentration for circular and elliptical holes: **02 marks**

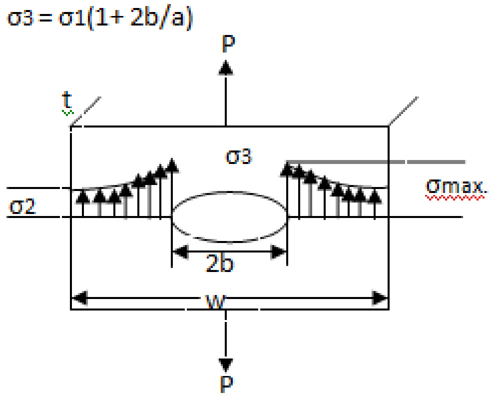
$K_t = \sigma_3 / \sigma_{av}$; where

$\sigma_{av} = P/t(w-2b)$

$\sigma_1 = P/tw$

$\sigma_3 = \sigma_1(1+2b/a)$

04 marks

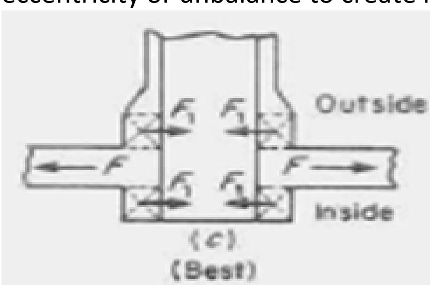
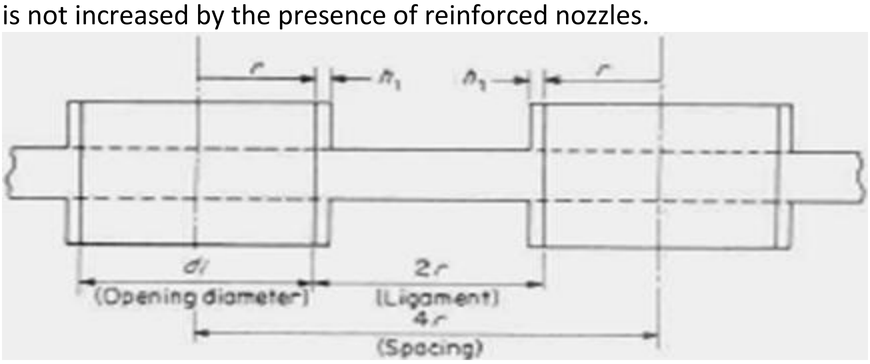


b/a	Kt
1	2.5
2	4.5
3	6.5
1/2	1.5
1/3	2.5
1/4	3.5
1/5	4.5

Where, b/a = 1 refers to circular opening

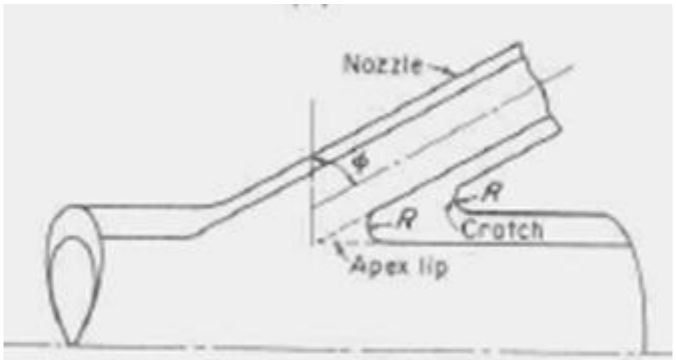
b/a = 1/2 refers to vertical ellipse with least stress concentration, Kt

4	**Attempt any <u>Two</u> of the following**		**16**
a)	Most common weld defects found are: 1. Poor weld shape due to misalignment of parts being welded 2. Cracks in welds due to thermal shrinkage 3. Pin holes on the weld surface 4. Slag inclusion when slag covering a run is not totally removed after every run before the following run. 5. Porosity in the form of voids (cavity) when gases are trapped in the solidifying weld metal 6. Incomplete fusion between the weld and base metal resulting from too little heat input and / or too rapid traverse of the welding torch (gas or electric). 7. Undercutting groove adjacent to the weld left unfilled by weld metal due to incorrect settings / procedure 8. Insufficient penetration of the weld metal in joints arises from too high a heat input and / or too slow traverse of the welding torch (gas or electric) 9. Etc.	**01 mark each**	**08**
b)	Ferrous materials for corrosive service: Mild steel (more common), Stainless steel Non ferrous materials for corrosive service: Copper, Nickel, Aluminum and their alloys (more common), Chromium and Cr alloys 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.	**01 mark each** **01 mark each (any two)** **04 marks (any two)**	**08**

