MECHANICAL ENGINEERING

[English Medium]

SSC JE

Chapterwise and Sub-topicwise SOLVED PAPERS

Chief Editor
Anand Kumar Mahajan

Compiled & Written by
Mechanical Engg. Expert Group

Computer Graphics by
Balkrishna, Charan Singh

Editorial Office
12, Church Lane Prayagraj-211002
Mob. : 9415650134
Email : yctap12@gmail.com
website : www.yctbooks.com/www.yctfastbook.com

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CONTENT

SSC Junior Engineer Paper Syllabus

MECHANICAL ENGINEERING

The Examination will be conducted in two stages :

A. Paper-I (Pre) (200 marks)

B. Paper-II (Mains) (300 marks)

Total Written Test (500 marks)

Written Test :

Paper	Subject	Number of Questions/ Max. Marks	Duration & Timing
Paper-I Objective type	(i) General Intelligence & Reasoning (ii) General Awareness (iii) General Engineering (Mechanical)	50 /50 50 / 50 100 / 100	2 Hours
Paper-II Objective type	General Engineering (Mechanical)	100/ 300	2 Hours

There will be **negative marking equal to one-fourth (1/4) of the marks** allotted to the question for each wrong answer in Paper-I & negative marking of one mark for each wrong answer in Paper-II.

Syllabus of Examination

- The standard of the questions in Engineering subjects will be approximately of the level of Diploma in Mechanical Engineering from a recognized Institute, Board or University recognized by All India Board of Technical Education. All the questions will be set in SI units. The details of the syllabus are given below.

Paper-I

- ***General Intelligence & Reasoning:*** The Syllabus for General Intelligence would include questions of both verbal and non-verbal type. The test may include questions on analogies, similarities, differences, space visualization, problem solving, analysis, judgment, decision making, visual memory, discrimination, observation, relationship concepts, arithmetical reasoning, verbal and figure classification, arithmetical number series etc. The test will also include questions designed to test the candidate's abilities to deal with abstract ideas and symbols and their relationships, arithmetical computations and other analytical functions.
- ***General Awareness:*** Questions will be aimed at testing the candidate's general awareness of the environment around him/her and its application to society. Questions will also be designed to test knowledge of current events and of such matters of everyday observations and experience in their scientific aspect as may be expected of any educated person. The test will also include questions relating to India and its neighbouring countries especially pertaining to History, Culture, Geography, Economic Scene, General Polity and Scientific Research, etc. These questions will be such that they do not require a special study of any discipline.
- **General Engineering : Civil and Structural, Electrical & Mechanical**

Mechanical Engineering

- Theory of Machines and Machine Design, Engineering Mechanics and Strength of Materials, Properties of Pure Substances, 1st Law of Thermodynamics, 2nd Law of Thermodynamics, Air standard Cycles for IC Engine Performance, IC Engines Combustion, IC Engine Cooling & Lubrication, Rankine cycle of System, Boilers, Classification, Specification, Fitting & Accessories, Air Compressors & their cycles, Refrigeration cycles, Principle of Refrigeration Plant, Nozzles & Steam Turbines. Properties & Classification of Fluids, Fluid Statics, Measurement of Fluid Pressure, Fluid kinematics, Dynamics of Ideal fluids, Measurement of Flow rate, basic principles, Hydraulic Turbines, Centrifugal Pumps, Classification of steels.

Detailed Syllabus JE Mechanical Engineering

Theory of Machines and Machine Design

- Concept of simple machine, Four bar linkage and link motion, Flywheels and fluctuation of energy, Power transmission by belts – V-belts and Flat belts, Clutches – Plate and Conical clutch, Gears – Type of gears, gear profile and gear ratio calculation, Governors – Principles and classification, Riveted joint, Cams, Bearings, Friction in collars and pivots.

Engineering Mechanics and Strength of Material

- Equilibrium of Forces, Law of motion, Friction, Concepts of stress and strain, Elastic limit and elastic constants, Bending moments and shear force diagram, Stress in composite bars, Torsion of circular shafts, Bucking of columns – Euler's and Rankin's theories, Thin walled pressure vessels.

Thermal Engineering

Properties of Pure Substances:

- P-V & P-T diagrams of pure substance like H_2O, Introduction of steam table with respect to steam generation process; definition of saturation, wet & superheated status. Definition of dryness fraction of steam, degree of superheat of steam. H-S chart of steam (Mollier's Chart).

1st Law of Thermodynamics :

- Definition of stored energy & internal energy, 1st law of Thermodynamics of cyclic process, Non-Flow Energy Equation, Flow Energy & Definition of Enthalpy, Conditions for Steady State and Steady Flow; Steady State Steady Flow Energy Equation.

2nd Law of Thermodynamics :

- Definition of Sink, Source Reservoir of Heat, Heat Engine, Heat Pump & Refrigerator; Thermal Efficiency of Heat Engines & co-efficient of performance of Refrigerators, Kelvin – Planck & Clausius Statements of 2nd Law of Thermodynamics, Absolute or Thermodynamic Scale of temperature, Clausius Integral, Entropy change calculation of ideal gas processes. Carnot Cycle & Carnot Efficiency, PMM-2; definition & its impossibility.

Air standard Cycles for IC engines :

- Otto cycle; plot on P-V, T-S Planes; Thermal Efficiency, Diesel Cycle; Plot on P-V, T-S planes; Thermal efficiency.
  IC Engine Performance, IC Engine Combustion, IC Engine Cooling & Lubrication.

Rankine cycle of steam :

- Simple Rankine cycle plot on P-V, T-S, H-S planes, Rankine cycle efficiency with & without pump work. Boilers; Classification; Specification; Fittings & Accessories : Fire Tube & Water Tube Boilers. Air Compressors & their cycles; Refrigeration cycles; Principle of a Refrigeration Plant; Nozzles & Steam Turbines

Fluid Mechanics & Machinery

Properties & Classification of Fluid :

- Ideal & real fluids, Newton's law of viscosity, Newtonian and Non-Newtonian fluids, compressible and incompressible fluids.

Fluid Statics : Pressure at a point.

Measurement of Fluid Pressure : Manometers; U-tube, Inclined tube.

Fluid Kinematics : Stream line, laminar & turbulent flow, external & internal flow, continuity equation.

Dynamics of ideal fluids : Bernoulli's equation, Total head; Velocity head: Pressure head; Application of Bernoulli's equation.

Measurement of Flow rate Basic Principles : Venturimeter, Pilot tube, Orifice meter

Hydraulic Turbines : Classifications, principles

Centrifugal Pumps : Classifications, Principles, Performance.

Production Engineering

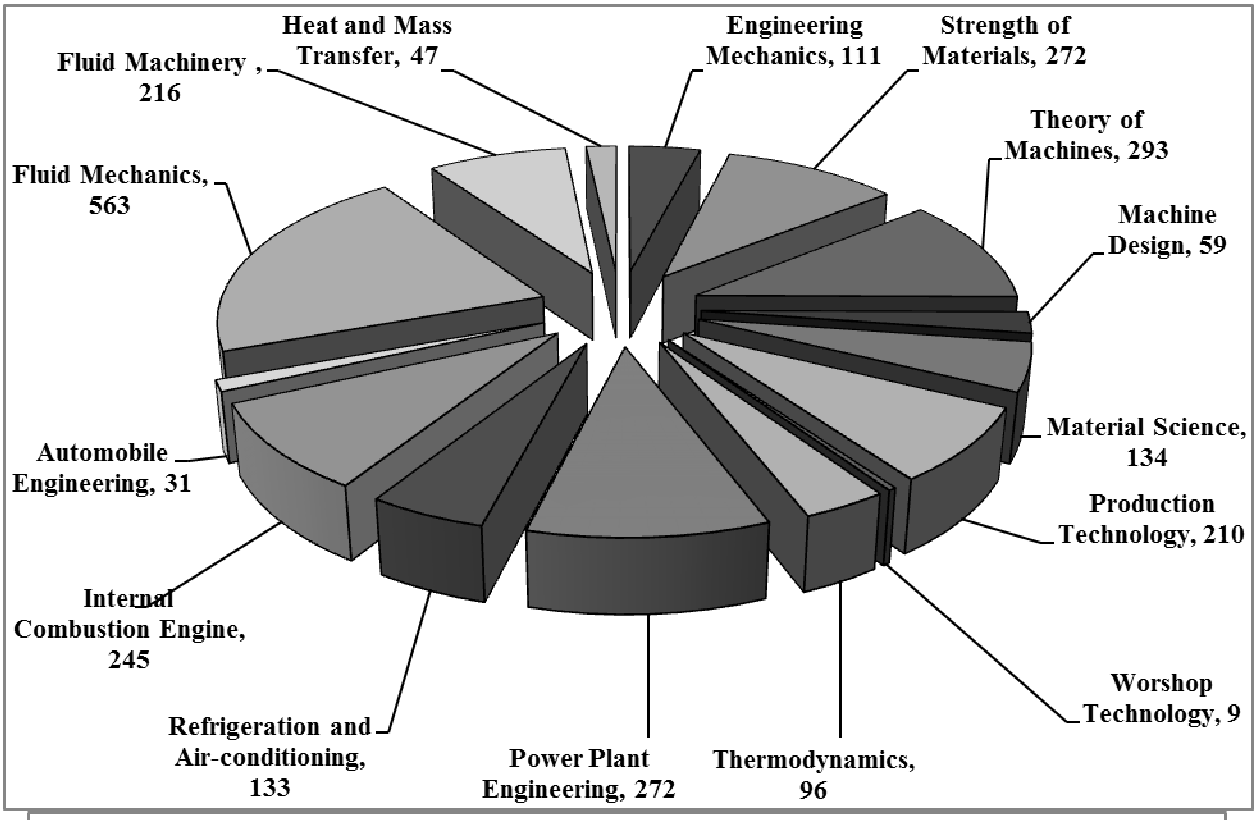
Classification of Steels :

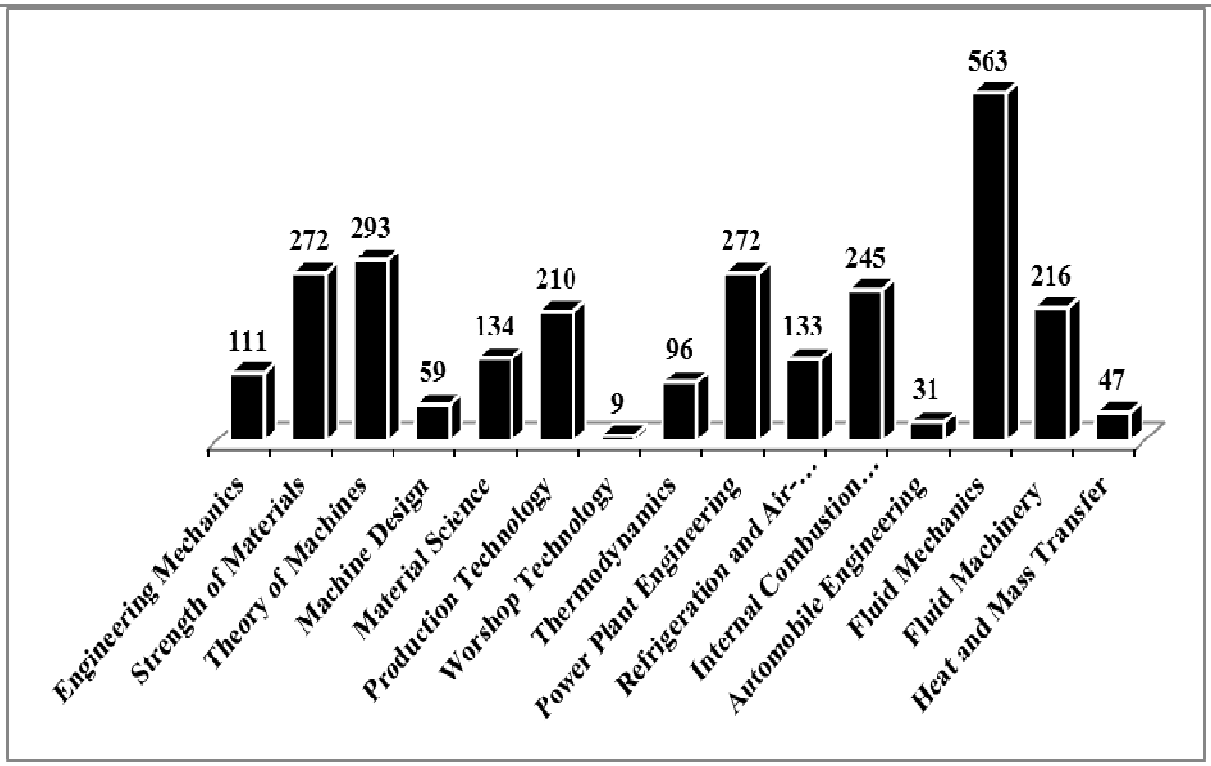
- Mild steal & alloy steel, Heat treatment of steel, Welding – Arc Welding, Gas Welding, Resistance Welding, Special Welding Techniques i.e. TIG, MIG, etc. (Brazing & Soldering), Welding Defects & Testing; Foundry & Casting – methods, defects, different casting processes, Forging, Extrusion, etc, Metal cutting principles, cutting tools, Basic Principles of machining with (i) Lathe (ii) Milling (iii) Drilling (iv) Shaping (v) Grinding, Machines, tools & manufacturing processes.

Mechanical Engineering JE Previous Years Exam Papers Analysis Chart

Sl No	Exam	Proposed Year	Total Question
1.	SSC (JE) Shift-II	09.10.2023	100
2.	SSC (JE) Shift-II	11.10.2023	100
3.	SSC (JE) Shift-II	14.11.2022	100
4.	SSC (JE) Shift-II	16.11.2022	100
5.	SSC (JE) Shift-I	22.03.2021	100
6.	SSC (JE) Shift-II	22.03.2021	100
7.	SSC (JE) Shift-I	27.10.2020	100
8.	SSC (JE) Shift-II	27.10.2020	100
9.	SSC (JE)	28.10.2020	100
10.	SSC (JE)	11.12.2020	100
11.	SSC (JE)	25.09.2019	100
12.	SSC (JE) Shift-I	27.09.2019	100
13.	SSC (JE) Shift-II	27.09.2019	100
14.	SSC (JE) Shift-I	22.01.2018	100
15.	SSC (JE) Shift-II	22.01.2018	100
16.	SSC (JE) Shift-I	23.01.2018	100
17.	SSC (JE) Shift-II	23.01.2018	100
18.	SSC (JE) Shift-I	24.01.2018	100
19.	SSC (JE) Shift-II	24.01.2018	100
20.	SSC (JE) Shift-I	25.01.2018	100
21.	SSC (JE) Shift-II	25.01.2018	100
22.	SSC (JE) Shift-I	27.01.2018	100
23.	SSC (JE) Shift-II	27.01.2018	100
24.	SSC (JE) Shift-I	29.01.2018	100
25.	SSC (JE) Shift-II	29.01.2018	100
26.	SSC (JE) Shift-I	01.03.2017	100
27.	SSC (JE) Shift-II	01.03.2017	100
28.	SSC (JE) Shift-I	02.03.2017	100
29.	SSC (JE) Shift-II	02.03.2017	100
30.	SSC (JE) Shift-I	03.03.2017	100
31.	SSC (JE) Shift-II	03.03.2017	100
32.	SSC (JE) Shift-I	04.03.2017	100
33.	SSC (JE) Shift-II	04.03.2017	100
34.	SSC (JE)	2015	100
35.	SSC (JE) Shift-I	2014	100
36.	SSC (JE) Shift-II	2014	100
37.	SSC (JE)	2013	100
38.	SSC (JE)	2012	100
39.	SSC (JE)	2011	100
40.	SSC (JE)	2010	50
41.	SSC (JE)	2009	50
42.	SSC (JE)	2008	50
43.	SSC (JE)	2007	50

Trend Analysis of Previous Years Questions of Mechanical Engineering Through Pie Chart & Bar Graph





Highlights of SSC JE Mechanical Engineering-2023

Chapter-1 Engineering Mechanics

Forces and Force Systems

1. Select the correct statement of Lami's theorem.

(a) If two forces are in equilibrium, then each force is directly proportional to sine of the angle between them

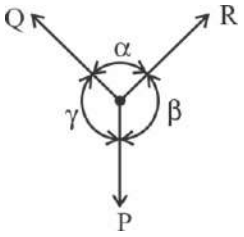
(b) If three forces are non-coplanar, then each force is directly dependent on sine of the angle between the other two forces

(c) If three forces are not in equilibrium, then each force is inversely proportional to sine of the angle between the other two forces

(d) If three forces acting on a body are said to be in equilibrium, then each force is directly dependent on sine of the angle between the other two forces

SSC JE 11.10.2023 Shift-II

Ans. (d) : Lami's theorem– If three forces acting on a body are said to be in equilibrium, then each force is directly dependent on sine of the angle between the other two forces.



$$\frac{P}{\sin\alpha} = \frac{Q}{\sin\beta} = \frac{R}{\sin\gamma}$$

2. Which of the following statements about equilibrium is correct?

(a) Summation of all the forces in all the possible directions must be zero

(b) Summation of all the forces acting in all the possible directions must be non-zero

(c) Summation of all the forces acting in one direction must not be zero

(d) Summation of all the forces in one direction must be zero

SSC JE 09.10.2023 Shift-II

Ans. (a) : According to equilibrium forces, summation of all the forces in all the possible direction must be zero.

$\Sigma F_H = 0, \quad \Sigma F_V = 0, \quad \Sigma F_M = 0,$

Where,

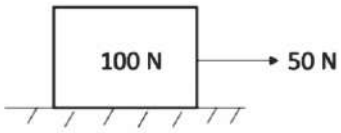
$\Sigma F_H \Rightarrow$ Algebraic summation of all forces in horizontal direction.

$\Sigma F_V \Rightarrow$ Algebraic summation of all forces in vertical direction.

$\Sigma F_M \Rightarrow$ Algebraic summation of all moments.

Moments and Couples

3. A body of weight 100 N is lying on a rough horizontal surface, an the horizontal force of 50 N is applied on the body as shown in the figure, which is just enough to move the body. What will be the coefficient of friction?



(a) 0.6 (b) 0.4

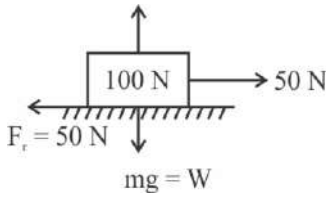
(c) 0.5 (d) 0.3

SSC JE 11.10.2023 Shift-II

Ans. (c) : Given,

Weight (w) = 100 N

F = 50 N



So, seeing the FBD of figure

W = R = 100 N

$F = F_r = 50$ N

Formula-

$F_r = \mu R$

$$\mu = \frac{F_r}{R} = \frac{50}{100} = 0.5$$

$\boxed{\mu = 0.5}$

Friction

4. The friction experienced by the body when the body tends to move is known as :

(a) sliding friction (b) rolling friction
(c) static friction (d) dynamic friction

SSC JE 11.10.2023 Shift-II

Ans. (d) : Static friction– It is the friction experienced by a body when it is at rest. Or in other words, it is the friction when the body tends to move.

Dynamic friction– It is the friction experienced by a body when it is in motion. It is also called kinetic friction.

Limiting friction– The maximum value of frictional force, which come into play, when a body just begins to slide over the surface of the other body, is known as limiting friction.

5. The direction of the friction force is :

(a) in the direction of motion of the body
(b) in the inclined direction of the motion of the body
(c) in the opposite direction of motion of the body or in the opposite direction of the tendency to move
(d) in the perpendicular direction of the motion of the body

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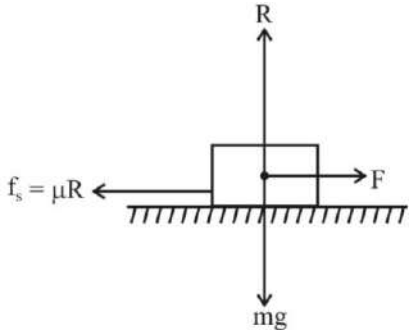
Ans. (c) : Friction force : It is a resisting force. The direction of friction force is in the opposite direction of motion of the body or in the opposite direction of the tendency to move the body.

- The friction force prevents or reduces the relative motion between two solid surfaces.



Noted Points :

(i) Friction is independent from contact surface area.
(ii) Friction force is directly proportional to normal reaction ($f_s \propto R$, $f_s = \mu R$)
(iii) Ratio of friction force to normal reaction is always constant.

Chapter-2 Strength of Materials

Simple Stress-Strain & Elastic Constants

6. The correct relation between the modulus of elasticity (E) and modulus of rigidity (G) is : Given, μ = Poisson's ratio.

(a) $G = 2E(1 + \mu)$ (b) $E = 2G(1 + \mu)$
(c) $E = 4G(1 + \mu)$ (d) $G = 4E(1 + \mu)$

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Ans. (b) : Relation between E, G, K & μ

$\Rightarrow \boxed{E = 2G(1+\mu)}$

$\Rightarrow \boxed{E = 3K(1-2\mu)}$

$\Rightarrow \boxed{E = \dfrac{9KG}{G+3K}}$

$\Rightarrow \boxed{\mu = \dfrac{3K-2G}{3K+2G}}$

Notations–
E = Young's modulus, G = Modulus of rigidity
μ = Poisson's ratio, K = Bulk modulus.

7. The behaviour of a material at different stages of loading is represented by a diagram called the _____ diagram.

(a) iron carbon (b) stress strain
(c) hysteresis (d) circumferential stress

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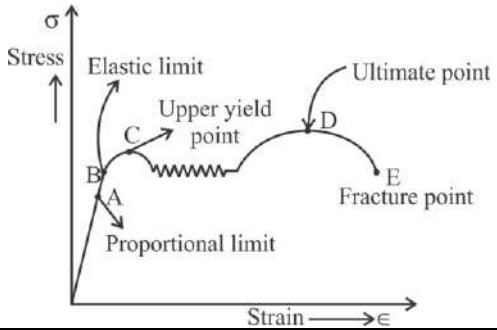
Ans. (b) : The behaviour of a material at different stages of loading is represented by 'stress-strain'. diagram.

- A stress-strain curve is a graphical representation of the relationship between stress and strain in a material.
- Stress is the force applied to a material per unit area. While a strain is the resulting deformation of the material.

Stress-Strain curve–



8. On the stress-strain diagram, the material obeys Hooke's law till :

(a) Point of ultimate stress (b) Elastic limit

(c) Upper yield point (d) Lower yield point

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Ans. (b) : On the stress - strain diagram, the material obeys Hook's law till Elastic limit.

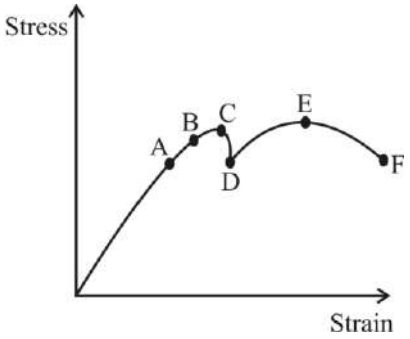
■ **According to Hook's law-**

stress (σ) $\propto$ strain (ε)

$\sigma = E.\varepsilon$

Modulus of Elasticity (E) = $\frac{\sigma}{\varepsilon}$

Stress -strain diagram for ductile material :



Notations -

Point 'A' → Proportional limit

Point 'B' → Elastic limit

Point 'C' → Upper yield point

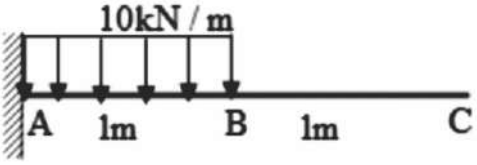
Point 'D' → Lower yield point

Point 'E' → Ultimate stress

Point 'F' → Fracture point

Shear Force and Bending Moment Diagram

9. A cantilever beam carries a uniformly distributed load over a span of 1 m as shown in the figure below. The reactive moment at point A is .....



(a) 0 kN-m (b) 30 kN-m

(c) 10 kN-m (d) 5 kN-m

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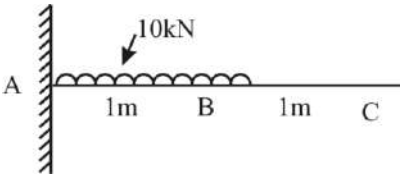
Ans. (d) : Cantilever beam with uniformly load (VDL) shear force calculation:-



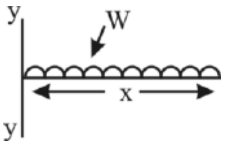
Fx = W.x

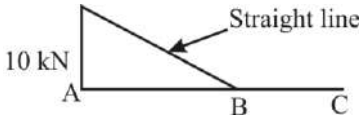
When, x = 0, $F_B = 0$

and x = L, $F_A = W.L$

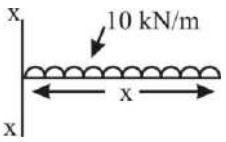
$F_A = 10 \times \{L=1\}$

$= 10kN$

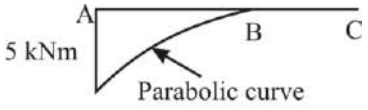




Bending moment calculation:-



$M_x = w.x.\frac{x}{2}$



BMD

When, x=0 , $M_A = \frac{WL.L}{2}$

if L = 1m

Then $M_A = 10 \times 1 \times \frac{1}{2}$

$\boxed{M_A = 5\,kNm}$

Torsion of Shafts

10. A solid circular shaft of diameter d is subjected to the twisting moment T. Which of the following relations can be used to determine the stress developed in the shaft?

(a) $\tau = \frac{32T}{\pi d^3}$ (b) $\tau = \frac{16T}{\pi d^3}$

(c) $\tau = \frac{64T}{\pi d^3}$ (d) $\tau = \frac{128T}{\pi d^3}$

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Ans. (b) : Maximum stress developed in the solid shaft :

$$\tau_{max} = \frac{16T}{\pi d^3}$$

Where,

T = twisting moment

d = diameter of solid circular shaft

■ Maximum shear stress of hollow shaft.

$$\tau_{hollow} = \frac{16T}{\pi d^3 (1 - k^4)}$$

Where,

$$\left\{ k = \frac{d_i}{d_o} \right\}$$

d_i = Inner diameter of hollow shaft.

d_o = Outer diameter of hollow shaft.

Theory of Columns

11. A seamless pipe having a diameter of 600 mm and thickness of 9 mm, contain the fluid under a pressure of 4 MPa, find the longitudinal stress developed in the pipe.

(a) 88.8 Mpa (b) 133.3 Mpa

(c) 66.6 Mpa (d) 77.7 Mpa

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Ans. (c) : Given,

d = 600 mm, t = 9 mm

p = 4 Mpa σ_L = ?

$$\sigma_L = \frac{pd}{4t}$$

$$= \frac{4 \times 600}{4 \times 9} = \frac{600}{9}$$

= 66.6 MPa

Chapter-3 Theory of Mechanics

Cams and Follower

12. If the line of stroke of a follower passes through the centre of rotation of a cam, then the cam is called .....

(a) Globoidal cam

(b) Oscillating cam and follower

(c) Offset cam

(d) Radial cam

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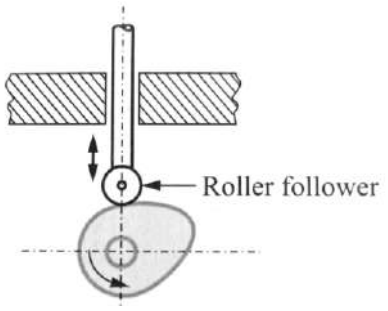
Ans. (d) : Radial or disc cam : The line of stroke of a follower passes through the centre of rotation of a cam, called radial (disc) cam.

■ The axis of the follower passes through the axis of the cam.



Gears and Gear Trains

13. The speed ratio of a compound gear train is defined as _____.

(a) $\frac{\text{Product of number of teeth of driver shafts}}{\text{Product of number of teeth on driven shafts}}$

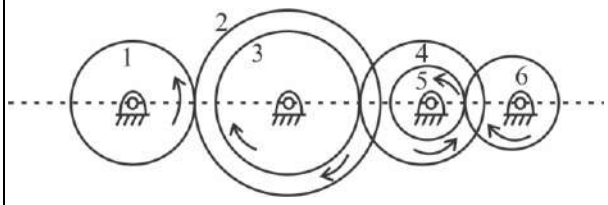
(b) $\frac{\text{Speed of last follower}}{\text{Speed of first driver}}$

(c) $\frac{\text{Product of number of teeth on driven shafts}}{\text{Product of number of teeth on driver shafts}}$

(d) $\frac{\text{Product of speed of followers}}{\text{Product of speed of drivers}}$

SSC JE 11.10.2023 Shift-II

Ans. (c) : Compound gear train– In this gear train, each shaft supports two gear wheels except the first and the last.



Train value,

$$\frac{N_{output}}{N_{input}} = \frac{\text{Product of no. of teeth on driving gears}}{\text{Product of no. of teeth on driven gears}}$$

$$\boxed{\frac{N_6}{N_1} = \frac{T_1 \times T_3 \times T_5}{T_2 \times T_4 \times T_6}}$$

- Speed ratio = $\frac{1}{\text{Train value}}$

$$\boxed{\text{Speed ratio} = \frac{\text{Product of number of teeth on driven shafts}}{\text{Product of number of teeth on driven shafts}}}$$

Belts, Ropes and Chains

14. Which of the following statements related to rope drives is incorrect?

(a) Shafts do not require exact alignment
(b) Rope drives have high mechanical efficiency
(c) It is used to transmit power only for shorter distances
(d) It has good crushing resistance

SSC JE 09.10.2023 Shift-II

Ans. (c) : Advantages of Rope drive-

- Rope drive are used for long distance and for large amount of power transmission.
- Rope drive can be employed when there is a misalignment between the pulleys within limits.
- In the rope drive, frictional grip is more than belt drives.
- Rope drives have high mechanical efficiency.
- It has good crushing resistance.

Flywheel and Governors

15. Which of the following statements is correct about a working engine?

(a) Operation of the governor is continuous, whereas operation of the flywheel is more or less intermittent
(b) Operation of both the flywheel and the governor is continuous
(c) Operation of both the flywheel and the governor is intermittent
(d) Operation of the flywheel is continuous, whereas operation of the governor is more or less intermittent

SSC JE 11.10.2023 Shift-II

Ans. (d) : If Engine is continuous working then It's fly wheel is continuous operated but the governor is more or less intermittent operated.

Flywheel:-It is used to control the variations in speed during each cycle of an engine flywheel of suitable dimensions attached to the crankshaft, makes the moment to inertia of the rotating parts quite large and thus acts as a reservoir of energy.

Governor :- The function of a governor is to maintain the speed of an engine with in specified limits whenever there is a variation of load.

Gyroscope

16. Which of the following statements is correct regarding governor?

(a) It is not a compulsory device of the prime mover
(b) It controls acceleration of the prime mover
(c) It controls the temperature of the prime mover
(d) It controls the mean speed of the prime mover

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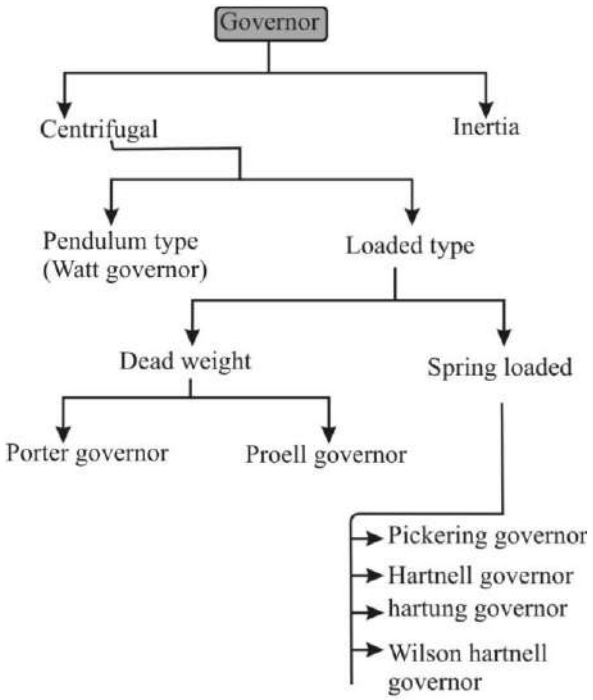
Ans. (d) : Governor controls the mean speed of the prime mover with in specified limits when there is a variation of load.



Chapter-4 Machine Design

Design of Bearings, Brakes and Clutches

17. Under steady state operation of a cone clutch, if semi-cone angle (α) decreases then _____ .

(a) does not affect the axial force
(b) the axial force increases
(c) the torque produced by clutch increases
(d) the torque produced by clutch decreases

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Ans. (c) : Under steady state operation of a cone clutch, if semi-cone angle (α) decreases then the torque produced by clutch increase.

Torque transmitted ($T = n\mu wR$) – for plate clutch.

$$T = \frac{\mu wR}{\sin\alpha}$$ ...For cone clutch

Where, R = Mean radius of the friction surfaces.

$$R = \frac{2}{3}\frac{(r_1)^3 - (r_2)^3}{(r_1)^2 - (r_2)^2}$$ (For uniform pressure)

$$R = \frac{r_1 + r_2}{2}$$ (For uniform wear)

Chapter-5 Material Science

Material Properties

18. The property of tool material to retain its hardness at elevated temperature is known as :

(a) Elasticity (b) Red hardness
(c) Plasticity (d) Toughness

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Ans. (b) : Red hardness is the ability of the material to retain its hardness at elevated temperatures. It is to resist plastic deformation and reduce wear rate at elevated temperatures.

19. Which of the following is NOT an example of brittle material ?

(a) High carbon steel (b) Ceramic materials
(c) Cast iron (d) Aluminium

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Ans. (d) : Aluminium is not on example of brittle material.

Brittle material:- Brittle material show little deformation before fracture and failure occurs suddenly without any warning.

- Normally if the elongation is less than 5% then these material is called brittle nature.

Example → Cast iron, glass, ceramics etc.

- Characteristics of Brittle material-

(i) High compressive strength
(ii) Low tensile strength
(iii) They have good toughness

Heat Treatment Process

20. Due to the refinement of grains, mechanical properties such as toughness, ductility, elongation and reduction in the area are improved in _____ process.

(a) Hot working (b) Forming
(c) Joining (d) Cold working

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Ans. (a) : Due to the refinement of grains, mechanical properties such as toughness, ductility, elongation and reduction in the area are improved in hot working process.

Advantage of hot working–

- Significant plastic deformation.
- Significant change in workpiece shape.
- Lower forces are required.
- Forming of materials with low ductility.
- No work hardening.

Disadvantage of hot working–

- Shorter tool life.
- Poor surface finish
- Lower dimensional accuracy.
- High production cost.

Chapter-6 Production Technology

Metal Cutting Processes

21. If the cutter and workpiece movements are in opposite direction, the milling process is known as :

(a) Side milling (b) Up milling
(c) Down milling (d) Face milling

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Ans. (b) : Up milling – (conventional milling)

- The cutter and work piece movement are in opposite direction
- **Cutting force-**

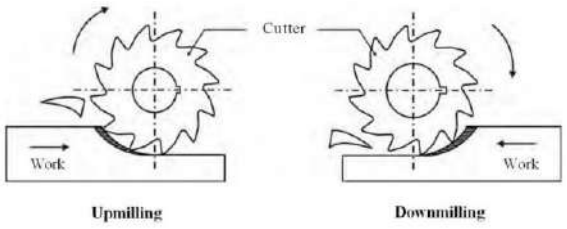
minimum at beginning
maximum at the end

- The cutting action tends to lift the work piece.

Down milling :- (climb milling) :-

- Cutter rotation is in the same direction as the motion of the work piece being fed.
- **Cutting force-**

max at beginning
min at the end.



Upmilling and Down Milling

Machining and Machine Tool Operations

22. Choose the correct option related to lathe turning operation.

(a) Work piece will rotate
(b) Both tool and work piece will not rotate
(c) Tool will rotate
(d) Both tool and work piece will rotate

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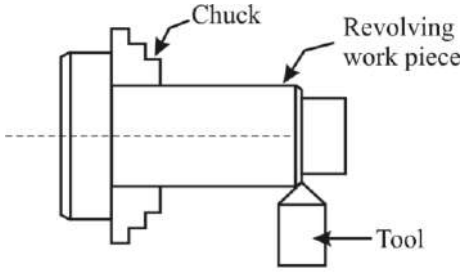
Ans. (a) : Lathe turning operation :- in this operation work piece will be rotate but cutting tool will be slide linear motion on the work pieces.

- The Cutting tool moves in a linear motion along the surface of the work piece, removing material around the circumference until the desired diameter is achieved.
- The primary objective of turning is to reduce the work piece's diameter to the desired dimension.



Turning operation

23. Which of the following machining operations is NOT related to turning?

(a) External threading (b) Boring
(c) Facing (d) Shaping

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Ans. (d) : Shaper machining operations is not related to turning.

Shaper– The shaper machine is a reciprocating type of machine basically used for producing horizontal, vertical or flat surfaces. The shaper holds the single point cutting tool in ram and the workpiece is fixed in the table. During the return stroke, no metal is cutting.

24. Which of the following milling operations is used to produce a flat surface parallel to the axis of rotation of the cutter?

(a) Profile milling (b) Plain milling
(c) End milling (d) Face milling

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Ans. (b) : Plain milling– It is an operation of producing flat or horizontal surface parallel to the axis of cutter.

Face milling– Operation of producing flat surface at right angles to the axis of rotation of the cutter.

End milling– Operation of producing flat surface either horizontal, vertical or at an angle by using an end milling cutter.

Form/profile milling– This milling process is used for machining those surface which are of irregular shapes. The form milling cutter used has the shape of its cutting teeth conforming to the profile of the surface to be produced.

25. In the shaping process, the cutting tool moves _____.

(a) in a straight line
(b) in a circular motion
(c) in a parabolic motion
(d) in an elliptical motion

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Ans. (a) :

- Shaper is a reciprocating type of machine tool in which the ram moves the cutting tool backwards and forwards in a straight line.
- A shaper is used to generate flat (plane) surface by means of a single point cutting tool similar to a lathe tool.

26. Which of the following point angles of a twist drill is used for general purpose work?

(a) 128^o (b) 118^o
(c) 138^o (d) 108^o

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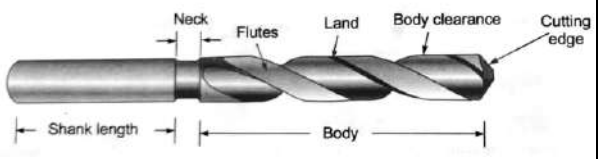
Ans. (b) : Twist drill : It is an end cutting tool with two, three or four cutting lips. It has a cylindrical body on which the grooves are cuts. These grooves are called flutes. While drilling the drill is held by a shank.



Point angles may be :

(i) For General purpose (Mild steel and brase) $\rightarrow 118^o$

(ii) For bakellite and firbrous plastic $\rightarrow 90^o$

(iii) For stainless steel $\rightarrow 135^o$

■ The point angle is kept less than 118^o for softer materials and more than 118^o for harder alloy steel.

27. A workpiece is taper turned using lathe, where large diameter of workpiece is D and small diameter d. If the length of this workpiece is L, then haft angle α is given by :

(a) $\tan\alpha=\frac{(D-d)}{4L}$ (b) $\tan\alpha=\frac{(D-d)}{3L}$

(c) $\tan\alpha=\frac{(D-d)}{L}$ (d) $\tan\alpha=\frac{(D-d)}{2L}$

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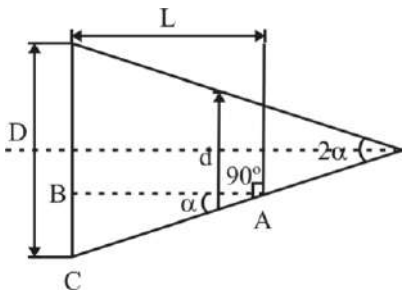
Ans. (d) : Taper : When the diameter of the bar either increases or decreases along the length of the bar then it is called a taper.

■ This operation is performed on a lathe machine with the help of a taper-turning attachment.

■ The formula for taper angle (α) is :



$$\tan\alpha = \frac{D - d}{2L}$$

Where,

α = Semi taper angle,

2α = Full taper angle (included angle)

D = Large diameter of the bar

d = small diameter of the bar

L = Length of the bar.

Metal Forming Processes

28. _____ is a metalworking process which is an example of forging.

(a) Upsetting (b) Extrusion

(c) Casting (d) Welding

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Ans. (a) : Upsetting is a metal working process which is an example of forging.

Upset forging– Upset forging involves increasing the cross-section of material at the expense of its corresponding length. examples of upset forged parts are fasteners, valves, nails and coupling. An upset forging operation is used to form a head on a bolt.

29. Which of the following statement is true about hot working process?

(a) It is a process of working above room temperature

(b) It is a process of working above recrystallisation temperature of the material

(c) All hot working processes must be done above local environment temperature

(d) Hot working process of tin is also a cold working process

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Ans. (b) : Hot working Process:-

- It is a process of the working of metals above the recrystallisation temperature is called hot working process.
- Recrystallisation temperature is the temperature at which, the deformed new grains are replaced by defects-free gains in the metal.

$$\text{Recrystalisation temperature} = (0.3 - 0.5)T_m$$

Where Tm = melting point in Kelvin.

Advantages:-

- The porosity of metal is largely eliminated.
- the grain structure of the metal is refined ie. the coarse trains are converted into fine grains.
- Increase the ductility of metal.
- Yield strength can be reduced.

30. The process of pushing the heated billet or slug of metal through an die orifice, thus forming an elongated part of a uniform cross-section corresponding to the shape of the die orifice is known as .....

(a) Machining process (b) Extrusion process

(c) Drawing process (d) Rolling process

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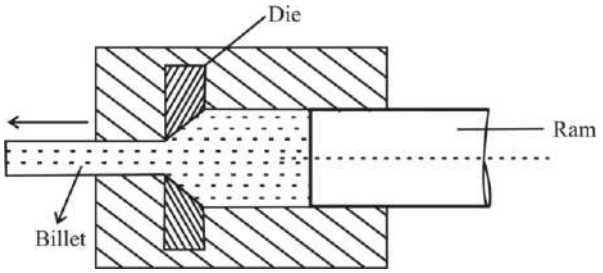
Ans. (b) : The process of pushing the heated billet or slug of metal through an orifice provided into a die is known as extrusion process.