	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, laquer.		
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. 	**01 mark** **02 mark** **02 mark**	**08**

3. Non radial nozzles — **02 mark**

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.



Nozzle shape: — **01 mark**

Nozzles may be circular, elliptical or oval in shape

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

2b = Major axis and 2a = Minor axis

Where, b/a = 1 refers to circular opening

b/a = 1/2 refers to vertical ellipse with least stress concentration, Kt

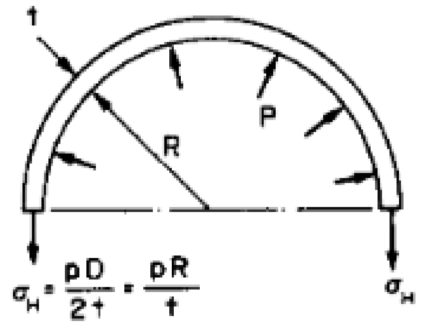
Q. No.		Marks	Total
5	**Attempt any Two of the following**		16

a) Some factors while calculating earthquake load are; — **02 mark (any four)** — **08**

1. Identify seismic prone areas with respect to frequency, direction and
2. amplitude of earthquake magnitude
3. Magnitude of damping
4. Allowable stress increase for component materials
5. Live load for seismic load
6. Etc.

Thin cylinders: — **01 mark**

The theoretical treatment of thin cylinders assumes that the hoop stress is constant across the thickness of the cylinder wall and also that there is no pressure gradient across the wall.