Types of extrusion –

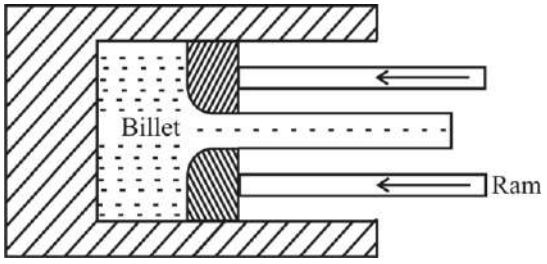
1. Forward or Direct extrusion :- In this process piston and outgoing materials move in the same direction.



Direct forward extrustion

2. Indirect or backword extrustion :- In this process die is placed in the piston so out going material will come out in the opposite direction that of the piston.

■ Less friction generated in this process.



Backword or indirect extrusion

Chapter-7 Workshop Technology

Foundry Works

31. The Molten metal is used in _____ process

(a) Machining (b) Deep Drawing
(c) Forging (d) Casting

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Ans. (d) : The molten metal is used in casting process.

Casting– Casting is a manufacturing process in which a liquid material is usually poured into a mold, which contains a hallow cavity of the desired shape and then allowed to solidify. The solidified part is known as a casting.

Process of casting–

Mold making → Melting of metal → Pouring into mould → Heat treatment → Casting.

Chapter-8 Thermodynamics

Basic Concepts & Zeroth Law of Thermodynamics

32. Flow process is used for which of the following systems?

(a) Both open and closed systems
(b) Closed system
(c) Open system
(d) Isolated system

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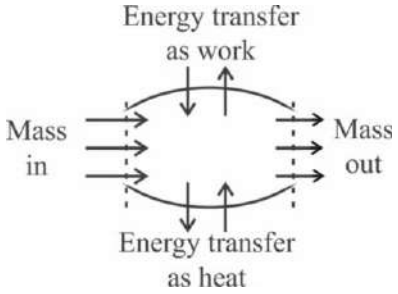
Ans. (c) : (i) Open system–

- Open system in thermodynamics is also known as a flow process (flow system) / control volume system.
- In this system, mass transfer and energy transfer are possible.

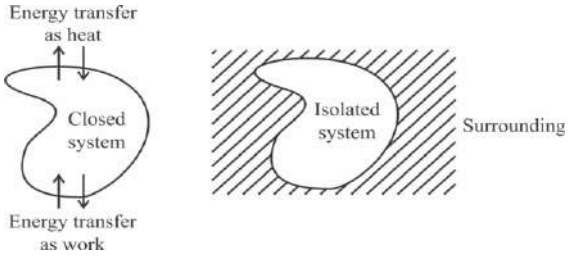
Example– Motor cars engine, steam generation (boiler) and human body.



(ii) Closed system/fixed mass system (control mass)/ non flow system–

- No mass transfer
- Energy transfer possible
- Volume can change

Example– Pressure cooker without valve, refrigerator ice cream freezer.



(iii) Isolated system

- No mass or energy transfer
- System + surrounding = Isolated system (universe)

Example– Thermos Flask/casserole.

33. Which of the following statements is true for a throttling process?

(a) It is an isothermal process
(b) it is a reversible process
(c) It is an isentropic process
(d) It is a constant enthalpy process

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Ans. (d) : Throttling process– When a fluid flow through a narrow passage like an orifice, partially opened valve, there is an appreciable drop in pressure. This process is called throttling process.

- In this process, enthalpy is constant, no heat and no work transfer.
- It is an irreversible process.
- In this process [P↓, V↑, $\partial Q = 0$, $\partial W = 0$, U = constant, T = constant, h = constant, S↑]

34. For the same compression ratio, which of the following processes will require the least compression work?

(a) Isothermal process (b) Isochoric process
(c) Polytropic process (d) Adiabatic process

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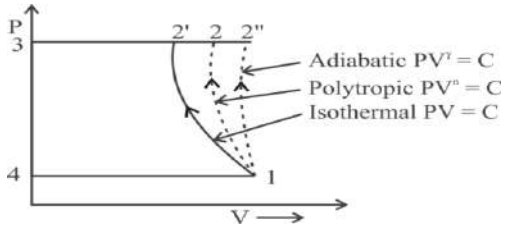
Ans. (a) : For the same compression ratio, isothermal processes will require the least compression work.



From the figure, it is clearly evident that the area under the curve (work done) is minimum for isothermal compression and maximum for isentropic compression.

- Work input is minimum for isothermal compression.

35. When any gas is heated at constant pressure, its change in volume varies directly with change in absolute temperature. This law is known as _____.

(a) Joule's law (b) Boyle's law
(c) Avogadro's law (d) Charle's law

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Ans. (d) : When any gas is heated at constant pressure, its change in volume varies directly with change in absolute temperature. This law is known as Charle's law.

- Boyle's law states that for a fixed mass of gas at a constant temperature, the volume is inversely proportional to the pressure.
- Gay-Lussac's law states that at constant volume, the pressure of a fixed amount of a gas varies directly with temperature.

36. Which thermodynamic property of steam does NOT change in throttling calorimeter?

(a) Pressure (b) Entropy
(c) Enthalpy (d) Temperature

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Ans. (c) : Enthalpy remains constant in a throttling calorimeter.

- A throttling calorimeter is a device that measures the state of a liquid vapour converting a high pressure fluid to low pressure using a throttle valve.

37. Which of the following ideal gas processes has the highest polytrophic index?

(a) Isochoric process (b) Isothermal process
(c) Isobaric process (d) Isentropic process

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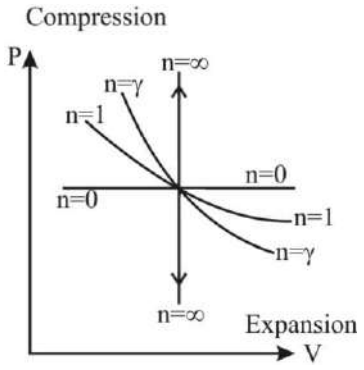
Ans. (a) : Polytrophic process is represent by-

$$\boxed{PV^n = C}$$

Where P = Pressure
V = Volume
n = Polytrophic index.



Equation	Volume of n	Type of process	Type of curve
P = c	n = 0	Constant pressure	Straight horizontal line
PV = c	n = 1	Constant temperature Process (Isothermal process)	Hyperbolic curve
$PV^{\gamma} = c$	$n = \gamma$	Adiabatic process	Polynomial curve
V = c	$n = \infty$	Constant volume process (Isochoric Process)	Straight vertical line

From above equation, Isochoric process has the highest Poly tropiz in Index.

ie $\boxed{n = \infty}$

38. If the temperature of 'A' is equal to the temperature of 'B' and 'C', then the temperature of 'B' will be equal to the temperature of 'C'. This is known as :

(a) Joule's law
(b) Zeroth law of thermodynamics
(c) Law of equality of temperature
(d) Law of thermal equilibrium

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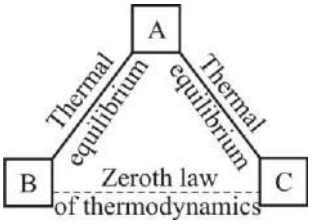
Ans. (b) : Zeroth low of thermodynamics:-

- Zeroth law of thermodynamics states that "If two thermodynamic system are each in thermal equilibrium with a third, then the are in thermal equilibrium with each other" as shown in below.



- This figure shown that when body A is in thermal equilibrium with body B, and also separately with body C, then B and C will be in thermal equilibrium with each other.
- A thermometer works on the principle of zeroth's law of thermodynamics.

39. Which of the following is an isochoric process?

(a) Heating of steam is cylinder containing a sliding piston
(b) Heat supplied is zero
(c) Heat is supplied during evaporation
(d) Heating of steam in a closed rigid vessel

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Ans. (d) : Isochoric process : -

- It is a thermodynamic process that take place at constant volume.
- It is also known as an isometric process
- In this process, volume of the gas remains constant so the work done is zero.

For Isochoric process –

$\therefore$ V = constant

$\therefore dv = 0$

Then work done (∂w) = p dv

$= P \times 0$

$\boxed{\partial w = 0}$

Ex-

(i) A gas is filled in a closed container then the volume of the gas will remain constant.

(ii) Heating of steam in a closed a closed rigid vessel.

40. The SI unit of specific heat is :

(a) J/kg (b) J/kg.K
(c) Jkg/K (d) JK/kg

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Ans. (b) : The SI unit of specific heat is J/kg. k

Specific heat : It is the amount of heat required to raise the temperature of its unit mass through 1°C.

$\Delta Q = mC\,\Delta t \Rightarrow C = \frac{\Delta Q}{m \times \Delta t}$

■ All the liquids and solids have one specific heat only.

■ Gas can have any number of specific heats (lying between zero and infinity) depending upon the conditions, under which it is heated.

■ **There are two types of specific heats of a gas -**

1. Specific heat at constant volume (C_v)
2. Specific heat at constant pressure (C_p)

$C_p - C_v = R$

Where,

R = characteristic gas constant (J/kg k)

41. Heat addition during the constant pressure process is equal to .....

(a) change in enthalpy
(b) change in internal energy
(c) change in entropy
(d) specific heat

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Ans. (a) :

Heat addition during the constant pressure process is equal to change in enthalpy.

According to first law of thermodynamics,

$\delta Q = \delta w + dU$

For constant pressure process;

$\delta w = p\,dv$

Form 1st law, $dU = \delta Q - d(PV)$

$\delta Q = d(U + PV)$

$\delta Q = dH$

$dH = mC_p dT$

$\therefore \delta Q = dH = mC_p dT$

42. A thermometer works on the principle of .....

(a) Zeroth law of thermodynamics
(b) 3rd law of thermodynamics
(c) 2nd law of thermodynamics
(d) Joule's law

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Ans. (a) : A thermometer works on the principle of zeroth law of thermodynamics.

■ Zeroth law of thermodynamics is deals with temperature measurement.

■ **Types of thermometer :**

Type of thermometer	Principle	Thermometric Property
Resistance	Wheat stone bridge	Resistance
Thermocouple	See back effect	E.M.F. (Voltage)
Constant Volume gas thermometer	Ideal gas equation	Pressure
Constant pressure gas thermometer	Ideal gas equation	Volume

First Law of Thermodynamics

43. The cyclic integral of Q/T for a reversible cycle is equal to zero. This statement is known as :

(a) Clausius theorem
(b) Rankine theorem
(c) Carnot theorem
(d) the principle of Carathéodory

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Ans. (a) : Clausius theorem– The algebraic sum of the ratio $\frac{\delta Q}{T}$ i.e., the heat interaction to the absolute temperature for a reversible heat engine is equal to zero.

$$\frac{Q_i}{T_i} \quad 0 \text{ or } \oint_R \frac{\delta Q}{T} \quad 0$$

Clausius inequality– The algebraic sum of the ratio $\frac{\delta Q}{T}$ i.e., the heat interaction to the absolute temperature for an irreversible heat engine is less than zero.

$$\Sigma \frac{Q_i}{T_i} < 0 \text{ or } \oint_i \frac{\delta Q}{T} < 0$$

44. A closed system undergoes a process in which the work done by the system is 100 J and the internal energy decreases by 50 J. According to the first law of thermodynamics, what is the amount of heat transferred into or out of the system?

(a) –150 J (b) –50 J
(c) 150 J (d) 50 J

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Ans. (d) : Given that :- work by the system (∂w) = 100 J decreases in internal energy (dU) –50 J Amount of head transfer (∂Q) = ?

Into or to the first law of thermodynamics –

$\partial Q = \partial W + dU$

$\partial Q = 100 + (-50)$

$\boxed{\partial Q = 50\,J}$

45. A closed vessel contains 5 kg of air, and 50 kJ of heat is given to it. If 75 kJ of work is done by the system, then which of the following is true? (Take Cp = 1.005 J/kg-K, Cv = 0.718 kJ/kg-K)

(a) The temperature of the air will decrease by 7^o
(b) The temperature of the air will increase by 5^o
(c) The temperature of the air will decrease by 34.8^o
(d) The temperature of the air will increase by 7^o

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Ans. (a) : Given that -

mass of air (m) = 5 kg

heat supplied (∂Q) = 50 kJ

work done by the system (∂w) = 75 kJ

According to first law of thermodynamics ;

$\partial Q = du + \partial w$

$50 = mC_V dT + 75$

$50 - 75 = 5 \times 0.718 \times dT$

$dT = \frac{-25}{5 \times 0.718} = -6.96\,^\circ C$

dT = 7ºC (decrease)

∵ The temperature of the air will decrease by 7ºC.

Second Law of Thermodynamics

46. The enthalpy of water is considered as 'zero' at _____.

(a) 100^oC (b) 0.01^oC
(c) 37^oC (d) 4^oC

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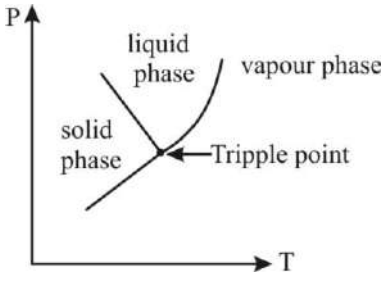
Ans. (b) : The enthalpy of water is considered as zero at 0.01°C. But.

For water, the triple point (T= 0.01°C and P = 0.611 k Pa) is selected as the reference state, where the internal energy and entropy of saturated liquid are assigned a zero value.

∵ $\boxed{h = u + PV}$

- At triple points, u=0, but $p \times v \neq 0$
- Therefore $h \neq 0$ at the triple point.



47. An engine is working with temperature limits of 29°C and 229°C. It receives 1000 kW and rejects 429 kW of heat. Possible cycle executed by the engine is :

(a) Carnot cycle (b) impossible cycle
(c) Irreversible cycle (d) Reversible cycle

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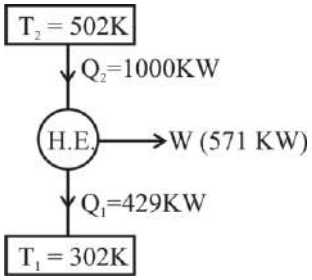
Ans. (b) : Temperature limits:-

$T_1 = 29°C = 29 + 273 = 302K$

$T_2 = 229°C = 229 + 273 = 502K$



According to clausius Inequality;

$$\oint \frac{\partial Q}{T} =\leq 0$$

$$\left(\frac{Q_2}{T_2}-\frac{Q_1}{T_1}\right)=\left(\frac{1000}{502}-\frac{429}{302}\right)=(1.99-1.42)$$

$$\left(\frac{Q_2}{T_2}-\frac{Q_1}{T_1}\right)=0.57>0$$

$\oint \frac{\partial Q}{T} > 0$ So, it is impossible cycle.

48. In a steam boiler, the actual evaporation is 8 kg of steam per kg of fuel burnt. The heat supplied per kg of water is 2500 kJ/kg. Higher calorific value of fuel is 25,000 kJ/kg. What is the boiler efficiency?

(a) 0.80 (b) 0.10
(c) 0.25 (d) 0.75

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Ans. (a) : Given that,
Actual evaporation (m_e) = 8 kg of steam / kg of fuel burnt.
Calorific value (C.V.) = 25000 kJ/kg
Heat produced by boiler = 2500 kJ/kg

$$\text{Boiler efficiency } (\eta_b) = \frac{m_e \times 2500}{\text{C.V.}}$$

$$= \frac{8 \times 2500}{25000}$$

$$= 0.8$$

49. A cyclic heat engine of thermal efficiency 80% does 60 kJ of work per cycle. The heat rejected per cycle will be equal to _____.

(a) 48 kJ (b) 75 kJ
(c) 20 kJ (d) 15 kJ

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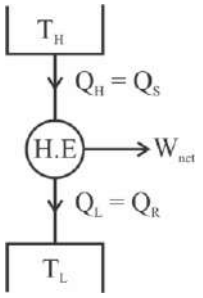
Ans. (d) :



Given,

$\eta = 80\%$, $W_{net} = 60$ kJ
$Q_R = ?$

$$\eta = \frac{W_{net}}{Q_S}$$

$$0.8 = \frac{60}{Q_S}$$

$Q_S = 75$
$Q_S = Q_R + W$
$Q_R = 75 - 60$
$Q_R = 15$ kJ.

50. A Carnot cycle operates between two temperatures T1 and T2. The efficiency of the cycle is given by η = (T1 − T2) / T1. Which of the following statements is correct?

(a) The efficiency of the Carnot cycle is always greater than that of any other heat engine operating between the same two temperatures
(b) The efficiency of the Carnot cycle is always less than that of any other heat engine operating between the same two temperatures
(c) The efficiency of the Carnot cycle depends on the working substance used
(d) The efficiency of the Carnot cycle is always equal to that of any other heat engine operating between the same two temperatures

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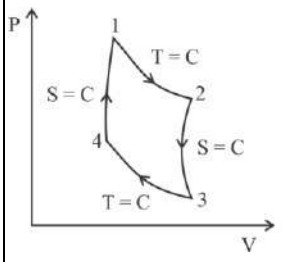
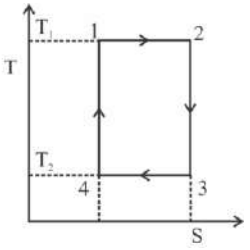
Ans. (a) : The efficiency of the carnot cycle is always greater than that of any other heat engine operating between the same two temperatures.





Process :
(1-2) - Isothermal expansion
(2-3) - Isentropic expansion
(3-4) - Isothermal compression
(4-1) - Isentropic compression.

- $\eta = 1 - \frac{T_2}{T_1}$

51. A heat engine operates between a source at 600 K and a sink at 300 K. What is the maximum possible efficiency of the engine according to the Kelvin-Planck statement of the second law of thermodynamics?

(a) 33.3% (b) 25%
(c) 50% (d) 67%

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Ans. (c) : T_H = Higher temperature (source temperature)

$T_H = 600K$

T_L = Lower temperature (sink temperature)

$T_L = 300K$

$$\eta = 1 - \frac{T_L}{T_H}$$

$$= 1 - \frac{300}{600} = 0.50$$

$$\eta = 50\%$$

52. Which of the following statements hold true, according to Kelvin Planck's statement?

(a) A heat engine must exchange heat from a single heat reservoir

(b) Some amount of heat taken from a source must be rejected to higher temperature

(c) It restricts the engine to have mechanical efficiency lesser than unity

(d) Perpetual motion machine of the 2nd kind is impossible

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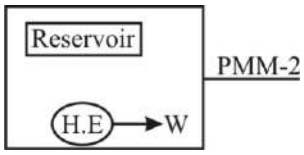
Ans. (d) : According to Kelvin Planck's statement the perpetual motion machine of the 2nd type is impossible.

PMM-2:-

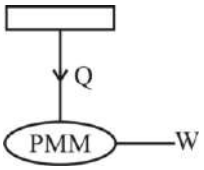
It says – continuously absorb heat from single thermal reservoir and would converted this head completely to work. such machine is called. PMM-2

$\eta_{PMM-2} = 100\%$



PMM-1:- There can be no machine would continuously supply mechanical work without consuming some other form of energy.

• PMM-1 violates the first law of thermodynamics



53. Which among the following options has same thermal efficiency under ideal conditions (Operate within the same temperature)?

(a) Carnot cycle and Brayton cycle

(b) Carnot cycle and Otto cycle

(c) Carnot and dual cycle

(d) Carnot cycle and Stirling

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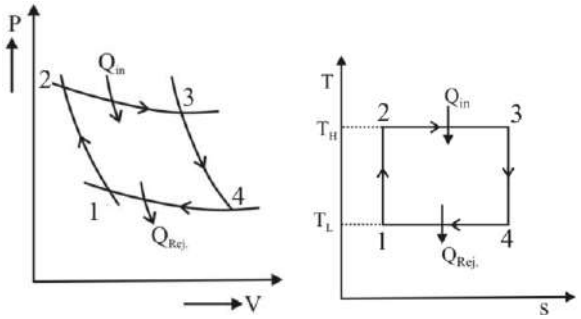
Ans. (d) : Under ideal condition (operate within the same temperature) the cornot cycle and stirling cycle has same thermal efficiency.

Cornot cycle - It consists four process



(1 to 2) - Isentropic compression

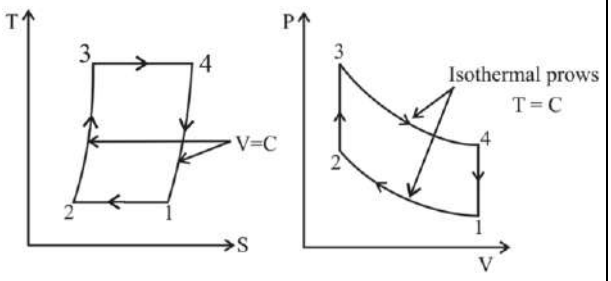
(2 to 3) - Isothermal heat addition

(3 to 4) - Isentropic expansion

(4 to 1) - Isothermal heat rejection

Efficiency of cornot cycle $\eta_{cornot} = 1 - \frac{T_L}{T_H}$

Stirling cycle - It consist four processes



■ Thermal efficiency under ideal condition depends on temperature range

(1-2) - Isothermal compression

(2-3) - Constant volume compression

(3-4) - Isothermal Expansion

(4-1) - Constant volume expansion

Efficiency of striling cycle

$$\eta_s = 1 - \frac{T_L}{T_H}$$

54. 0.2 m^3 of an ideal gas at the pressure of 2 MPa and 600 K is expanded isothermally to 5 times the initial volume. It is then cooled to 300 K at constant volume and then, compressed back polytropically to its initial state. The pressure just after the constant volume process is .....

(a) 2.0 MPa (b) 0.8 MPa

(c) 0.2 MPa (d) 0.4 MPa

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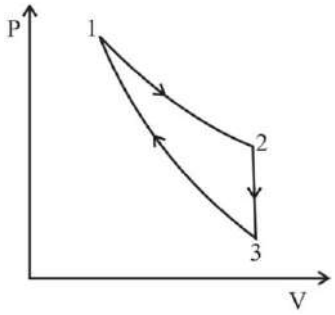
Ans. (c) :

Given -

Volume $V_1 = 0.2\ m^3$

Pressure $P_1 = 2$ mPa



Process 1 to 2 -

Isothermal expansion

$\therefore\ T_1 = T_2 = 600$ k

Process 2 to 3 –

Cooling at constant volume

$\therefore\ V_2 = V_3$

$\because\ V_2 = 5V_1$

$V_2 = 5 \times 0.2$

$V_2 = 1\ m^3$

$T_3 = 300$ k

$P_3 = ?$

From Process 1 to 2 - (isothermal expansion)

$$P_1V_1 = P_2V_2$$

$$P_2 = 2 \times \frac{0.2}{1}$$

$P_2 = 0.4$ mPa

From process 2 to 3 - (constant volume)

$$\frac{P_2}{T_2} = \frac{P_3}{T_3}$$

$$\frac{0.4}{600} = \frac{P_3}{300}$$

$P_3 = 0.2$ MPa

55. In a Carnot cycle .....

(a) Only isothermal processes are reversible

(b) All processes are reversible

(c) Only adiabatic processes are reversible

(d) All processes are irreversible

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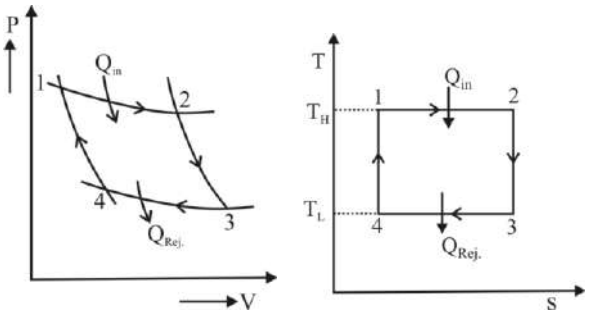
Ans. (b) : In a cornot cycle all processes are reversible.

Cornot cycle : It consists of two reversible adiabatic process and two isothermal process.

■ Isothermal process is a very high process and adiabatic process is a very fast process



Process :

(1-2) → Isothermal heat addition

(2-3) → Reversible adiabatic Expansion

(3-4) → Isothermal heat rejection

(4-1) → Reversible adiabatic compression

■ Efficiency of cornot cycle ;

$$\boxed{\eta_c = 1 - \frac{T_L}{T_H}}$$

Where,

T_L = Low temperature

T_H = High temperature

56. Which of the following about work transfer is NOT correct?

(a) Work transfer is a boundary phenomenon

(b) Work is given by the area under the curve on p-V diagram in case of non-flow process

(c) Work is a transient phenomenon

(d) Work transfer is a thermodynamic property

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Ans. (d) : Work transfer is the transfer of energy that doesn't involve temperature.

■ Work transfer is a boundary phenomenon.

■ Work is a path function and in exact or imperfect differential.

■ Work transfer is not a thermodynamic property.

■ Work is a transient phenomenon.

■ Work done by the system is positive.

■ Work doen on the system is negative.

Properties of Pure Substances, Gases and Gas Mixture

57. The point at which all the three phases – solid, liquid, and vapour co-exist in equilibrium in a p-T diagram is known as _____.

(a) melting point (b) triple point
(c) boiling point (d) critical point

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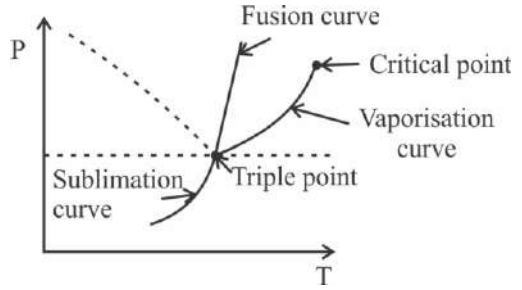
Ans. (b) : The point at which all the three phases-solid, liquid and vapour co-exist in equilibrium in a P-T diagram is known as triple point.

- Triple point is a line on P-V diagram while triple point is a point on P-T diagram.



- Triple point is a line on T-V, and P-V diagram, a point on P-T diagram.

58. Find the enthalpy of 1 kg of dry and saturated steam at 10 bar if sensible heat at 10 bar is 762.8 kJ/kg and latent heat of evaporation at 10 bar is 2015.3 kJ/kg.

(a) 2015.3 kJ (b) 1252.5 kJ
(c) 762.8 kJ (d) 2778.1 kJ

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Ans. (d) : Given that,

Sensible heat (h_f) = 762.8 kJ/kg

Latent heat (h_{fg}) = 2015.3 kJ/kg

Enthalpy (h_g) = $h_f + h_{fg}$

= 762.8 + 2015.3

= 2778.1 kJ/kg

So, Enthalpy of 1 kg of dry and saturated steam is

(h_g) = 2778.1 × 1

= 2778.1 kJ

59. The value of enthalpy of vaporisation approaches to zero on the saturation curve of water on a temperature entropy diagram.

(a) at critical point
(b) never approaches to zero
(c) above critical point
(d) below critical point

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Ans. (a) : At critical point, the value of enthalpy of vaporisation approaches to zero on the saturation curve of water on a temperature entropy diagram.

- At a critical, latent heat of vaporization is zero because at critical point no energy is required to convert the liquid phase to the gaseous phase.
- Critical temperature (T_C) = 373°C and Critical pressure (P_C) = 221 bar.

60. The reversible adiabatic process in Mollier chart is represented by :

(a) A vertical line
(b) A line parallel to the saturated vapour line
(c) A horizontal line
(d) A line parallel to the saturated water line

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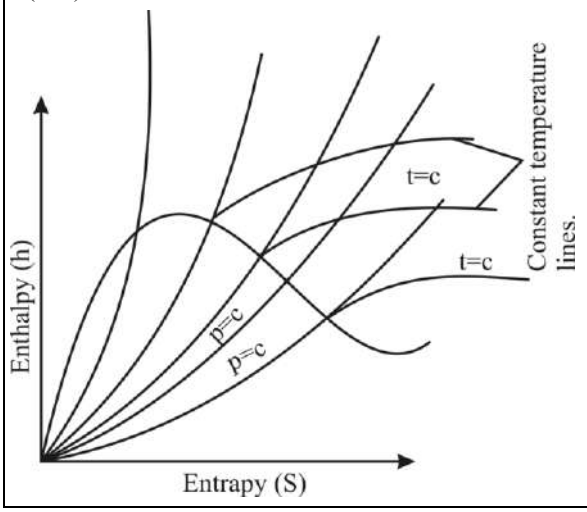
Ans. (a) : The reversible adiabatic process in mollier chart is represented by a vertical line.

Mollier Diagram:-

- Mollier diagram is also know as (h-s) diagram,
- It consist of constant pressure lines, constant temperature lines and dryness fraction lines plotted on enthalpy – Entropy (h-s) coordinator.
- A vertical line in the mollier diagram represents the isentropic process (S=C) and
- A horizontal line is represents the isenthalpic process. (h=s)



Thermodynamic Relations

61. In the thermodynamic system, the primary driving force for mass transfer is _____.

(a) mass difference
(b) temperature difference
(c) pressure difference
(d) concentration difference

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Ans. (d) : In the thermodynamic system, the primary driving force for mass transfer is concentration difference.

- Concentration difference, refers to a difference in the amount of a particular substance in two regions.
- If there is a concentration difference, then there will be a tendency for the substance to move from the region of higher concentration to the region of lower concentration.

Chapter-9 Power Plant Engineering

Steam Power Plant

62. According to the American Society of Mechanical Engineers (ASME), the evaporation of 15.63 kg of water at 100°C per hour from 100°C feed water in a steam boiler is known as _____.

(a) Boiler efficiency
(b) Actual evaporation
(c) Boiler horsepower
(d) Equivalent evaporation

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Ans. (c) : According to the American society of mechanical engineers (ASME), the boiler power is defined as :

$$\text{Boiler power} = \frac{\text{Equivalent evaporation form and at } 100^\circ\text{C per hour}}{21.296}$$

- According to ASME, the evaporation of 15.63 kg of water at 100°C per hour from 100°C feed water in a steam boiler is known as boiler horse power (one boiler h.p.)

63. Which of the following is a water-tube boiler?

(a) Lancashire boiler
(b) Babcock & Wilcox boiler
(c) Cochran boiler
(d) Cornish boiler

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Ans. (b) : List of water tube and fire tube boilers–

Water tube boiler	Fire tube boiler
Babcock & Wilcox boiler	Cochran boiler
La-mount boiler	Cornish boiler
Sterling boiler	Lancashire boiler
Benson boiler	Locomotive boiler
Velox boiler	
Loffler boiler	

Fire tube boiler– In this type of boilers hot flue gas travels through tubes that are surrounded by water.

Water tube boiler– In this type of boilers the water travels through tubes surrounded by flue gas.

64. The ratio of the energy received by the steam to the energy supplied by the fuel to produce steam in a steam boiler is known as _____.

(a) Equivalent evaporation
(b) Actual evaporation
(c) Boiler horsepower
(d) Boiler efficiency

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Ans. (d) : Boiler efficiency– It may be defined as the ratio of heat actually used in producing the steam to the heat liberated in the furnace. It is also known as thermal efficiency of the boiler. Mathematically, boiler efficiency or thermal efficiency,

$$\eta = \frac{\text{Heat actually used in producing steam}}{\text{Heat liberated in the furnace}}$$

$$\eta = \frac{m_e\left(h - h_{f_i}\right)}{C}$$

m_e = Mass of water actually evaporated or actual evaporation in kg/kg of fuel, and

C = Calorific value of fuel kJ/kg of fuel.

h = Total heat of steam in kJ/kg of steam

h_{f_i} = Sensible heat of feed water in kJ/kg of steam.

$$m_e = \frac{m_s}{m_f}$$

m_s = Total mass of water evaporated into steam in kg

m_f = Mass of fuel in kg

$$\eta = \frac{m_s\left(h - h_{f_i}\right)}{m_f \times C}$$

65. Generation of steam in a boiler is an example of an _____.

(a) isobaric process (b) isothermal process
(c) adiabatic process (d) isochoric process

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Ans. (a) : Generation of steam in a boiler is an example of an isobaric process.

Steam generation in a boiler– Water enters the boiler and is heated to its boiling point, vaporized, and then the steam is superheated. All these processes take place isobarically.

66. Which of the following is NOT a type of steam separator?

(a) Impact or baffle type
(b) Reverse current type
(c) Centrifugal type
(d) Reciprocating type

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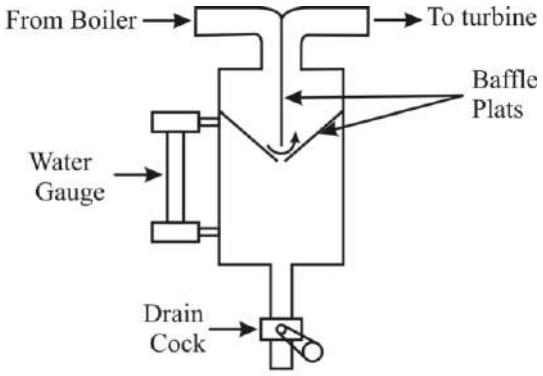
Ans. (d) : Steam Separator:- A steam separator is a device for separating water droplets from stream.

- It is installed close to the steam engine or turbine.

Classification:-

- Impact or baffle type
- Reverse current type
- Centrifugal type.

Working Principle:-



Baffle type steam Separator

- The above figure shows a baffle type steam separator.
- The steam is allowed in to the separator. the steam strides the baffle plates and the direction of the flow is changed.
- As a result, heavier water particles in steam fall down to the bottom of the separator. The separated steam is free from water particles.

67. What is the main function of the condenser in a Rankine cycle power plant?

(a) To increase the efficiency of the cycle
(b) To increase the temperature of the cooling water
(c) To decreases the efficiency of the cycle
(d) To condense the steam till it transforms into saturated liquid

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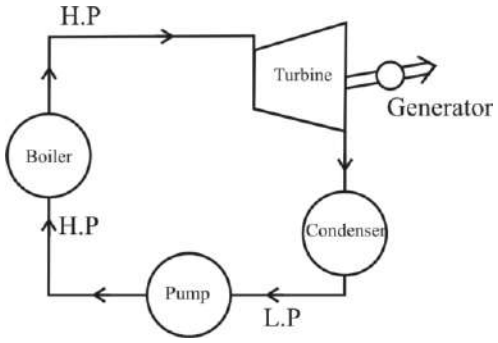
Ans. (d) : The condenser is a device that converts the low pressure exhaust steam from the turbine into water. In other words, Condenser condenses the steam which comes from the turbine into water at very low pressure.



HP = High pressure
LP = Low pressure

68. Latent heat of vaporisation is NOT the .....

(a) Heat required for complete conversion of ice into water
(b) Heat added at constant temperature of 100^oC convert water into steam
(c) Heat required for complete conversion of saturated liquid into dry saturated vapour
(d) Sum of internal latent heat and external work of evaporation

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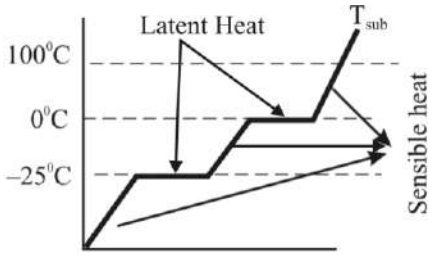
Ans. (a) : Latent heat of vaporization is not the heat required for complete conversion of ice into water.

Latent heat of vaporization:-It is the energy required to change 1 kg of the material in its liquid state at its boiling points to 1 kg of the material in its gaseous state.

Latent heat of Fusion:- It latent heat of fusion is the head energy required to change 1 kg of the material in its solid state at its melting points to 1 kg to the material in its liquid state.

- Latent heat of vaporization is more than the latent heat of fusion.



Boiler Mountings & Accessories

69. The air pre-heater increases the temperature of _____ before it/they enter(s) the furnace.

(a) Air (b) feedwater
(c) flue gases (d) fuel

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Ans. (a) : The air pre-heater increase the temperature of air before it enters the furnace.

- Air preheated is used to increase the temperature of inlet air there fore the efficiency of thermal power plant will be increase.

70. In a steam boiler, an economiser is used for heating of _____.

(a) flue gases (b) feedwater

(c) fuel (d) air

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Ans. (b) : Economiser:- It is a device used to heat lead water by utilizing the heat in the exhaust flue gases before leaving through the chimney. It improves the economy of the steam boiler.

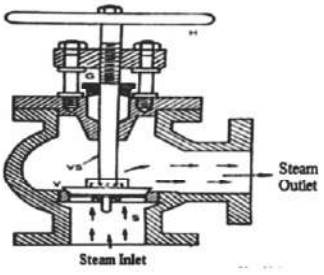
Advantages of Economiser:-

(a) There is about is to 20% of cool saving

(b) It boiler because it shortens the time required to convert water in to steam.

(c) It prevent formation of scale in boiler water tubes.

71. Following figure shows which of the following parts of a steam generator?



Steam inlet

Steam outlet

(a) Feed check valve (b) Steam stop valve

(c) Blow-off cock (d) safety valve

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Ans. (b) : The given figure shows the steam stop valve of a steam generator.

- Steam stop valve is a mounting of boiler.

Mounting– Mountings are used in boiler to maintain safety. e.g.– Water level indicator, feed check valve, pressure gauge etc.

Accessories– These are the components which is used in increase the efficiency of boiler.

e.g.– Air preheater, economiser, super heater etc.

72. Which of the following is NOT a merit of dead weight safety valve?

(a) Gives satisfactory performance during operation

(b) Simplicity of design

(c) Suitable for high pressure boiler

(d) It is good choice for low pressure vessels

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Ans. (c) : Merit of dead weight safety value-

- Given satisfactory performance during operation.
- Simplicity of design.
- It is good choice for low pressure vessels.

Safety value-

- The function of safety value is to release the excess steam when the pressure of steam inside the boiler exceeds the rated pressure.

Type of safety valves-

- Dead weight safety valve
- Lever safety valve.
- Spring loaded safety valve
- High steam and low water safety value.

73. Which of the following statements is INCORRECT about the Benson boiler?

(a) The Benson boiler is heavier than other boilers

(b) Benson boilers can be switched on very quickly

(c) In Benson boilers, drums are not used

(d) The average operating pressure for the Benson boiler is higher is higher than 200 bar

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Ans. (a) : Benson Boiler-

- The Benson boiler is a water tube high pressure, drum less, force circulated boiler.
- The critical pressure is the pressure at which the liquid and gas phase is at equilibrium.
- In this boiler the water enters the boiler at just above the critical pressure so it suddenly converts into steam without generating air bubbles.
- It has a unique characteristic of the absence of a drum.
- The average operating pressure for the Benson boiler is higher than 200 bar.
- Benson boiler can be switched on very quickly.

74. What is the unit of measurement of actual evaporation in steam boilers?

(a) m^3/kg

(b) kg

(c) kg water evaporated/kg fuel burnt

(d) kg fuel burnt/kg water evaporated

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Ans. (c) : Equivalent Evaporation:- It is the amount water at 100°C and formed into dry and saturated steam at 100°C at normal atmospheric pressure (1.01 bar)

- It is usually , written as "**from and at 100°C**"
- Mathematically, equivalent evaporation

$$E = \frac{m_e \left(h - h_{f_1}\right)}{2257}$$

Where,

$$me = \frac{\text{Mass of water acutally evaporated}}{\text{or, steam produced in kg/h or}}$$

kg water evaprated/kg fuel burnt

To = Total heat of steam in kJ/kg of steam

h_{fl} = sensible head of feed water in kJ/kg of steam.

Hence , The unit of measurement of actual evaporation in steam boiler

= **kg water evaporated / kg fuel burnt**

75. The function of an air pre-heater is .....

(a) To increase the temperature of air after entering the furnace

(b) To decrease the temperature of air before entering the furnace

(c) To increase the temperature of air before entering the furnace

(d) To decrease the temperature of air after entering the furnace

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Ans. (c) : Boiler accessories :-

- Those components which are installed either inside or outside the boiler to increase the efficiency of the boiler.
- Various boiler accessories are.

1. Air preheated
2. Economizer
3. Super- heater
4. Feed pump
5. injector

Air Pre-heater:- It is used to increase the temperature of the air before it enters the furnace. It is generally placed after the economizer; so that the flue gases pass through the economizer and then to the air preheater.

76. In the boiler mountings, the blow-off cock is fitted at .....

(a) Near the steam supply line

(b) The middle of the boiler shell

(c) The bottom of the boiler shell

(d) The top of the boiler shell

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Ans. (c) : In the boiler mounting, the blow-off cock is fitted at the bottom of the boiler shell.

Blow-off- cock-

- The blow- off cock helps to drain out the water periodically from the boiler.
- It ensures the discharge of mud, scale or sediments and other impurities that settle down at the bottom of the boiler.
- To empty the boiler when necessary for cleaning repair, and inspection.
- To permit a rapid lowering of water level in the boiler if accidently it becomes too high.

Some other mountings-

(i) Pressure gauge

(ii) Fusible plug

(iii) Safety valves

(iv) Feed check valve

77. The evaporation of feed water at 100°C into dry and saturated steam at 100 °C at atmospheric pressure is known as :

(a) Boiler horsepower

(b) Actual evaporation

(c) Equivalent evaporation

(d) Boiler efficiency

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Ans. (c) : Equivalent evaporation:- Equivalent Evaporation – may by the from Boiler at given condition to the amount to water evaporated from water at 100°C to dry and saturated steam at 100°C.

Factor of evaporation $(F_e) = \left(\frac{h - h_w}{2257}\right)$

E = Total heat required to evaporate feed water from and at 100°C.

$$\boxed{E = \frac{m_e(h - h_f)}{2257}}$$

Where me is mass of steam actually product in kJ/kg of fuel or like units.

78. Which of the following statements is correct about water-tube and fire-tube boilers?

(a) In case of fire-tube boilers, water flow in the tubes

(b) In case of water-tube boilers, hot gases flow in the tubes

(c) In case of fire-tube boilers, hot gases are surrounded over the tubes

(d) In case of fire-tube boilers, hot gases flow in the tubes

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Ans. (d) : In the case of fire tube boiler hot gases flow in the tubes.

Fire-tube boiler:-

- Hot Flue gases are present in inside the tube and water surrounds them
- Low pressure boiler (operating pressure 25 bar)
- **Example**-

Cornish boiler

Cochran boiler

Locomotive boiler

Lancashire boiler

Scotch marine boiler

Water tube boiler:-

- Water is present inside the tubes and the hot flue gases surround them.
- High pressure (operating pressure 250 bar)
- **Example:-**

  Stirling boiler
  Babcock and Wilcox boiler
  Yarrow boiler
  Lamont boiler
  Loeffler boiler
  Velox boiler

79. Which of the following is a forced circulation type of boiler?

(a) Lancashire boiler
(b) LaMont boiler
(c) Cochran boiler
(d) Babcock & Wilcox boiler

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Ans. (b) : Natural circulation type boiler : In this type of steam boilers the circulation of water is by natural convection currents which are set up during the heating of water.

Examples : Cochran boiler, Locomotive boiler, Lankashire boiler, Stirling boiler cornish boiler and Babcock & Wilcox boiler.