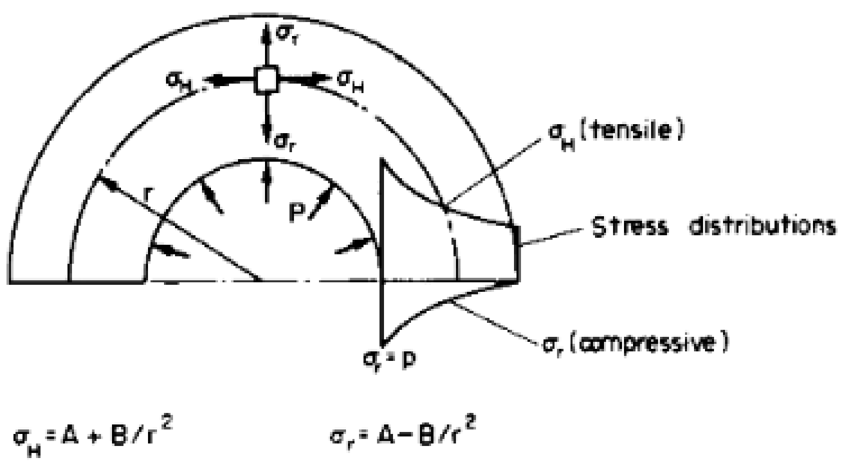
02 mark

01 mark

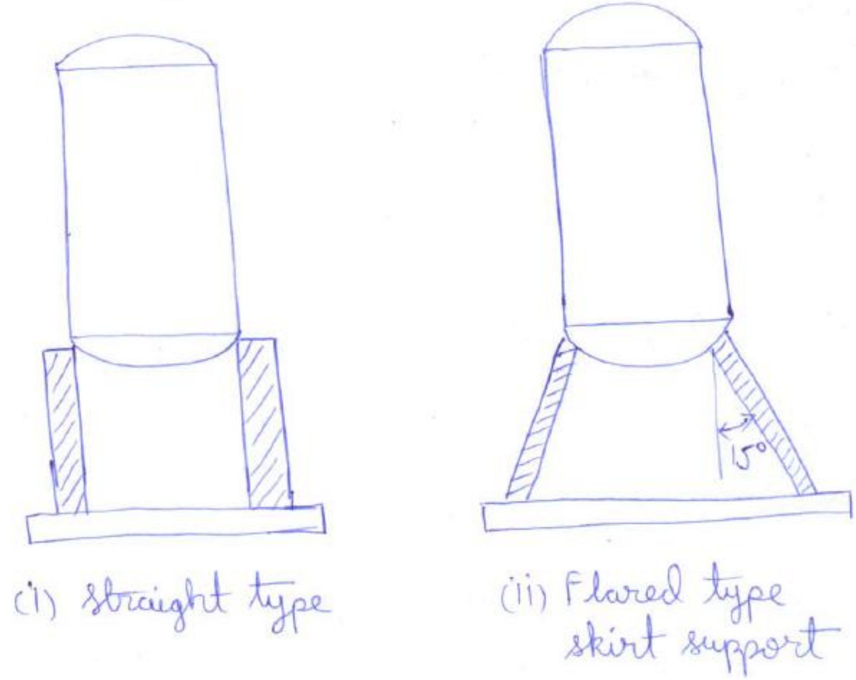
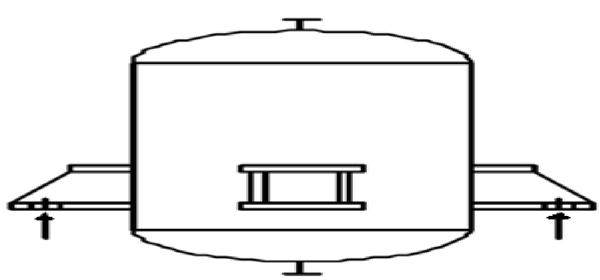
Thick cylinders:
Neither of these assumptions can be used for thick cylinders for which the variation of hoop and radial stresses is shown in figure below, their values being given by the Lame equations:

$$\sigma_H = A + \frac{B}{r^2} \quad \text{and} \quad \sigma_r = A - \frac{B}{r^2}$$

Development of the theory for thick cylinders is concerned with sections remote from the ends since distribution of the stresses around the joints makes analysis at the ends particularly complex. Consideration of any element in the wall of a thick cylinder involves, in general, consideration of a mutually perpendicular, tri-axial, principal stress system, the three stresses being termed radial, hoop (tangential or circumferential) and longitudinal (axial) stresses.



02 mark

b)i)		**0.5 mark**	**08**
	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.	**0.5 mark**	
	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.	**0.5 mark**	
	2) Flared type skirt support is used for very high columns with high external moments. The angle of skirt is maximum 15°.	**0.5 mark**	
b)ii)		**0.5 mark**	

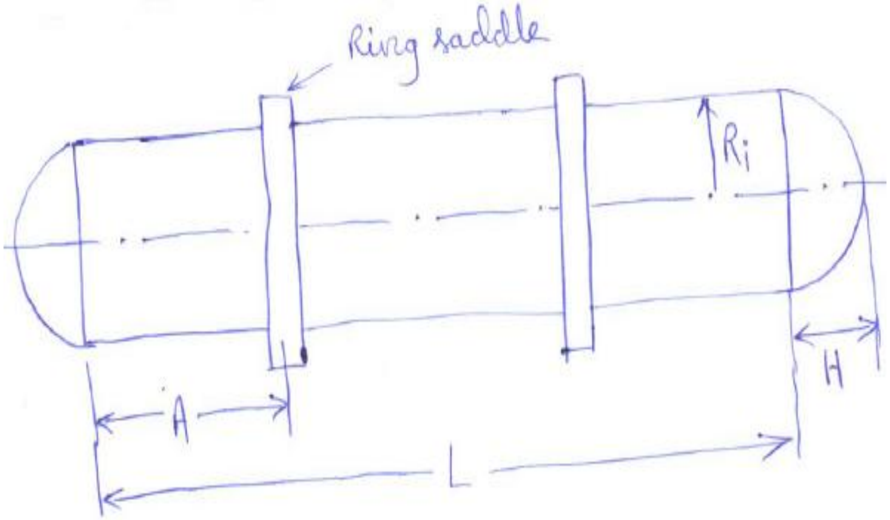
Support lug:
Brackets are fabricated from plates and are attached to the vessel wall. They are made to rest on small columns or beams of structure depending on the elevation required. They can be easily leveled. Due to the eccentricity of these supports, compressive, tensile and shear stresses are induced in the vessel wall. Bracket supports are suitable for vessels with thick walls. **0.5 mark**