Force circulation type boiler : In this type of steam boilers, There is a forced circulation of water by a centrifugal pump driven by some external power. Use of forced circulation is made in high pressure boilers.

Examples : Benson boiler La-Mont boiler Loeffler boiler and velox boiler.

80. Which of the following statements is correct about the forced-draught fan used in steam boilers?

(a) The power required by an induced-draught fan is less than that required by a forced draught fan for the same amount of draught
(b) The power required by an induced draught fan is greater than that required by a forced-draught fan for the same amount of draught
(c) The power required by an induced-draught fan may be greater than or less than that required by a forced-draught fan for the same amount of draught
(d) The power required by an induced-draught fan is equal to that required by a forced draught fan for the same amount of draught

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Ans. (b) : The power required by an induced draught fan is greater than that required by a force - draught fan for the same amount of draught.

- Forced draft fans suck air from the atmosphere, they handle fresh air. So they need low maintenance, consume less power and operating costs are low.
- ID fan is normally location at the outlet between the dust collector and chimney.
- ID fans can handle hot flue gases.
- ID fans creates a negative pressure or suction to discharge the gases out after combustion from the furnace.

Fuels and Combustion

81. Which of the following statements is INCORRECT?

(a) The value of dryness fraction is 1 for saturated steam condition
(b) The value of dryness fraction is greater than 1 for superheated steam condition
(c) The value of dryness fraction is 0 for saturated water condition
(d) The value of dryness fraction always lies between 0 and 1

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Ans. (b) : Dryness fraction– If in 1 kg of liquid vapour mixture, x kg is the mass of vapour and (1-x) kg is the mass of liquid, then x is known as the quality of dryness fraction of the liquid vapour mixtures.

$$x = \frac{m_v}{m_v + m_s}$$

For saturated water, x = 0

For saturated vapour, x = 1

- The value of dryness fraction always lies between 0 and 1.

82. The mass of water evaporated per unit mass of fuel burnt is termed as _____ steam boilers.

(a) Boiler performance of
(b) Equivalent evaporation in
(c) Actual evaporation in
(d) Boiler efficiency of

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Ans. (c) : In steam boiler, actual evaporation is defined as the mass of water evaporated per unit mass of fuel burnt. It is denoted by (m_e)

Equivalent evaporation– Equivalent evaporation is the amount of water evaporated from feed water at 100°C and formed into dry and saturated steam at 100°C at

atmospheric pressure (1.01 bar). It is usually written as "from and at 100°C".

The equivalent evaporation, $\boxed{E = \frac{m_e\left(h - h_{fg}\right)}{2257}}$

m_e = Actual evaporation

h = Total heat of steam in kJ/kg at given working pressure.

h_{fg} = Latent heat of feed water or fluid enthalpy.

Steam Turbine

83. The mass flow is same at inlet and outlet in case of _____.

(a) Closed system
(b) isolated system
(c) steady flow process
(d) non-steady flow process

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Ans. (c) : The mass flow is same at inlet and outlet in case of steady flow process.

- Steady and unsteady flow:- If fluid flow characteristics (such as density, velocity pressure etc.) at a point do no change with time, the flow is said to be steady flow.

$\frac{dv}{dt} = 0, \frac{dp}{dt} = 0, \frac{d\rho}{dt} = 0$ -------- for steady flow

where,

v = velocity
ρ = density
p = pressure

- If the fluid flow variables at a point may change with time, the flow will be unsteady.

84. In a mechanical draught system, draught is produced by a _____.

(a) chimney (b) blower
(c) pump (d) chain grate stoker

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Ans. (b) : Mechanical (or artificial) draught– It is the draught produced by a fan, blower or steam jet. In general, the mechanical draught is provided, when natural draught is not sufficient. It may be induced or forced.

There are three types–

(i) Induced draught (I.D.)
(ii) Balanced draught (B.D.)
(iii) Forced draught (F.D.)

- Balanced draught (B.D.) = ID + FD.

85. Natural draft cooling towers are also known as _____.

(a) artificial cooling towers
(b) mechanical draft cooling towers
(c) automatic spray cooling towers
(d) atmospheric cooling towers

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Ans. (d) : Natural draft cooling towers are also known as atmospheric cooling towers.

- Natural draft cooling towers use very large concrete chimneys to introduce air through the media. Due to very large size these are installed in open space only.

86. Which of the following turbine has 50% degree of reaction?

(a) Curtis turbine (b) Rateau turbine
(c) Hero's turbine (d) Parson's turbine

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Ans. (d) : Degree of Reaction = $\frac{\text{Enthalpy drop in roter}}{\text{Enthalpy drop in stage}}$

- In impulse turbine there is no change in enthalpy drop in the rotor. therefore degree of reaction is zero.
- For parson's turbine (R) = 50% = 0.5
- For Hero's turbine (R) = 100% = 1

87. In the context of work done of turbine, the power developed by the runner depends on which of the following parameters?

(a) Blade velocity
(b) Velocity at the exit of draft tube
(c) Whirl velocity only
(d) Whirl and blade velocities

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Ans. (d) : In the turbine the power developed the runner depends on the whirl and blade velocities.

Runner power = $\frac{\text{work done}}{\text{time}}$

$\boxed{R.P. = (V_{w1u1} + V_{w2u2})}$ Watt

V_w = whirl velocity
u = blade velocity

$\boxed{\eta_{hyraulic} = \frac{(V_{w1u1} + V_{w2u2})}{gH_{net}}}$

88. An impulse turbine is running at 100 rpm with a net head 600 m. If the discharge through the nozzle is 0.1 m^3/s, then what will be the power available at the nozzle? Take g = 10 m/s^2.

(a) 450 kW (b) 600 kW
(c) 700 kW (d) 525 kW

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Ans. (b) : Given that -
Net haed (H) = 600 m
Discharge (Q) = 0.1 m^3/sec.
gravity (g) = 10 m/s^2
density (ρ) = 1000 kg/m^3
Power(p) = γQH
p = ρgQH
p = $10^3 \times 10 \times 0.1 \times 600$
p = 600 kw

89. If difference of axial components of velocity at inlet and outlet of a de-Laval turbine is found to be 120 m/s and mass flow rate of steam is 7 kg/s then axial thrust on the rotor is :
(a) 120 N (b) 840 N
(c) 7 N (d) 17.14 N

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Ans. (b) :
Given that : Difference of axial component of velocity at inlet and outlet of a turbine $\left(C_{f_1} - C_{f_2}\right) = 120$ m/s
mass flow rate of steam (m) = 7 kg/sec.
Axial thrust (force) on a rotor (f_a) = $m\left(C_{f_1} - C_{f_2}\right)$
$f_a = 7 \times 120 = 840$ N

90. The value of the gross stage efficiency and blade efficiency of the single stage of the impulse turbine are 65% and 78% respectively then the value of the nozzle efficiency will be :
(a) 100% (b) 50%
(c) 50.7% (d) 83.33%

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Ans. (d) : Given that -
Gross stage efficiency (η_s) = 65% = 0.65
Blade efficiency (η_b) = 78% = 0.78

$\therefore$ nozzle efficiency (η_N) $= \dfrac{\eta_s}{\eta_b}$

$= \dfrac{0.65}{0.78}$

= 0.8333

= 83.33%

Steam Nozzle

91. Which of the following equations is NOT used in deriving the expression for discharge through the steam nozzle?
(a) Continuity equation
(b) Newton's equation of viscosity
(c) Steady flow energy equation
(d) Momentum equation

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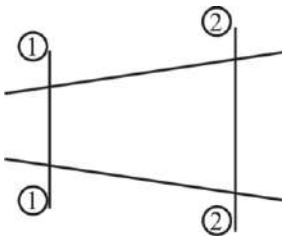
Ans. (b) : The following equations are used in deriving the expression for discharge through the steam nozzle.
- Continuity equation
- Steady flow energy equation.
- Momentum equation.
- **Continuity equation**:-
- It is based on the principle of conservation of mass.
- It states that mass can neither be created nor be destroyed.



Rate of flow in section 1-1 = Rate of flow in section 2-2

$$\rho_1 A_1 V_1 = \rho_2 A_2 V_2$$

- Steady flow energy equation :- (SFEE)

$$m\left(h_1 + \frac{u_1^2}{2} + gz_1\right) + Q = mh_2 + \frac{v_2^2}{2} + gz_2) + w$$

92. The ratio of the actual mass flow rate to that due to isentropic expansion in the steam nozzle is known as .....
(a) Mach number
(b) Nozzle efficiency
(c) Coefficient of discharge
(d) Critical pressure ratio

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Ans. (c) :

$$\text{Mach number} = \frac{\text{velocity of object in fuid}}{\text{Velocity of sound in that fuid}}$$

$$\text{Nozzle efficiency} = \frac{\text{Actual heat drop}}{\text{Issentropic heat drop}}$$

$$\text{Critical pressure ratio} = \left(\frac{P_2}{P_2}\right) = \left(\frac{2}{n+1}\right)^{\frac{n}{n-1}}$$

Where P_2 = Pressure a the throat
P_1 = Pressure at the inlet of the nozzle.

93. Functionality of nozzle is that .....
(a) It produces steam jet at very high pressure
(b) It produces steam at very low velocity
(c) It produces steam at very low pressure
(d) It produces steam jet at very high velocity

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Ans. (d) : The function of nozzle is that it produces steam Jet at very high velocity.

Exit steam velocity of nozzle :-

$$C_2 = 44.7 \times \sqrt{\Delta h}\ \text{m/s}$$

Critical pressure ratio:-

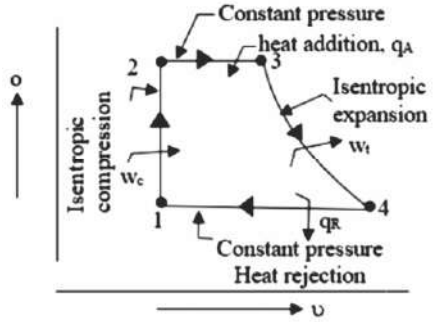
$$\frac{P_2}{P_1} = \left(\frac{2}{n+1}\right)^{\frac{n}{n-1}}$$

P_1 = Pressure at entering

P_2 = Pressure at throat

Gas Turbine

94. The figure shown the P-V diagram of the .....



Constant pressure
Heat addition
Isentropic expansion
Heat rejection
Isentropic compression

(a) Steam engine (b) Steam turbine
(c) Open cycle gas turbine (d) Otto cycle

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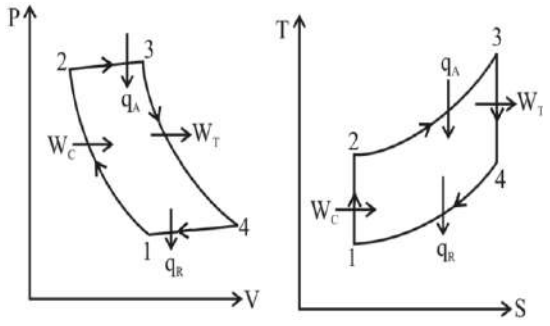
Ans. (c) : Closed cycle gas turbine : It consists of a compressor, heating chamber, gas turbine which drives the generator and compressor and a cooling chamber.

- This turbine is also called a constant pressure closed cycle gas turbine because the heating and cooling of air takes place at constant pressure. It works on Joule's cycle as shown by P-V and T-S diagram.



Processes :

(1-2) : → isentropic compression of air in the compressor.

(2-3) : → constant pressure heat addition in heating chamber.

(3-4) : → isentropic expansion of air in the turbine.

(4-1) : → Cooling of air at constant pressure in cooling chamber.

Open cycle Gas turbine : It consists of a compressor combustion chamber and a gas turbine which drives the generator and compressor.

- In this turbine, the air is first sucked from the atmosphere.
- It is also called continuous combustion gas turbine as the combustion of fuel takes place continuously. This turbine also works on Joule's cycle.

95. Which one of the following is correct statement about blade cross sectional fluid flow area from inlet to outlet of a turbine?

(a) Constant for impulse turbine and converging for reaction turbine
(b) Constant for reaction turbine and diverging for impulse turbine
(c) Constant for impulse turbine and converging for reaction turbine
(d) Constant for impulse turbine and diverging for reaction turbine

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Ans. (c) :

- In impulse turbine, the blade passages have a constant cross-sectional area because there is no expansion of steam.
- In reaction turbines, the blade passages have a variable cross-sectional area (converging type) due to expansion of steam.
- Turbines are used blades and buckets to alter the direction of water. This changes the momentum of water, which produces to rotate the shaft in a hydraulic machine.

Air Compressors

96. For a two-stage reciprocating air compressor, the suction pressure is 1.6 bar and the delivery pressure is 40 bar. What is the value of the ideal intercooler pressure (in bar)?

(a) 8 (b) 9
(c) 4.56 (d) 20.8

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Ans. (a) : Given, suction pressure (P_1) = 1.6 bar

delivery pressure (P_2) = 40 bar

For perfect (ideal) intercooling in the two-stage compressor–

$$P_i = \sqrt{P_1 P_2}$$

Where, P_i = Ideal intercooler pressure

P_1 = Suction pressure

P_2 = Delivery pressure

So, $P_i = \sqrt{1.6 \times 40}$

$= \sqrt{64}$

$\boxed{P_i = 8}$ bar

So, the intercooler pressure is 8 bar.

97. The correct expression of the dimensional formula of volumetric discharge in the fluid equations is given by .....

(a) L^3T^{-2} (b) L^3T^{-1}

(c) L^2T^{-1} (d) L^3T^{-3}

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Ans. (b) : Dimensional of formula of volumetric discharge is L^3T^{-1}

$$\text{discharge} = \frac{\text{Volume}}{\text{time}} \left(\text{m}^3/\text{s}\right)$$

Chapter-10 Refrigeration and Air-Conditioning

Vapour Compression Refrigeration System

98. Which of the following air-cooled condensers are used only in small capacity applications such as domestic refrigerators and room air conditioners?

(a) Natural convection air-cooled condensers

(b) Base mounted air-cooled condensers

(c) Remote air-cooled condensers

(d) Shell and coil condensers

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Ans. (a) : Natural convection air-cooled condensers are use in small capacity applications such as domestic refrigerators, freezers, water coolers and air-condensing surface area because the circulating air quantity is less.

- Force convection air-cooled condensers are used in water coolers and room air conditioners.

99. The net effect of superheating after compression in vapour compression refrigeration cycle is to have :

(a) decrease in refrigeration effect

(b) decrease in refrigeration capacity

(c) high C.O.P

(d) low C.O.P

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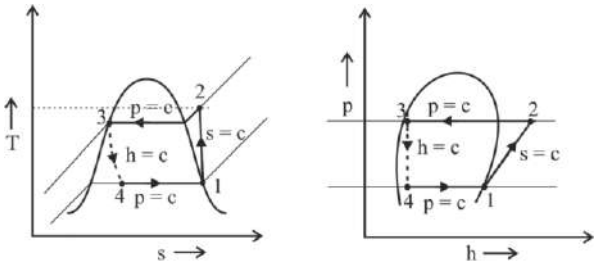
Ans. (d) : A vapour compression cycle with superheated vapour after compression is shown in T-S and p-h diagram.



VCC cycle

The coefficient of performance may be found out as usual from the relation,

$$\text{C.O.P.} = \frac{\text{Refrigerating effect}}{\text{Work done}} = \frac{h_1 - h_{f_3}}{h_2 - h_1}$$

- It may be noted the superheating increases the refrigerating effect and the amount of work done in the compressor. Since the increase in refrigerating effect is less as compared to the increase in work done. Therefore, the net effect of superheating is to have low coefficient of performance.

100. In air-conditioning of aeroplanes, using air as a refrigerant, the cycle used is :

(a) Reversed joule cycle

(b) Reversed carnot cycle

(c) Reversed brayton cycle

(d) Reversed otto cycle

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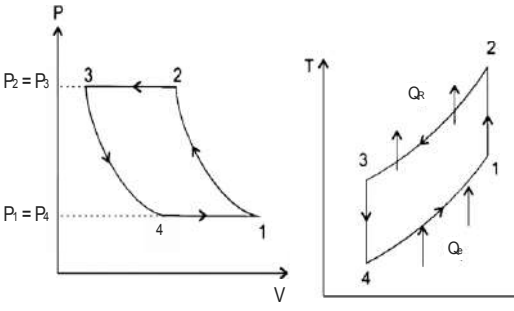
Ans. (c) : Air refrigeration system works on the reverse Brayton cycle or Bell coleman cycle.



Processes :-

1-2 $\Rightarrow$ Isentropically compression of air

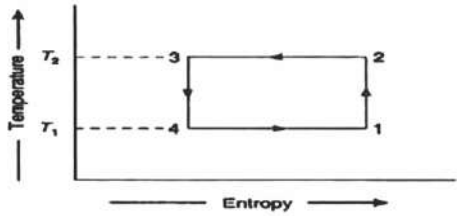
2-3 $\Rightarrow$ Isobarically heat rejection

3-4 $\Rightarrow$ Isentropically expansion

4-1 $\Rightarrow$ Isobarically heat extraction

$$\boxed{COP = \frac{1}{(r_p)^{\frac{\gamma-1}{\gamma}} - 1}}$$

101. The following Temperature – Entropy diagram represents a Refrigeration system operates on the reversed Carnot cycle. The higher temperature of the refrigerant in the system is 35°C and the lower temperature is -15°C. What will be the C.O.P?



Temperature

Entropy

(a) 5.16 (b) 2.75

(c) 3.45 (d) 4.82

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Ans. (a) : Given,

$T_L = -15°C = -15 + 273 = 258$ K

$T_H = 35°C = 35 + 273 = 308$ K

For COP of reverse carnot cycle-

$$\boxed{COP = \frac{T_L}{T_H - T_L}}$$

$$(COP)_{Rec} = \frac{258}{308 - 258}$$

$$= \frac{258}{50}$$

$$\boxed{COP = 5.16}$$

102. In an ammonia vapour compression system, the pressure in the evaporator is 2 bar. Ammonia at exit is 0.85 dry and at entry its dryness fraction is 0.19. During compression, the work done per kg of ammonia is 150 kJ. The latent heat and specific volume at 2 bar are 1325 kJ/kg and 0.58 m^3 /kg, respectively. What will be its C.O.P?

(a) 5.83 (b) 4.34

(c) 3.82 (d) 6.74

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Ans. (a) : Given,

$P_1 = P_4 = 2$ bar

$x_1 = 0.85$, $x_2 = 0.19$

$W = 150$ kJ/kg, $ma = 4.5$ kg/min

$h_{fg} = 1325$ kJ/kg, $Vg = 0.58$ m^3/kg

Since the ammonia vapour at entry to the evaporator (at point-4) has dryness fraction (x_4) equal to 0.19 therefore enthalpy at point 4-

$h_4 = x_4 \times h_{fg} = 0.19 \times 1325$

$h_4 = 251.75$ kJ/kg

Similarly, enthalpy of ammonia vapour at exit i.e. at point-1

$h_1 = x_1 \times h_{fg} = 1126.25$ kJ/kg

Therefore heat extracted from the evaporator or refrigerating effect-

$R_e = h_1 - h_4 = 1126.25 - 251.75$

$R_e = 874.5$

We know that work done during compression

$W = 150$ kJ/kg.

So, $COP = \frac{R.F}{W} = \frac{874.5}{150}$

$$\boxed{C.O.P. = 5.83}$$

103. Which of the following statements is true regarding vapour-compression refrigeration system (VCRS)?

(a) VCRS with both water cooled and air cooled condenser will require same power for same refrigeration effect

(b) Power consumption of VCRS with air cooled condenser is less as compared to that of VCRS with water cooled condenser

(c) Power consumption of VCRS with air cooled condenser is more as compared to that of VCRS with water cooled condenser

(d) Power consumption of VCRS with air cooled condenser may be lesser or greater than that of VCRS with water cooled condenser

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Ans. (c) : Power consumption of VCRS with air cooled condenser compared to VCRS with water cooled condenser will be higher due to high discharge temperature.

Discharge temperature– The discharge of the compressor is the hottest part of the system. Higher the discharge temperature higher the work input required, the discharge temperature in the air cooled system is higher as compared to the water cooled system, therefore power input to the VCRS is more in the air-cooled system as compared to water cooled system.

104. If Q_1 is the heat rejected to the source and Q_2 is the heat extracted from the sink, the coefficient of performance (COP) of a heat pump is given by _____.

(a) $\frac{Q_1}{Q_1 - Q_2}$ (b) $\frac{Q_1 - Q_2}{Q_1}$

(c) $\frac{Q_2}{Q_1 - Q_2}$ (d) $\frac{Q_1 - Q_2}{Q_2}$

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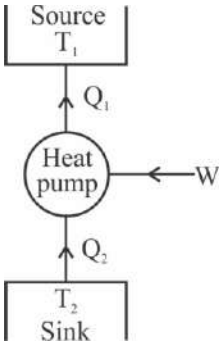
Ans. (a) : Heat pump– A heat pump is a device that works on a reversed Carnot cycle and transfers heat from a lower temperature body to a higher temperature body.



$$(COP)_{heat\ pump} = \frac{Heating\ effect}{work\ input}$$

$$= \frac{Q_1}{Q_1 - Q_2} = \frac{T_1}{T_1 - T_2}$$

$$(COP)_{heat\ pump} = \frac{Q_1}{Q_1 - Q_2}$$

$$(COP)_{heat\ pump} = 1 + (COP)_{ref}$$

105. The expansion process in a vapour compression refrigeration cycle is a/an _____.

(a) Constant volume process

(b) Isenthalpic process

(c) Isentropic process

(d) Reversible isothermal process

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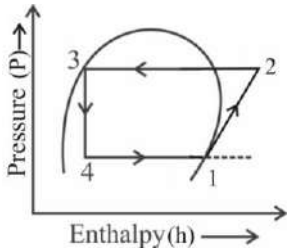
Ans. (b) : The expansion process in a vapour compression refrigeration cycle is an isenthalpic process.

Expansion valve– The expansion valve allows the liquid refrigerant under high pressure and temperature to pass at a controlled rate after reducing its pressure and temperature. It is a constant enthalpy process.



106. In the refrigeration system, heat rejection factor is the ratio of .....

(a) Heat rejected to the refrigeration capacity

(b) Work done by compressor to the refrigeration capacity

(c) Load on the condenser to the COP

(d) Refrigeration capacity to the work done by compressor

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Ans. (a) : In the refrigeration system, heat rejection facture is the ratio of Heat rejected to the refrigeration capacity.

$$HRR = \frac{Heat\ rejected\ by\ condenser}{Refrigeration\ effect}$$

$$HRR = \frac{Q_R}{RE} = 1 + \frac{1}{COP}$$

107. In Bell-Coleman cycle, the pressure at the end of isentropic compression is same as :

(a) The pressure at the start of isentropic expansion

(b) The pressure at the end of isentropic expansion

(c) The pressure in constant pressure expansion

(d) The pressure at the start of isentropic compression

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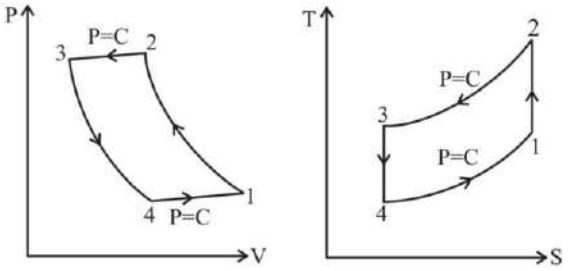
Ans. (a) : Gas Refrigeration cycle or Reverse Brayton cycle (Bell Colleman cycle) : In this cycle, the Pressure at the end of isentropic compression is same as the pressure at the start of isentropic expansion.

■ It consists of four process :



Process 1-2 : → Isentropic compression.

Process 2-3 : → Constant pressure heat rejection

Process 3-4 : $\rightarrow$ Isentropic expansion

Process 4-1 : $\rightarrow$ Constant pressure heat absorption

C.O.P. of Bell colleman cycle ;

$$COP = \frac{1}{\left(r_p\right)^{\frac{\gamma-1}{\gamma}} - 1}$$

where, pressure ratio $(r_p) = \frac{p_2}{p_1} = \frac{p_3}{p_4}$

■ It is used in aircraft because of low weight of per tonne of refrigeration.

108. In actual air-conditioning applications for R-12 and R-22 refrigerant and operating at a condenser temperature of 40°C and an evaporator temperature of 5°C, the heat rejection factor is about :

(a) 1 (b) 5.12

(c) 1.25 (d) 2.15

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Ans. (c) : Given that :

Condenser temperature $(T_H) = 40°C = 40 + 273$

$= 313$ k

evaporator temperature $(T_L) = 5°C = 5 + 273$

$= 278$ k

$$\text{C.O.P. of air conditioning} = \frac{T_L}{T_H - T_L}$$

$$= \frac{278}{313 - 278}$$

C.O.P. = 7.94

$$\text{Heat rejection factor (HRF)} = 1 + \frac{1}{\text{C.O.P.}}$$

$$= 1 + \frac{1}{7.94}$$

HRF = 1.12 $\simeq$ 1.25

109. Which of the following is a suitable for measuring the capacity of refrigeration?

(a) TR (b) kW/kg

(c) kg (d) kJ

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Ans. (a) : The capacity of refrigeration is measured in 'TR'. It is an unit of refrigeration.

1 TR $\Rightarrow$ Refrigeration effect produce by melting 1 ton of ice from at 0°C in 24 hrs.

1TR = 210 kJ/min

= 50 kcal/min

= 200 B.Th.U/min

= 3.5 kw

110. The difference in low temperature cascade condenser temperature and high temperature cascade evaporator temperature is called .....

(a) Temperature overlap

(b) Degree of superheat

(c) Degree of subcooling

(d) Average temperature

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Ans. (a) : The difference between the low - temperature cascade condenser temperature and high-temperature cascade evaporator temperature is called temperature overlap.

■ Temperature overlap is the important factor for achieving a higher C.O.P. because it shows the heat transfer in the system.

■ The cascade condenser serves as an evaporator for the low temperature circuit (LTC) and a condenser for higher temperature circuit (HTC).

The low - temperature circuit is uses in low-boiling refrigerants.

111. If the lower temperature fixed by the refrigeration application is high, the C.O.P. of the Carnot refrigerator will be .....

(a) the same (b) less

(c) very less (d) high

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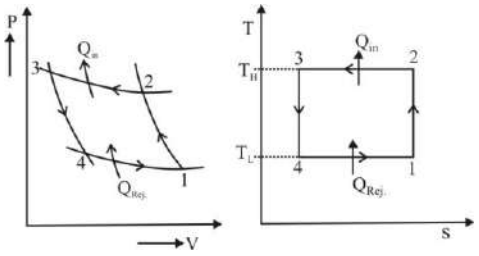
Ans. (d) : Ideal refrigeration cycle/reverse carnot cycle.



Processes :

(4-1) $\rightarrow$ Isothermal expansion or heat extraction.

(1-2) $\rightarrow$ Reversible adiabatic or isentropic compression.

(2-3) $\rightarrow$ Isothermal compression or heat rejection.

(3-4) $\rightarrow$ Reversible adiabatic or isentropic expansion.

COP of refrigerator is ;

$$\boxed{(COP)_{reg^r} = \frac{T_L}{T_H - T_L}}$$

Where,

T_H = Temperature of atmosphere

T_L = Temperature of storage space.

■ All reversible cycles have the same C.O.P. operating between same temperature range.

■ COP does not depend upon working substance in case of reversible cornot cycle.

■ If $T_L \uparrow$, T_H = constant then $(COP)_{reg^r} \uparrow$

■ If $T_L \downarrow$, T_H = constant then $(COP)_{reg^r} \downarrow$

112. In the Bell-Coleman refrigeration cycle, the temperature of the refrigerant is maximum at the :

(a) End of the constant pressure cooling process
(b) End of isentropic compression
(c) Start of isentropic compression
(d) End of isentropic expansion

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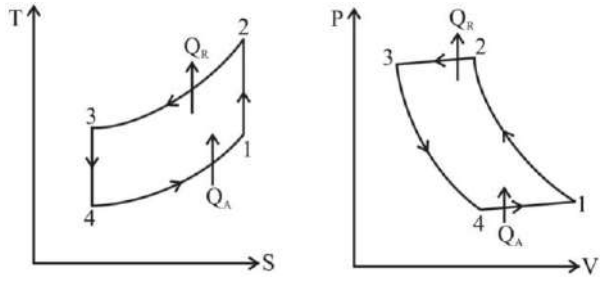
Ans. (b) : In the Bell-coleman refrigeration cycle, the temperature of the refrigerant is maximum at the end of isentropic compression.

■ Bell coleman cycle is also known as reversed Brayton cycle or reversed joule cycle.

■ The working fluid of the Bell coleman refrigeration cycle is Air.



Where,

Process 1-2 : isentropic compression

Process 2-3 : constant pressure heat rejection

Process 3-4 : isentropic expansion

Process 4-1 : constant pressure heat absroption

■ Air refrigeration system is used for air craft refrigeration and it has light weight.

Vapour Absorption Refrigeration System

113. The highest temperature during the cycle, in a vapour compression refrigeration system, occurs after.

(a) expansion (b) compression
(c) condensation (d) evaporation

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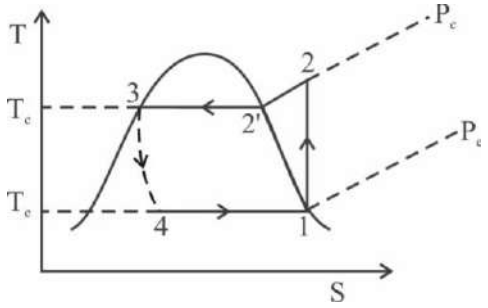
Ans. (b) : The highest temperature during the cycle, in a vapour compression refrigeration system, occurs after compression.



- Process (1-2) : Isentropic compression
- Process (2-3) : Constant pressure heat rejection
- Process (3-4) : Isenthalpic expansion
- Process (4-1) : Constant pressure heat absorption.

114. In aqua-ammonia absorption refrigeration system, incomplete refrigeration leads to accumulation of water in :

(a) Condenser (b) Absorber
(c) Evaporator (d) Heat exchanger

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Ans. (a) : In aqua- ammonia absorption refrigeration system, incomplete rectification leads to accumulation of water in condenser.

115. Ammonia is NOT used in domestic refrigeration and comfort air-conditioning because :

(a) It is not soluble in water
(b) It is toxic and flammable
(c) Its heat transfer coefficient is very low
(d) Lubricating oil is not soluble in ammonia at all

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Ans. (b) : Ammonia is not used in domestic refrigeration and comfort air-conditioning because it sis toxic and flammable.

- Ammonia (NH_3) is used as a refrigerant prominently in the refrigeration systems of the food industry like dairyes, ice plants, frozen food. production plants, Cold storage, warehouses and other applications.

116. If the C.O.P. of 1 TR ammonia-water absorption refrigeration plant is 0.5, then the heat supplied in the generator is ..... . (1 TR = 3.51 kw)

(a) 7 kW (b) 3.5 kW
(c) 10.5 kW (d) 1.5 kW

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Ans. (a) : The C.O.P of 1 TR ammonia- water absorption refrigeration plant = 0.5

1 TR = 3.51 kW

$$COP = \frac{Q_{out}}{Q_{gen}}$$

$$Q_{gen} = \frac{Q_{out}}{COP}$$

$$Q_{gen} = \frac{3.51}{0.5}$$

$\boxed{COP = 7\ KW}$

117. Which fluid is used to increase the rate of evaporation of the liquid ammonia passing through the evaporator in domestic Electrolux refrigeration system?

(a) Hydrogen (b) Water

(c) Ammonia (d) Mercury

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Ans. (a) : Hydrogen is used to increase the rate of evaporation of the liquid ammonia passing through the evaporator in domestic Electrolux system.

- Electrolux Refrigerator works on a 3-fluid system. its working on liquid ammonia and water (NH_3+H_2O) system with (H_2) as the third fluid.
- Liquid ammonia (NH_3) evaporates in the evaporator in the pressure of Hydrogen (H_2),
- Hydrogen is chosen as it is non-corrosive and insoluble in water.
- In vapour absorption refrigeration system, water is used as absorber.

Refrigerants & Refrigerants Properties

118. Match the following.

Halocarbon Refrigerant	Example
1. Halons	**A. R-32**
2. CFCs	**B. R-22**
3. HFCs	**C. R-11**
4. HCFCs	**D. R-10**

(a) 1-A, 2-C, 3-D, 4-B (b) 1-A, 2-C, 3-D, 4-B

(c) 1-D, 2-C, 3-B, 4-A (d) 1-D; 2-C, 3-A, 4-B

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Ans. (d) :

S.N.	Halo carbon Refrigerant	Examples	Chemical name and formula of Refrigerant
1.	Halons	R-10	CCl_3 (tri-chloromethane)
2.	CFCs (Chlorofloro carbon's)	R-11	CCl_3F (tri-chloro-fluoro methane)
3.	HFCs (Hydro floro carbon's)	R-32	CH_2F_2 (Difluoromethane)
4.	HCFCs (Hydro chloro flore carbon's)	R-22	$CHClF_2$ (chlorodi-fluoro methane)

119. A rectifier is fitted in an ammonia absorption plant to :

(a) only remove the unwanted water vapour by cooling the vapour mixture

(b) remove the unwanted water vapour by cooling the vapour mixture and condensing the water vapour

(c) remove the unwanted water vapour by heating the vapour mixture

(d) superheat ammonia vapour

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Ans. (b) :

- A rectifier is fitted in an ammonia absorption plant to remove the unwanted water vapour by cooling the vapour mixture and condensing the water vapour.
- The common vapour absorption refrigeration system is based on NH_3-H_2O where, NH_3 if refrigerant and H_2O is absorbent.

120. Match the types of refrigerants with their representations.

Type of refrigerant		Representation	
1.	**CFC Refrigerants**	**A.**	**R-22**
2.	**HFC Refrigerants**	**B.**	**R-11**
3.	**HC Refrigerants**	**C.**	**R-134a**
4.	**HCFC Refrigerants**	**D.**	**R-390**

(a) 1-A, 2-C, 3-D, 4-B (b) 1-B, 2-C, 3-D, 4-A

(c) 1-A, 2-D, 3-B, 4-C (d) 1-B, 2-D, 3-C, 4-A

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Ans. (b) : Type of Refrigerant:-

(1) CFC Refrigerant → R–11

(2) HFC Refrigerant → R– 134a

(3) HC Refrigerant → R–390

(4) HCFC Refrigerant → R–22

Refrigerating Equipments

121. The function of condenser in refrigeration cooling system is _____.

(a) to give heat into the system
(b) to reject heat out of the system
(c) to given external work to the system
(d) to convert liquid refrigerant into vapour refrigerant

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Ans. (b) :

- The main function of condenser in refrigeration cooling system is to reject heat out of the system.
- The condenser or cooler consists of coils of pipe in which the high pressure and temperature vapour refrigerant is cooled and condensed.
- By the condenser, the vapour refrigerant is changed into liquid refrigerant.

122. The pressure at the inlet of a refrigerant compressor is called _____.

(a) suction pressure (b) discharge pressure
(c) critical pressure (d) back pressure

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Ans. (a) : The pressure at the inlet of a refrigerant compressor is called suction pressure. It's the absolute pressure at which the refrigerant enters the compressor.

Chapter-11 Internal Combustion Engine

Air Standard Cycles

123. What is the function of the transfer port inside the engine?

(a) It is the port through which scavenging of the gases takes place
(b) It is used to move charge from the crankcase to the cylinder head portion
(c) It is the port through which the engine gets the fuel
(d) It is used to transfer unburnt fuel to the exhaust port

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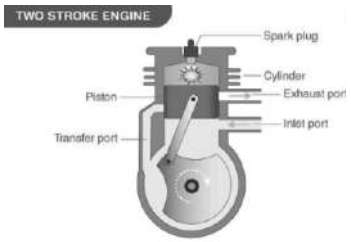
Ans. (b) : The function of the transfer port inside the engine is that it is used to transfer charge from the crankcase to the cylinder head portion.

- The component 'port' is used only in 2-stroke engine and does not used in 4-stroke engine.
- A two-stroke engine has three ports–

(i) Suction port
(ii) Exhaust port
(iii) Transfer port.



124. In which of the following cycles does heat addition NOT take place at constant volume?

(a) Dual cycle (b) Diesel cycle
(c) Lenoir cycle (d) Otto cycle

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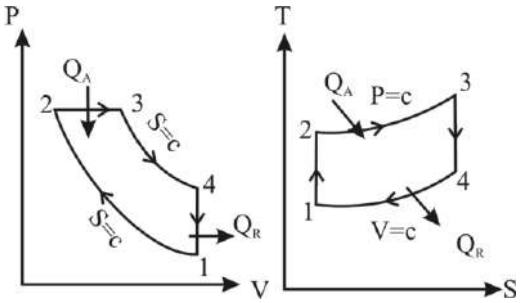
Ans. (b) : Diesel cycle:- Diesel cycle is also known as a constant pressure cycle. In this cycle, heat is supplied at constant pressure.

- A diesel cycle is shown below.



Process 1-2 : Is isentropic compression
Process 2-3 : Is constant pressure heat addition
Process 3-4 : Is isentropic expansion
Process 4-1 : Constant volume heat rejection

- **Cut- off ratio**:-
- The cut-off ratio is the ratio of the volume ofter combustion to the volume before combustion.

$$\text{Cut-off } (\rho) = \frac{V_3}{V_2}$$

- Compression ratio $(r) = \frac{V_1}{V_2}$
- The efficiency of diesel cycle is given by-

$$\eta = 1 - \frac{1}{r^{\gamma-1}}\left[\frac{\rho^{\gamma}-1}{\gamma(\rho-1)}\right]$$

$$\boxed{\eta \uparrow \Rightarrow \rho \downarrow}$$

125. For the same temperature limit, which of the following cycles has maximum efficiency?

(a) Normal stirling cycle (b) Otto cycle

(c) Diesel cycle (d) Carnot cycle

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Ans. (d) : The Carnot cycle is the maximum efficiency of thermodynamic cycle for given temperature limits.

- Carnot cycle. its consists of two isothermal (Constant Temperature) and two adiabatic (no heat transfer) processes.

126. In case of dual cycle of an IC engine, heat addition is .....

(a) Both an isochoric and isobaric process

(b) An isentropic process

(c) Only an isobaric process

(d) Only an isochoric process

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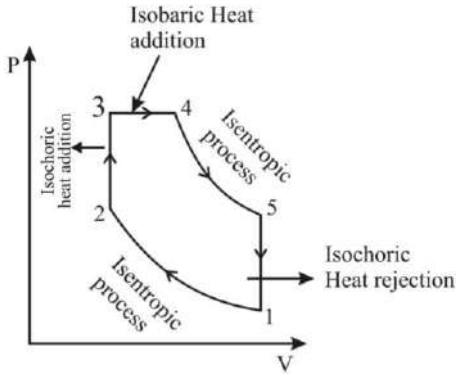
Ans. (a) : In case of dual cycle of an IC engine, heat addition is both an isochoric and isobaric process.



- The dual cycle is a thermodynamic cycle that combines the Otto cycle and Diesel cycle. In this cycle, the head addition occurs. partly at constant volume and party at constant at constant pressure.
- Dual cycle also called a mixed cycle or limited pressure cycle.

SI Engines

127. Which of the following statements is true about a four-stroke engine in comparison to a two stroke engine?

(a) Owing to one power stroke in two revolutions, a lighter flywheel is required

(b) Volumetric efficiency of a four-stroke engine is comparatively low, due to less power output

(c) Thermal efficiency and part-load efficiency of a four-stroke engine are better than those of a two-stroke engine

(d) A four-stroke engine only uses the diesel cycle, while a two-stroke engine only uses the Otto cycle

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Ans. (c) : Advantages and Disadvantages of two stroke over four stroke cycle engine–

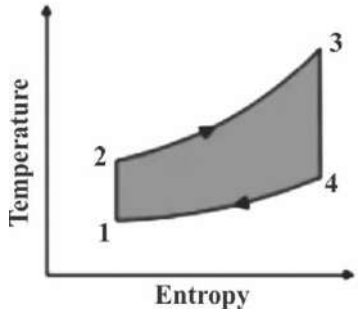
Advantages–

- A two stroke cycle engine gives twice the number of power strokes than the four stroke cycle engine at the same engine speed. Theoretically, a two stroke cycle engine should develop twice the power as that of a four stroke cycle engine.
- For the same power developed, a two stroke cycle engine is lighter, less bulky and occupies less floor area.
- A two stroke cycle has a lighter flywheel and gives higher mechanical efficiency than a four stroke cycle engine.

Disadvantages–

- The thermal efficiency of a two stroke cycle engine is less than that of a four stroke cycle engine, because a two stroke engine has less compression ratio than that of a four stroke cycle engine.
- The overall efficiency of a two stroke cycle engine is also less than that of a four stroke cycle engine.
- The consumption of lubricating oil is large in a two stroke cycle engine because of high operating temperature.

128. In the given T-S diagram of Otto cycle, which of the following process is a heat addition process?



Temperature

Entropy

(a) 1-2 (b) 4-1

(c) 2-3 (d) 3-4

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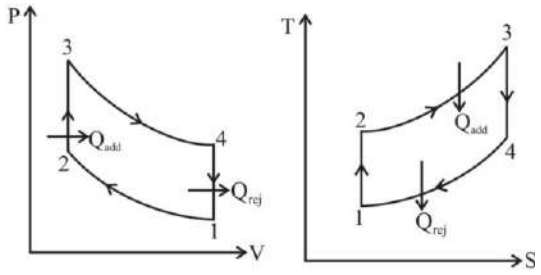
Ans. (c) : Otto cycle : It consists of four processes :

(1-2) : → Isentropic compression

(2-3) : → Constant volume heat addition

(3-4) : → Isentropic expansion

(4-1) : → Constant volume heat rejection.



■ Compression Ratio (r_c) = $\frac{V_1}{V_2}$

■ Expansion Ratio (r_e) = $\frac{V_1}{V_3} = \frac{V_4}{V_3}$

■ Efficiency of otto cycle :

$$\eta_{otto} = 1 - \frac{1}{r_c^{\gamma-1}}$$

$$\eta_{otto} = f(r_c, \gamma)$$

$$\eta_{otto} \downarrow \begin{cases} r_c \uparrow \\ \gamma \uparrow \end{cases}$$

where γ = Adiabatic index

■ $r_c \rightarrow$ (6 to 12) limited due to risk of pre-ignition detonation.