Diameter of vessel	Number of brackets
Upto 0.6m	2
Upto 3.0m	4
Upto 5.0m	6
Above 5.0m	8

0.5 mark

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. **0.5 mark**

b)iii) **0.5 mark**



0.5 mark

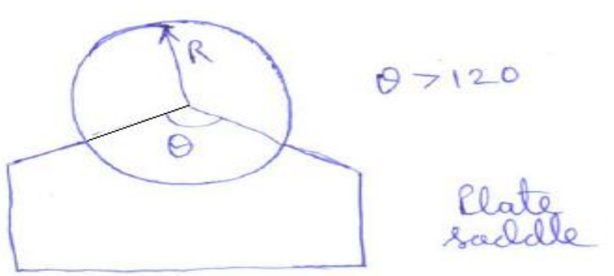
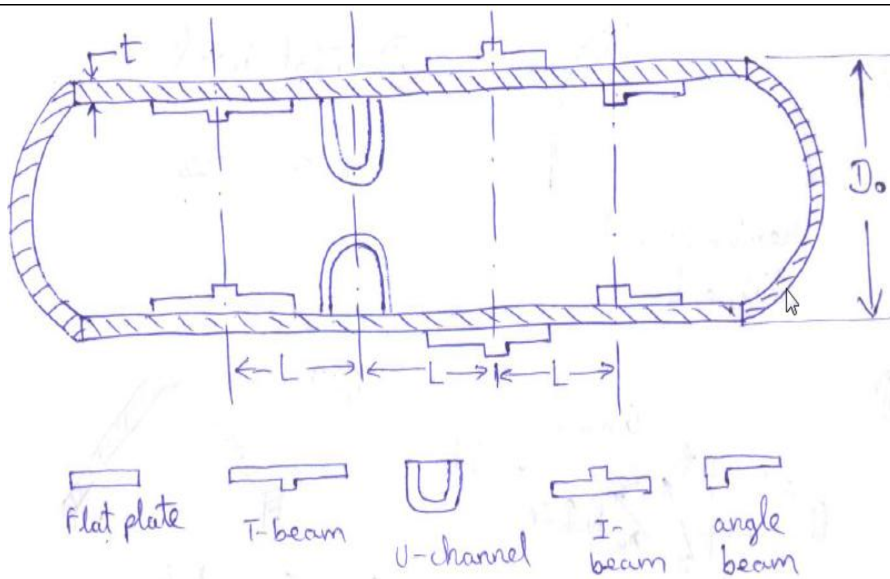
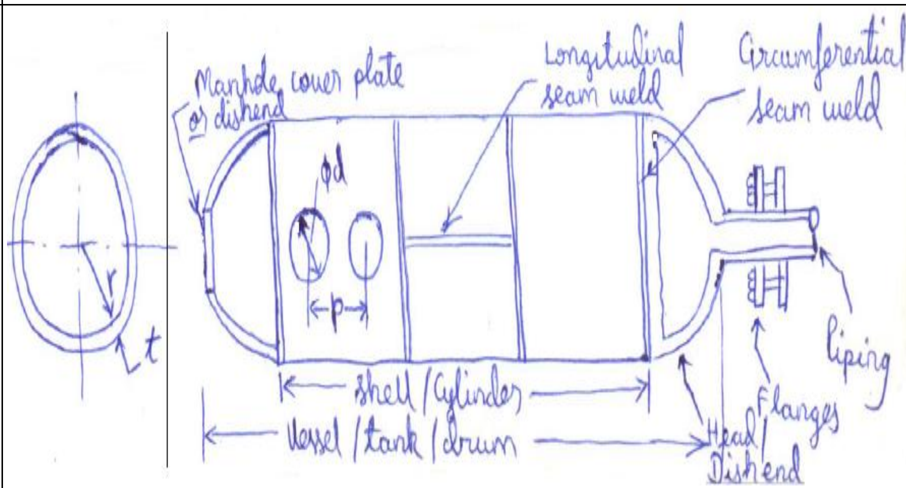
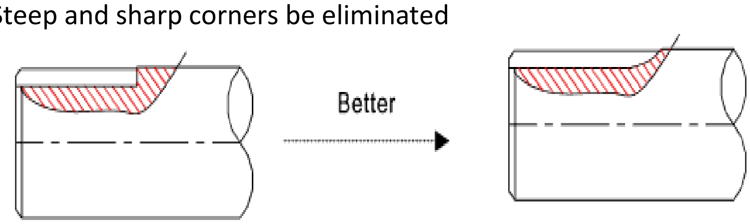


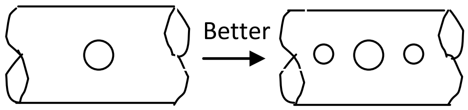
Plate type saddle support

Saddles:
Horizontal cylindrical vessels are supported on saddles. These are placed **0.5 mark**

	at minimum two positions. The shell of a vessel is strengthened by stiffeners and supported by using saddle supports. These are used for large thin walled vessels or vessels under vacuum. Supports in the form of rings are preferable for vessels in which supports at more than two positions are essential. Types are; 1) Plate type saddle support: In this included angle θ should be greater than 120^o. 2) Ring type saddle support: In this support, distance A = (0.4 to 0.5) times Ri or A < 0.2L Commonly used material for saddle is steel. The design load for saddle supports are; Operating weight + wind load + earthquake load + friction between saddle and foundation + test load	 **0.5 mark**	
b)iv)	 Stiffners: Considerable saving in weight and material can be made by use of stiffening rings (reinforcing rings). Stiffening rings are attached on the inside or outside surface of the shell. These rings extend over the whole circumference and serve the purpose of end supports. T- beams, flat plate rings, I-beam, U-channel, angles, etc. bolted/ riveted/welded to the shell can be used as stiffening rings.	**01 mark** **01 mark**	
c)	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; 1. Temperature 2. Hydrogen pressure 3. Time,	**04 marks (any four)**	**08**

	4. Composition of materials, 5. etc. i.e. because hydrogen attack on steels causes cracks in the shell plates or causes blistering (blisters i.e. swelling). Plain carbon steels or low alloy steels are the materials used for hydrogen service at low temperature and high pressure or vice-versa. Austenitic stainless steels also resist hydrogen damage.	**04 marks**	
6	**Attempt any <u>Four</u> of the following**		**16**
a)	 Pressure vessel consists of basic parts such as; Cylinders/shell, Rings, Baffle plates, Curved shape dish ends/ heads/ closure ends Nozzles, Flanges, Pipings, etc. Metal pressure components are fabricated by <u>welding</u>. When the vessel diameter is in the size range of procurable (which can be purchased) tubular products, the cylindrical part is normally selected directly. When the vessel diameter is more, rolled plates or castings or partial forged weld in to cylinders are used. Vessels must have openings (nozzles) for functional purposes like in boiler drums, heat exchangers, etc.	**02 marks** **01 mark** **01 mark**	**04**
b)	Datas: Seamless spherical shell Diameter, D = 900mm Thickness, t = 10mm	**04 marks**	**04**

	Vf = Final volume Vi = Initial volume $V_f - V_i = 150 * 10^3 mm^3$ i.e. Dilation, $\delta = (V_f - V_i) / 2$ $= (150 * 10^3) / 2$ Modulus of elasticity, $E = 200 KN/mm^2$ Poisson ratio, $\mu = 0.3$ Dilation, $\delta = Pr^2 (1 - \mu) / (2tE)$ Hence, $P = \delta(2tE) / r^2 (1 - \mu)$ =		
c)	Design of anchor bolts: 1. Number of bolts; n = D /600 where, n = number of bolts D = Outer diameter of skirt = Outer diameter of shell + 2 * thickness of skirt The number of bolts will be even number and minimum 04 nos. 2. Size of bolts; $W = \prod/4 * dc^2 * fc * n$ where, W = Weight of vessel with its content dc = core diameter of bolt fc = crushing stress of bolt material n = number of bolts Now, Size of bolt, d = dc / 0.84 The size of bolts will be even number and minimum of M24	**02 marks** **02 marks**	**04**
d)	Causes: 1. Abrupt changes in cross-section 2. Contact stresses (bearing, gear, etc) 3. Material discontinuities (hole) 4. Initial stresses due to manufacturing process 5. Cracks 6. etc. Remedies: 1. Steep and sharp corners be eliminated  2. Selecting materials which are tolerant to cyclic loading (ductile /tough materials)	**02 marks (any two)** **02 marks (for the two causes)**	**04**