CI Engines

129. Which of the following does NOT describe the Diesel cycle?

(a) Constant volume heat addition

(b) High compression ratio

(c) Limited maximum temperature

(d) No spark plug needed

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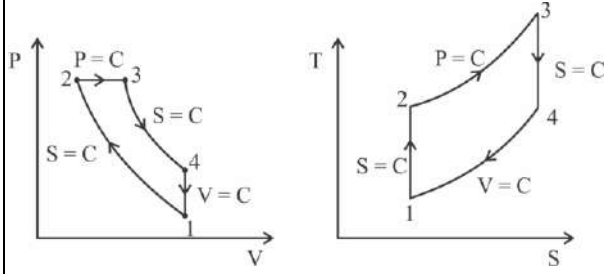
Ans. (a) : Diesel cycle– It differs from the otto cycle in that heat is supplied at constant pressure instead of at constant volume.



It consists of four processes :

1-2 → Isentropic compression.

2-3 → Constant pressure heat addition.

3-4 → Isentropic expansion.

4-1 → Constant volume heat rejection.

- Compression ratio (r) = $\frac{V_1}{V_2}$
- Cut-off ratio (ρ) = $\frac{V_3}{V_2}$
- Expansion ratio (r_e) = $\frac{V_1}{V_3} = \frac{V_4}{V_3}$
- $\rho = \frac{r}{r_e}$
- $\eta = 1 - \frac{1}{r^{\gamma-1}} \frac{\rho^{\gamma} - 1}{\gamma(\rho - 1)}$

130. An air standard diesel cycle working with a compression ratio of 13 and cut off takes places at 5 % of the stroke volume. The value of cut off ratio will be :

(a) 1.3 (b) 1.6

(c) 2.3 (d) 1.9

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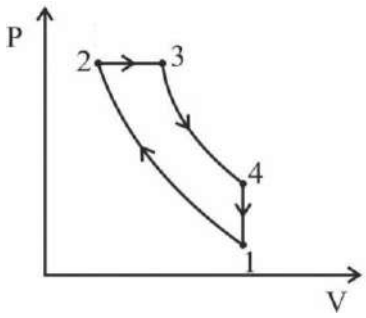
Ans. (b) :



Compression ratio, $r = \frac{V_1}{V_2}$

$$r = 13$$

$$V_3 - V_2 = 5\% (V_1 - V_2)$$

$$V_3 - V_2 = \frac{5}{100}(V_1 - V_2)$$

$$\frac{V_3}{V_2} - 1 = 0.05 \quad \frac{V_1}{V_2} - 1$$

$$\frac{V_3}{V_2} - 1 = 0.05(13 - 1)$$

$$\frac{V_3}{V_2} - 1 = 0.6$$

Cutoff ratio = $\frac{V_3}{V_2} = 1.6$

Fuels

131. In an I.C. engine, when the primary circuit in the coil ignition system break, the voltage produced across the secondary terminal is in the rang of _____.

(a) 800 V to 1200 V (b) 8000 V to 12,000 V
(c) 80 V to 120 V (d) 2000 V to 5000 V

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Ans. (b) : In an IC engine, when the primary circuit in the coil ignition system break, the voltage produced across the secondary terminal is in the rang of 8000 V-12000 V.

132. In two-stroke petrol engine, the air fuel mixture is prepared :

(a) Inside the crank case chamber
(b) Inside the carburetor but outside the cylinder
(c) Inside the transfer port
(d) Inside the carburetor and inside the cylinder

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Ans. (b) : In two- stroke petrol engine, the air fuel mixture is prepared inside the carburetor but outside the cylinder.

Carburetor:- The Carburetor is a device used in petropl engines for atomizing and vaporizing the fuel and mixing it with the air in the varying proportions to suit the changing operating conditions of the engine.

- The process of breaking up and mixing the fuel with the air is called carburetion.

Supercharging of SI & CI Engines

133. Scavenging phenomenon occurred in Two-stroke IC engine when :

(a) Both inlet and outlet vale are opened for a while simultaneously
(b) Both transfer port and exhaust port are opened for a while simultaneously
(c) Both inlet and outlet valve are fully closed
(d) Both transfer port and exhaust port are fully closed

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Ans. (b) : Scavenging-

- The scavenging in an IC engine, is the process of removing the burnt gases from the combustion chamber of the engine cylinder.
- In two-stroke IC engine, at four process take place in one revolution of the crankshaft or two strokes of the piston.
- During scavenging both transfer port and exhaust port are opened for a while simultaneously.

Engine Cooling and Lubrication

134. Which of the following is NOT a component of the water-cooling system with radiator?

(a) Thermostat (b) Centrifugal pump
(c) Condenser (d) Fan

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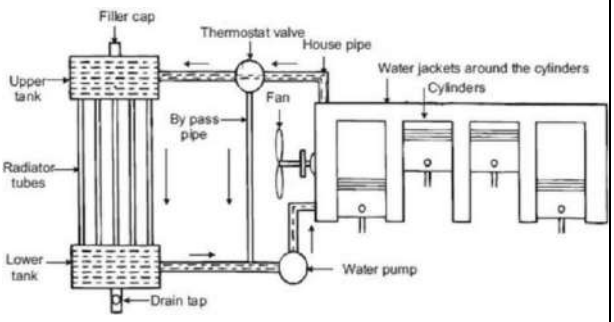
Ans. (c) : Condenser is not a component of the water-cooling system with radiator.



The main component of water cooling–
(i) Thermostat (ii) Centrifugal pump (iii) Fan
(iv) Radiator tubes (v) Upper and lower tanks.

135. In a lubrication method, the oil is kept in the crank case sump and it is splashed by using the end of a connecting rod to various components of the engine. This method is called _____.

(a) Splash lubrication (b) Pump lubrication
(c) Sump lubrication (d) Pressure lubrication

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Ans. (a) : In a lubrication method, the oil is kept in the crank case sump and it is splashed by using the end of connecting rod to various components of the engine. This method is called splash lubrication system.

136. Which of the following is NOT a type of wet sump lubrication system?

(a) Pump lubrication system
(b) Splash lubrication system
(c) Pressure lubrication system
(d) Mist lubricating system

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Ans. (d) : Types of lubricating system– There are mainly 3 types of lubricating system :

- Mist lubrication system
- Wet sump lubrication system
- Dry sump lubrication system

Wet sump lubrication system– In this type, it contains oil in just the sump, serving as a reservoir and it uses a single oil pump. The oil circulating process seems to be fast in this lubricating system because the oil is pumped directly to the moving parts.

Type of wet sump lubrication systems–

- Pump lubrication system
- Splash lubrication system
- Pressure lubrication system.

137. In which percentage generally is lubricating oil mixed with the fuel, which is then inducted into the carburetor in mist lubricating system?

(a) Zero (b) 40% to 50%

(c) 30% to 40% (d) 3% to 6%

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Ans. (d) : 3% to 6% percentage generally is lubricating oil mixed with the fuel in the mixed lubrication system. The oil and fuel mixture is induced through the carburator.

- Generally in two stroke engine mist lubrication is used where crankcase lubrication is not possible.
- The fuel is vaporised and the oil (mist from) goes through the crank case into the engine cylinder. The mist from the oil strikes the crankcase walls, lubricates connecting rod bearings, piston, piston rings and the cylinder.

Chapter-13 Fluid Mechanics

Properties of Fluid

138. If the specific weight of a fluid is 19620 N/m^3, then what will be its specific volume in m^3/kg? (Take g = 9.81 m/sec^2)

(a) 0.5×10^{-3} (b) 5×10^{-3}

(c) 0.5×10^{-5} (d) 5×10^{-5}

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Ans. (a) : Given that,

Specific weight (γ) = 19620 N/m^3

$$\rho g = 19620$$

$$\rho = \frac{19620}{9.81} = 2000\ kg/m^3$$

Specific volume $(V) = \frac{1}{\rho} = \frac{1}{2000}$

$$(V) = 0.0005\ m^3/kg$$

$$\boxed{V = 0.5 \times 10^{-3}\ m^3/kg}$$

139. What will be the mass density of one litre of a fluid which weighs 9.81 N? (Take g = 9.81 m/sec^2)

(a) 100 kg/m^3 (b) 1000 gm/cm^3

(c) 1000 kg/m^3 (d) 100 gm/cm^3

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Ans. (c) : V = 1 l = 1000 cm^3 = 10^{-3} m^3

w = 9.81 N, g = 9.81 m/s^2

w = mg

$$m = \frac{9.81}{9.81}$$

m = 1 kg

$$\rho = \frac{m}{V} = \frac{1}{10^{-3}}$$

ρ = 1000 kg/m^3.

140. The dimensional formula of specific gravity is given by :

(a) $M^1L^{-3}T^{-2}$ (b) $M^2L^{-3}T^0$

(c) $M^0L^0T^0$ (d) $M^1L^{-3}T^0$

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Ans. (c) : Specific gravity or relative gravity is a dimensionless quantity that is defined as the ratio of the density of substance to the density of the water at a specified temperature (means at 4^0 C) and is expressed as

$$\text{S.G.} = \frac{\rho_{substance}}{\rho_{water}}$$

141. What is the value of the density of water at 4^{o}C?

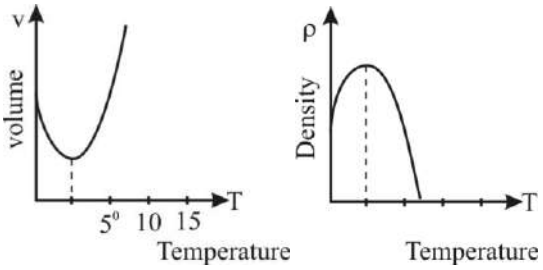
(a) 1000 gm/cm^3 (b) 100 gm/cm^3

(c) 10 gm/cm^3 (d) 1 gm/cm^3

SSC JE 09.10.2023 Shift-II

Ans. (d) : The value of the density of water at 4°C is 1gm/cm^3

- The volume of water exhibits an anomalous behavior. It contracts on heating between 0°C to 4°C.
- Water has a maximum density (1gm/cm^3) at 4°C.
- The volume of a given amount of water decrease as it is cooled from room temperature units its temperature reaches 4°C. Below 4°C, the volume increase and there fore the density decreases.



142. If 5 litres of a certain oil weight 30 N, then what will be the specific weight of that oil?

(a) 6000 N/m^3 (b) 600 N/m^3

(c) 3000 N/m^3 (d) 300 N/m^3

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Ans. (a) : Given :- W = 30N

$V = SL = 5\times10^{-3}m^3$

Specific weight, $w = \frac{mg}{V} = \frac{W}{V}$

$W = \frac{30}{5\times10^{-3}}$

$W = 6000\ N/m^3$

143. The unit of density in FPS (Foot Pound System) is given by :

(a) lb/ft^3 (b) lb/ft^2

(c) lb/ft^1 (d) Lb^2/ft^3

SSC JE 09.10.2023 Shift-II

Ans. (a) : The unit of density in FPS (foot pound) system is lb/ft^3

$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$

$\text{Unit} = \frac{Kg}{m^3}\ \text{or}\ \frac{g}{cm^3}$

$\text{in FPS} = \frac{lb}{Ft^3}$ (Pounds per cubic foot)

144. What will be specific weight of one litre of petrol of specific gravity 0.7? (Take g = 9.81 m/sec^2)

(a) $7286\ N/m^3$ (b) $6256\ N/m^3$

(c) $5436\ N/m^3$ (d) $6867\ N/m^3$

SSC JE 09.10.2023 Shift-II

Ans. (d) : Specific gravity (s) = 0.7

Specific weight (weight density) of liquid,

$= 0.7 \times 1000 \times 9.81\ N/m^3$

$= 6867\ N/m^3$

145. The dimensional formula for specific gravity is given by :

(a) $M^1L^2T^0$ (b) $M^0L^1T^1$

(c) $M^0L^0T^0$ (d) $M^1L^0T^1$

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Ans. (c) : Specific gravity or relative density : -

specific gravity (s) =

$$\frac{\text{Density or weight density of substance}}{\text{Density or weight density of standard substance}}$$

$$= \frac{\text{Specific weight of substance}}{\text{Specific weight of standard substance}}$$

Weight density of liquid = $S_p \times 1000 \times 9.81\ N/m^3$

Density of liquid = $S_p \times 1000\ Kg/m^3$

(Where, S_p = Specific gravity)

- Specific gravity is unit less and dimensionless ($M^0L^0T^0$) property.
- Specific gravity of water is 1.0 at 4ºC and for mercury it is 13.6.
- Specific gravity is measured by hydrometer.

Pressure and its Measurement

146. The pressure responsive element in the Bourdon tube pressure gauge is made of _____.

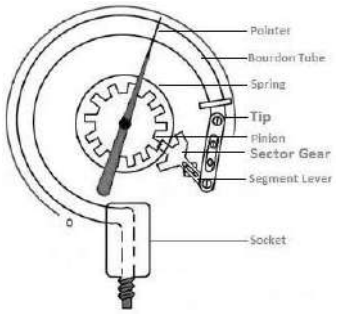
(a) cast iron (b) aluminium

(c) inconel (d) bronze

SSC JE 11.10.2023 Shift-II

Ans. (d) : Bourdon tube pressure gauge:- In this pressure gauge, the pressure responsive element is a tube of steel of bronze which is of elliptical cross-section curved into a circular arc.

- one end of the tube is closed and the other end is connected to the fluid under pressure.
- The closed end is free to move, where other end is rigidly fixed to the frame.



- When the fluid under pressure enters and fills the Bourdon tube, the elliptical cross-section of the tube tends to become circular due to the increase in internal pressure.

147. The position of centre of pressure depends on which of the following?

(a) Surface tension of fluid

(b) Velocity of liquid

(c) Weight of the object immersed in liquid

(d) Location of object from the free surface

SSC JE 11.10.2023 Shift-II

Ans. (d) : The position of centre of pressure depends on location of object from the free surface.

For horizontal planner surface– Total hydrostatic pressure force, $F = \rho g A\bar{h}$. Location of centre of pressure from free surface of the liquid, $y_{cp} = \bar{x}$

Inclined planner surface – Total hydrostatic force, $F = \rho g A\bar{h}$

Location of centre of pressure from free surface of the liquid, $y_{cp} = \frac{I_G \sin^2\theta}{A\bar{x}} + \bar{x}$

Where, $\bar{x}$ = distance of centroid from free surface of liquid

148. There are two horizontal pipes in which water is flowing. If we have to find the pressure difference between these two horizontal pipes using an inverted manometer, and two manometric fluids with specific gravities of 13.5 and 0.9 are available, then which manometric fluid will be appropriate?

(a) Both the Fluids can be used
(b) Cannot be predicated
(c) Fluid with the specific gravity of 13.5
(d) Fluid with the specific gravity of 0.9

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Ans. (d) : Differential manometers– Differential manometer are devices used for measuring the difference of pressure between two points in a pipe or in two different pipes.

The most common types of differential manometers are–

- U-tube differential manometer
- Inverted U-tube differential manometer.

Differential inverted U-tube manometer–

- It consists of an inverted U-tube containing a light liquid.
- Inverted U-tube manometers only used for measuring liquid pressure.
- It is used in two conditions :

(i) In underground pipeline
(ii) When the specific gravity of manometric fluid is less than 1.

149. Choose the correct mathematical relation of absolute pressure.

(a) $P_{abs} = P_{atm} + P_{gauge}$
(b) $P_{abs} = P_{atm} + 2P_{gauge}$
(c) $P_{abs} = P_{atm} / P_{gauge}$
(d) $P_{abs} = P_{atm} - P_{gauge}$

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Ans. (a) : Atmospheric pressure (P_{atm})– The atmospheric air exerts a normal pressure upon all surfaces with which it is in contact, it is known as atmospheric pressure.

Standard atmospheric pressure = 101.3 kN/m^2 or Pa
= 10.3 m of water
= 760 mm of Hg.

Gauge pressure (P_{gauge})– The pressure measured with the help of a pressure gauge is known as gauge pressure in which atmospheric pressure is taken as datum.

- **Absolute pressure (P_{abs})–** Absolute pressure is the sum of gauge pressure and atmospheric pressure.

$$\boxed{P_{abs} = P_{atm} + P_{gauge}}$$

150. Which of the following statements is correct for compressibility?

(a) Compressibility is equal to bulk modulus
(b) Compressibility is square root of bulk modulus
(c) Compressibility is reciprocal of bulk modulus
(d) Compressibility is square of bulk modulus

SSC JE 11.10.2023 Shift-II

Ans. (c) : Compressibility is reciprocal of bulk modulus of elasticity.

Bulk modulus– The ratio of hydrostatic stress to the volumetric strain within the elastic range is called bulk modulus.

$$K = \frac{dp}{-\frac{dv}{v}}$$

- SI unit of bulk modulus is N/m^2

Compressibility– The reciprocal of the bulk modulus of the material of a body is called the compressibility of the material.

$$\text{Compressibility} \propto \frac{1}{\text{Bulk modulus}}$$

$$\beta = \frac{\frac{-dv}{v}}{dp}$$

- Compressibility of water is approximately zero.

151. The value of atmospheric pressure in bar is _____.

(a) 1.5643 (b) 1.01325
(c) 0.9874 (d) 2.01324

SSC JE 11.10.2023 Shift-II

Ans. (b) : The value of atmospheric pressure is 1.01325 bar.

1 bar = 10^5 Pa.

- Atmospheric pressure, also called barometric pressure, force per unit area exerted by an atmospheric column.
- Atmospheric pressure measured using an aneroid barometer.

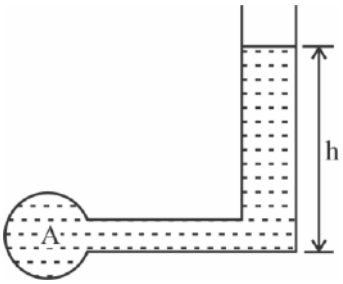
152. A piezometer is connected to a point in a pipe to measure the pressure of water flowing through it. If the piezometer reads 0.4 m, what will be the gauge pressure at that point?

Take atmospheric pressure = 101325 pascals and g = 10 m/s^2.

(a) 40 Kilo pascal (b) 97325 pascal
(c) 4000 pascal (d) 105325 pascal

SSC JE 11.10.2023 Shift-II

Ans. (c) :



$h = 0.4$ m, $P_{atm} = 101325$ Pa

$g = 10$ m/s^2, $\rho_w = 1000$ kg/m^3

$P_{gauge} = \rho_w \times g \times h$

$= 1000 \times 10 \times 0.4$

$P_{gauge} = 4000$ Pa

153. An oil of specific gravity 0.8 is flowing through a pipe. A differential manometer is connected at the two points, say A and B, and shows a difference in the mercury level as 20 cm. What will be the difference between the pressures at the two points?

Take density of mercury = 13600 kg/m^3 and g = 10 m/s^2 .

(a) 2560 N/m^2 (b) 25.6 kN/m^2

(c) 1280 N/m^2 (d) 25.6 N/m^2

SSC JE 11.10.2023 Shift-II

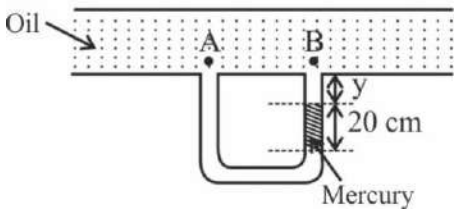
Ans. (b) : Given,

Oil of specific gravity = 0.8

Difference in mercury level = 20 cm = 0.2 m

$P_A - P_B = ?$, $\rho_{Hg} = 13600$ kg/m^3, $g = 10$ m/s^2

$\rho_{oil} = 0.8 \times 1000 = 800$ kg/m^3



$P_A + 800 \times g\,(0.2 + y)$

$= P_B + 800 \times g \times y + 13600 \times 0.2 \times g$

$P_A + 800 \times g \times 0.2 + 800 \times g \times y$

$= P_B + 800 \times g \times y + 13600 \times 0.2 \times g$

$P_A - P_B = 1360 \times 0.2 \times 10 - 800 \times 10 \times 0.2$

$P_A - P_B = 27200 - 1600$

$= 25600$ N/m2 $= 25.6$ kN/m^2

154. According to ..... the intensity of pressure in a liquid at rest is constant in all directions.

(a) Newton's law (b) Pascal's law

(c) Hydrostatic law (d) Boyle's law

SSC JE 09.10.2023 Shift-II

Ans. (b) : Pascal's Law:-

- According to Pascal's law, the pressure of intensity of pressure at a point in a **static fluid** is equal in all directions.
- Many of the principle of Pascal's law works on the principle Pascal's law.

(i) Hydraulic Press

(ii) Hydraulic lift

(iii) Hydraulic brakes.

$\boxed{PV^n = C}$

155. The bent tube of a Bourdon tube pressure gauge will change its shape when exposed to variations of .....

(a) Resistance (b) Displacement

(c) Voltage (d) Pressure

SSC JE 09.10.2023 Shift-II

Ans. (d) : The bent tube of a Bourdon tube pressure gauge will change its shape when exposed to variations of Internal and external pressure.

- As pressure is applied internally the tube straightens and returns to its original form when the pressure is released.

156. Which of the following pressure measurement devices consists of a hollow metal tube bent like a hook whose end is closed and connected to a dial indicator needle?

(a) Piezoelectric transducers

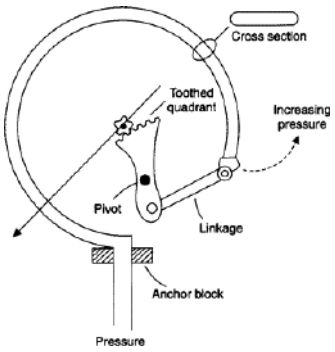
(b) Strain gauge pressure transducer

(c) Bourdon tube

(d) Pressure transducers

SSC JE 09.10.2023 Shift-II

Ans. (c) : Bourdon tube- It is the pressure measurement device consists of a hollow metal bent tube like a hook whose end is closed and connected to a dial indicator needle.