	3.  4. Specifying manufacturing processes to provide fatigue resistance (Peening /shot blasting/Cold Working) 5. Specifying heat treatment to provide fatigue resistance- (Carburising /Nitriding) or Overdesigning part to reduce stress levels 6. etc.		
e)	NDT of welds: 1. Visual inspection: Visual-weld-inspection represents the immediate **critical observation** of the external features visible on all welds. It is the first and most important assessment of quality to be performed as soon as the welding operations are accomplished. 2. Other inspection procedures may be required to detect discontinuities not visible to the eye or present below the external surface. Whatever additional non destructive inspection methods are applied, they are performed **only after** visual inspection is successfully completed. Some of them are; i)Penetrant testing detects only surface breaking defects in smooth and non porous materials. Penetrant solution is applied to the surface of a precleaned component. The liquid is pulled into surface-breaking defects by capillary action. Excess penetrant material is carefully cleaned from the surface. A developer is applied to pull the trapped penetrant back to the surface where it is spread out and forms an indication. The indication is much easier to see than the actual defect. ii)Magnetic Particle Testing can detect surface and subsurface flaws in ferromagnetic materials. A magnetic field is established in a component made from ferromagnetic material. The magnetic lines of force travel through the material and exit and reenter the material at the poles. Defects such as crack or voids cannot support as much flux and force some of the flux outside of the part. Magnetic particles distributed over the component will be attracted to areas of flux leakage and produce a visible indication. iii)Ultrasonic Testing is used to locate surface and subsurface defects in many materials including metals, plastics, and wood. It employs high frequency sound waves that are sent into a material by use of a transducer. The sound waves travel through the material and are received by the same transducer or a second transducer. The amount of energy transmitted or received and the time the energy is received are analyzed to determine the presence of flaws. Changes in material thickness and changes in material properties can also be measured. iv)Radiographic testing inspects almost any material for surface and	**01 mark** **03 marks** **(any ~~three)~~** two)	**04**

<table>
<tr><td></td><td colspan="2">subsurface defects. They can also be used to locate and measure internal features, confirm the location of hidden parts in an assembly and to measure thickness of materials. It employs X-rays that are used to produce images of objects using film or other detector that is sensitive to radiation. The test object is placed between the radiation source and detector. The thickness and the density of the material that X-rays must penetrate affect the amount of radiation reaching the detector. This variation in radiation produces an image on the detector that often shows internal features of the test object.

v)Etc……………………………………………………………………………………………………..</td><td></td><td></td></tr>
<tr><td>f)</td><td>Design by ASME Approach

Datas:
1. Cast Iron cylinder
Inside diameter, Di = 160mm
Design pressure, P = 15N/mm²
Permissible working stress, S = 25MPa
Assume, ε = 100%
t = PRi / (Sε – 0.6P)
=

2. Flat head plate
Inside diameter, D = 160mm
Design pressure, P = 15N/mm²
Permissible working stress, S = 25MPa
Constant, C = 0.1 to 0.33
Assume, ε = 100%
t = D √(CP/Sε)
=</td><td>Design by Internal Pressure Approach
Datas:
1. Cast Iron cylinder
Inside diameter, Di = 160mm
Design pressure, P = 15N/mm²
Permissible working stress, S = 25MPa
Assume, ε = 100%
t = PDi / (2Sε – P)
=

2. Flat head plate
Inside diameter, D = 160mm
Design pressure, P = 15N/mm²
Permissible working stress, S = 25MPa
Constant, C =
t = CD √(P/S)
=</td><td>02 marks (any one method)

02 marks (any one method)</td><td>04</td></tr>
</table>