Type of Bourdon tube- there are three type bourdon tube.

(i) C – type

(ii) Spiral type

(iii) helical type

157. Which of the following types of simple manometers measures the gauge pressure of only incompressible fluids?

(a) Differential U-tube manometer
(b) Single column manometer
(c) Piezometer
(d) U-tube manometer

SSC JE 09.10.2023 Shift-II

Ans. (c) : A piezometer is a simple manometer that measure gauge pressure.

- It consists of a glass tube that is inserted into the wall of a vessel or pipe.
- Its one end of the tube is connected to the point where the pressure will be measured and the other end remains open to the atmosphere.
- A piezometer can measure moderate pressure of liquids.
- It measures only positive gauge pressure.
- It can not measure very high pressure and the pressure of gases.

Hydrostatic Forces on Surfaces

158. Which of the following is the correct statement relating to the centre of pressure on an immersed surface?

(a) It is the point where the weight of the body and resultant pressure acts
(b) it is the point there weight of body the acts
(c) It is the point where the resultant pressure acts
(d) It is the point where the normal pressure acts

SSC JE 11.10.2023 Shift-II

Ans. (c) : Centre of pressure ($\bar{h}$)– It is the point where the resultant pressure acts.

For inclined immersed surface–

The depth of centre of pressure from the liquid surface

$$\bar{h} = \frac{I_G \sin^2\theta}{A\bar{x}} + \bar{x}$$

Where,

$\bar{x}$ = Depth of centre of gravity of immersed surface from the liquid surface.

I_G = Moment of inertia

A = Area of immersed surface

θ = Angle at which the immersed surface is inclined with the liquid surface.

159. What will be the absolute pressure (approximately) at a point 3 m below the free surface of a liquid having a density of 1530 kg/m^3, if the atmospheric pressure is equivalent to 750 mm of mercury? (The specific gravity of mercury is 13.6 and density of water is 1000 kg/m^3, g = 9.81 m/sec^2)

(a) 95,648 N/m^2 (b) 78,560 N/m^2
(c) 1,00,250 N/m^2 (d) 1,45,090 N/m^2

SSC JE 11.10.2023 Shift-II

Ans. (d) : Given,

$h = 3$ m, $\rho_l = 1530$ kg/m^3

$h_{Hg} = 750$ mm $= 0.75$ m

$S_{Hg} = 13.6$, $\rho_{Hg} = 13.6 \times 10^3$

$\rho_w = 1000$ kg/m^3, g = 9.81 m/s^2

$P_{abs} = P_{atm} + P_{gauge}$

$P_{atm} = \rho_{Hg} \times g \times h_{Hg}$

$= 13.6 \times 10^3 \times 9.81 \times 0.75$

$P_{atm} = 100{,}062$ N/m^2

$P_{gauge} = h.\rho_l .g$

$= 3 \times 1530 \times 9.81$

$P_{gauge} = 45027.9$ N/m^2

$P_{abs} = P_{atm} + P_{gauge}$

$= 100062 + 45027.9$

$P_{abs} = 145090$ N/m^2.

160. What will be the atmospheric pressure at a location when the barometric reading is 750 mm Hg and the gravitational acceleration is g = 9.81 m/s^2? Assume the density of mercury to be 13,600 kg/m^3.

(a) 10.006 kPa (b) 100.06 Pa
(c) 100.06 kPa (d) 1000.6 Pa

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Ans. (c) : Given that :-

$h = 750$ mm of Hg

g = 9.81 m/s^2

$\rho = 13600$ kg/m^3

Atmospheric Pressure (P) = ρgh

$$P = 13600 \times 9.81 \times \frac{750}{1000}$$

$P = 100062$ Pa

$\boxed{P = 100.6 \text{ kPa}}$

161. What will be the ratio of the pressure intensities of two fluids, one with a liquid column of 0.4 mm of water and the other with a liquid column of 0.2 m of an oil of specific gravity 0.8?

(a) $\frac{3}{2}$ (b) $\frac{7}{2}$
(c) $\frac{5}{2}$ (d) 2

SSC JE 09.10.2023 Shift-II

Ans. (c) : Given that-

$h_{water} = 0.4$ m

Specific weight of water (γ_{water}) = 9810 kg/m^3

and $h_{liquid} = 0.2$ m

Specific gravity of liquid = 0.8

Specific weight of liquid (γ_{liquid}) = 0.8 × 9810

Preussure (p) = ρgh

$$\frac{P_{water}}{P_{liquid}} = \frac{h_{water} \times \gamma_{water}}{h_{liquid} \times \gamma_{liquid}}$$

$$= \frac{0.4 \times 9810}{0.2 \times 0.8 \times 9810} = \frac{20}{8}$$

$$\boxed{\frac{P_{water}}{P_{liquid}} = \frac{5}{2}}$$

162. If the pressure intensity at a point in a fluid is given as 2.7 N/cm^2, then what will be the pressure head of oil of specific gravity 0.9 at that point? Take g = 10 m/s^2.

(a) 30 cm of oil (b) 3 m of oil

(c) 3 cm of oil (d) 3 mm of oil

SSC JE 09.10.2023 Shift-II

Ans. (b) : Given data-

P = 2.7 N/cm^2

Pressure intensity (P) = 2.7 × 10^4 N/m^2

Density = Specific gravity × 1000

(S) = 0.9, ρ = 0.9×10^3 kg/m^3

g = 10 m/s^2

find – pressure head (h) = ?

$$h = \left(\frac{P}{\rho g}\right) = \frac{2.7 \times 10^4}{0.9 \times 10^3 \times 10} = 3 \text{ m}$$

[h = 3m of oil column]

163. The pressure intensity at a point in a fluid is given as 3.924 N/cm^2. What will be the corresponding height of fluid when the fluid is water?

(a) 3.5 m of water (b) 6 m of water

(c) 2.5 m of water (d) 4 m of water

SSC JE 09.10.2023 Shift-II

Ans. (d) : Given- Pressure intensity (P) = 3.924 N/cm^2

P = 3.924 × 10^4 N/m^2

formula,

P = ρgh

$$h = \left(\frac{P}{\rho g}\right)$$

$$h = \frac{3.924 \times 10^4}{10^3 \times 9.8} = 4 \text{ m}$$

[h = 4 m of water column]

164. What pressure head of kerosene of specific gravity 0.8 will be equivalent to a pressure head of 100 m of water?

(a) 120 m (b) 110 m

(c) 125 m (d) 100 m

SSC JE 09.10.2023 Shift-II

Ans. (c) : Specific gravity of kerosene = 0.8

So, density (s) = 0.8 × 1000 = 800 kg/m^3

Water head = 100 m

for equal pressure

$\rho_1 g h_1 = \rho_2 \times g h_2$

or

$\rho_k \times g \times h_k = \rho_w \times g \times h_w$

$800 \times h_k = 1000 \times 100$

$$h_k = \frac{1000}{8} = 125$$

$$\boxed{h_k = 125\text{m}}$$

165. Which of the following is the correct expression for pressure intensity?

(a) P = 2ρgh (b) P = 1.5ρgh

(c) P = 0.5ρgh (d) P = ρgh

SSC JE 09.10.2023 Shift-II

Ans. (d) : The intensity of pressure is given by

$$\boxed{P = \rho gh}$$

Where ρ = density of the fluid

h = height of liquid column.

- The intensity of pressure at a point is defined as the external normal force per unit area.

166. A circular opening, 3 m diameter, in a vertical side of a tank is closed by a disc of 3 m diameter which can rotate about a horizontal diameter and depth of centre of gravity from free surface is 4 m. What will be the total pressure on the disc?

(a) 100 kN (b) 277.4 kN

(c) 175.7 kN (d) 234.89 kN

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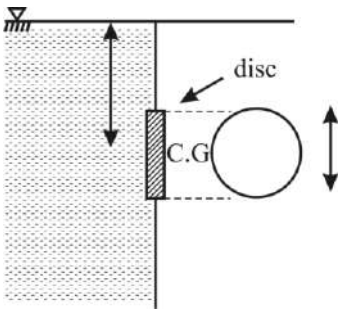
Ans. (b) : Diameter of disc = 3m



Area $= \frac{\pi}{4}d^2$

$= \frac{\pi}{4}3^2 m^2$

Depth of CG, $\bar{x} = 4m$

Total pressure on the disc

$= \rho g A \bar{x}$

$= 1000 \times 9.81 \times \frac{\pi}{4} \times 9 \times 4$

$\boxed{F_x = 277.230kN}$

167. The point of intersection of the line of action of the resultant hydrostatic force and the submerged surface is called .....

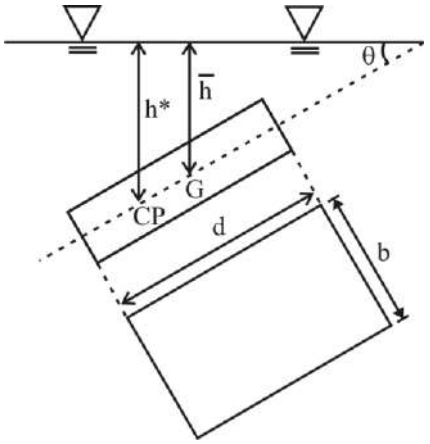
(a) Centre of gravity (b) Centre of mass

(c) Centre of pressure (d) Centre of buoyancy

SSC JE 09.10.2023 Shift-II

Ans. (c) : Centre of Pressure : The point of intersection of the line of action of the resultant hydrostatic force and the submerged surface is called the centre of pressure.

■ The centre of pressure is also defined as the point of application of the total pressure on the submerged surface.



■ **Cases of hydrostatic force on submerged surface-**

Cases	Force	Centre of Pressure (h*)
Horizontal position	$\rho g A \bar{h}$	$h^* = \bar{h}$
Vertical position	$\rho g A \bar{h}$	$h^* = \bar{h} + \frac{I_G}{A\bar{h}}$
Inclined position	$\rho g A \bar{h}$	$h^* = \bar{h} + \frac{I_G}{A\bar{h}} \sin^2\theta$

Fluid Kinematics

168. The continuity equation $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$ is valid for a .....

(a) Unsteady, 2D, compressible flow

(b) Steady, 2D, incompressible flow

(c) Steady, 2D compressible flow

(d) Unsteady, 2D, incompressible flow

SSC JE 09.10.2023 Shift-II

Ans. (b) : Generalized equation of continuity:-

$$\frac{\partial \rho}{dt} + \frac{\partial}{\partial x}(\rho u) + \frac{\partial}{\partial y}(\rho v) + \frac{\partial}{\partial z} + (\rho w) = 0$$

case- 1 for steady flow $\left(\frac{\partial \rho}{\partial t} = 0\right)$ then the above equation will become.

$$\frac{\partial}{dx}(\rho u) + \frac{\partial}{\partial y}(\rho v) + \frac{\partial}{\partial z}(\partial w) = 0$$

case – 2 for incompressible flow, i.e (ρ = c) density is constant then the above equation for steady, incompressible and 3-D flow –

$$\frac{\partial u}{dx} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0$$

Steady, incompressible and 2-D flow-

$$\boxed{\frac{\partial u}{dx} + \frac{\partial v}{\partial y} = 0}$$

Fluid Dynamics

169. The term $\rho V^2/2$ used in Bernoulli theorem is basically :

(a) hydrostatic pressure (b) dynamic pressure

(c) stagnation pressure (d) static pressure

SSC JE 11.10.2023 Shift-II

Ans. (b) : Bernoulli's theorem– Assumption :

(1) Fluid is ideal i.e. viscosity is zero.

(2) Steady flow

(3) The flow is incompressible

(4) The flow is irrotational

(5) The flow is along the steam line.

Bernoulli's equation is obtained by integrating the Euler's equation,

$$\boxed{\frac{dp}{\rho} + vdv + gdz = Constant}$$

If flow is incompressible, (ρ = C)

$$\frac{P}{\rho}+\frac{V^2}{2}+gz = C$$

$$\Rightarrow \boxed{P+\frac{\rho V^2}{2}+\rho gz = C}$$

$\Rightarrow$ P = Pressure head

$\Rightarrow \frac{\rho V^2}{2}$ = Dynamic pressure head/ K.E. head/ Velocity head

$\Rightarrow$ ρgz = Potential head.

170. Pressure head of a fluid represents.

(a) energy per unit mass
(b) energy per unit weight
(c) energy per unit length
(d) energy per unit volume

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Ans. (b) : Bernoulli's equation– Assumption
(i) Steady flow (ii) Non viscous fluid
(iii) Incompressible flow (iv) irrotational fluid.

$\frac{P}{\rho}+\frac{V^2}{2}+gz = \text{Constant}$ $\frac{\text{Energy}}{\text{Mass}}$

$P+\frac{\rho V^2}{2}+\gamma z = \text{Constant}$ $\frac{\text{Energy}}{\text{Volume}}$

$\frac{P}{\rho g}+\frac{V^2}{2g}+z = \text{Constant}$ $\frac{\text{Energy}}{\text{Weight}}$

Where,

$\frac{P}{\rho g}$ = Pressure head

$\frac{V^2}{2g}$ = Velocity head

z = Potential head.

171. The Energy Gradient line will_____.

(a) Coincide with Hydraulic Gradient line
(b) Coincide with pipe axis
(c) Lie above the Hydraulic Gradient line
(d) Lie below the Hydraulic Gradient line

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Ans. (c) : The energy gradient line will lie above the hydraulic gradient line and they are separated from each other by a vertical distance equal to the velocity head.
Thus, energy gradient line is always above the hydraulic gradient line and difference between them is equal to the velocity head of fluid.

Energy gradient line– The line which joins the total energy $\left(\frac{P}{\gamma}+\frac{V^2}{2g}+z\right)$ at various points in a flow is known as energy gradient line (EGL).

Hydraulic gradient line– The line which joins the piezometric head $\left(\frac{P}{\gamma}+z\right)$ at various point in a flow is known as hydraulic gradient line (HGL).

172. A Kaplan turbine has an outside diameter of runner and hub diameter as 4 m and 2 m, respectively. If the velocity of flow at inlet is 8 m/s, then what will be the discharge passing through the turbine?

(a) 68 m^3/s (b) 7.536 m^3/s
(c) 75.36 m^3/s (d) 6.8 m^3/s

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Ans. (c) : Given:- outside diameter of runner (D) = 4m
hub diameter (d) = 2m
At Inlet, velocity of flow (v) = 8 m/s
The discharge passing through the turbine

$$Q = A.V$$

$$=\frac{\pi}{4}\left(D^2-d^2\right)\times 8$$

$$=\frac{3.14}{4}(16-4)\times 8$$

$$\boxed{Q = 75.39 m^3/s}$$

173. Water is flowing steadily at a velocity of 20 m/s through a pipe of diameter 0.2 m. The pressure and elevation at point X are 400 kN/m^2 and 32 m, respectively, while those at another point Y are 300 kN/m^2 and 34m, respectively. What will be the head loss between the point X and Y? (g = 10 m/sec^2)

(a) 4 m (b) 10 m
(c) 8 m (d) 6 m

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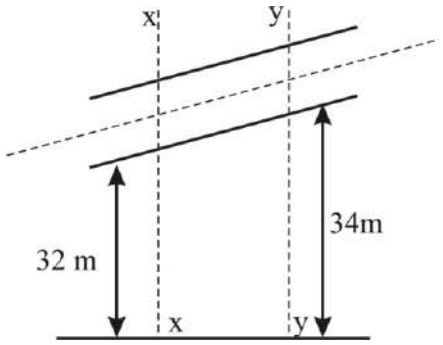
Ans. (c) : Given-
Diameter of Pipe = (a) = 0.2m
Velocity of water (v) = 20 m/s
Elevation as point x is z_1 = 32 m and pressure 400 kN/m^2
The pressure and elevation at point 'Y'
respectively 300kN/m^2 and 34 m.
gravitational force (g) = 10m/s^2



According of Barnauli's equation:-

$$\frac{P_1}{\rho g}+\frac{V_1^2}{2g}+Z_1=\frac{P_2}{\rho g}+\frac{V_2^2}{2g}+Z_2+h_f$$

$$\frac{400\times10^3}{1000\times10}+\frac{(20)^2}{2\times10}+32=\frac{300\times10^3}{1000\times10}+\frac{(20)^2}{2\times10}+34+h_f$$

$$\frac{400\times10^3}{1000\times10}-\frac{300\times10^3}{1000\times10}=2+h_f$$

$$\frac{100\times10^3}{1000\times10}=2+h_f$$

$10 = 2 + h_f$

$h_f = 8$ m

174. Which of the following is not the part of venturimeter setup?

(a) Diverging part (b) Float

(c) Converting part (d) Throat

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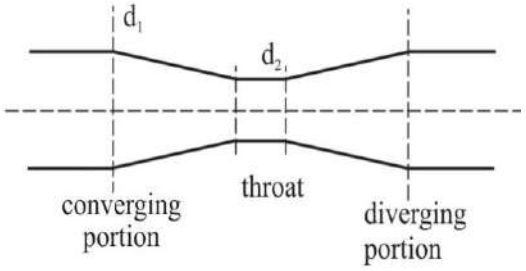
Ans. (b) : Float is not the part of venturimeter setup.

Venturimeter :- It is a device that is used to measure the rate of flow of fluid flowing through a pipe.



Angle of convergence = 15° –20°

Angle of divergence = 6–7°

$$d_2=\left(\frac{1}{3}\text{ to }\frac{1}{4}\right)d_1$$

$$Q=C_d\frac{A_1A_2}{\sqrt{A_1^2-A_2^2}}\sqrt{2gH}$$

Flow Through Pipes

175. The energy loss caused by abrupt enlargement is expressed by :

(a) $\frac{(V_1-V_2)^2}{g}$ (b) $\frac{(V_1-V_2)^2}{2g}$

(c) $\frac{(V_1-V_2)^2}{\sqrt{2g}}$ (d) $\frac{(V_1-V_2)^2}{2}$

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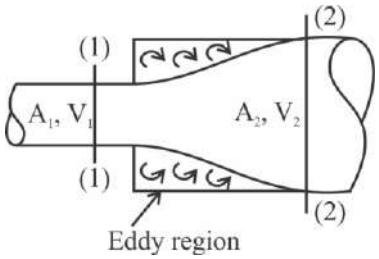
Ans. (c) : Different type of minor losses in pipe–

(i) Losses due to sudden expansion (abrupt enlargement)–



$$h_e=\frac{(V_1-V_2)^2}{2g}=\frac{V_1-V_2}{\sqrt{2g}}^2=\frac{V_1^2}{2g}\left(1-\frac{A_1}{A_2}\right)^2$$

(ii) Losses due to sudden contraction–

$$h_c=\frac{(V_c-V_2)^2}{2g}=\frac{V_2^2}{2g}\left(\frac{1}{C_c}-1\right)^2$$

Coefficient of contraction $(C_c) = \frac{V_2}{V_c}$

If C_c is not given,

$$h_c=\frac{0.5V_2^2}{2g}$$

(iii) Losses at exit of pipe, $h_o=\frac{V^2}{2g}$

(iv) Losses at entrance of pipe, $h_i=\frac{0.5V^2}{2g}$

Here, V = mean velocity of flow in pipe.

176. Which of following losses fall into the category of major losses?

(a) Head loss due to bend of pipe

(b) Head loss due to friction

(c) Head loss due to sudden enlargement

(d) Head loss due to sudden contraction

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Ans. (b) :

Energy (or Head) losses

Major Energy Losses	Minor Energy Losses
This is due to friction and it is calculated by the following formula- (i) Darcy-Weisbach Formula (ii) Chezy's Formula	This is due to (i) Sudden enlargement of pipe (ii) Sudden Contraction of pipe (iii) Bend in pipe (iv) Pipe fittings etc.

177. Which of the following is used to calculate major losses in pipes?

(a) Continuity equation
(b) Reynold's equation
(c) Darcy Weisbach equation
(d) Momentum equation

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Ans. (c) : There are mainly two losses in a-pipe

(1) Major loss :- It occurs due to friction only.

(2) Minor loss:- It depends on different factors.

Major Loss:- Major loss in the pipe due to friction is calculated by the Darcy- Weisbach equation -

$$\boxed{h_f = \frac{fLV^2}{2gD}}$$

Where, L = Length of pipe
D = Diameter of pipe
V = Mean velocity
f = Friction factor (0.02 to 0.04 for metals)
h_f = head loss due to friction.

- The minor loses occurs in pipe due to sudden expansion sudden contraction losses at the exit of pipe, losses due to bend.

178. The velocity of flow between two adjacent streamlines is inversely proportional to the :

(a) Specific weight
(b) Volume flow rate
(c) Circulation
(d) Spacing of the streamlines

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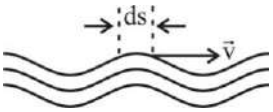
Ans. (d) : Stream line : It is an imaginary line or curve in a flow field such that the tangent drawn at particular point gives the direction of instantaneous velocity at that particular point.

■ The velocity of flow between two adjacent streamlines is inversely proportion to the spacing of the streamlines.



Let us consider a small displacement vector (ds) on a flow field.

$d\vec{s} = dx\hat{i} + dy\hat{j} + dz\hat{k}, \vec{v} = u\hat{i} + v\hat{j} + w\hat{k}$

$\vec{v} \times d\vec{s} = 0$

$$\begin{bmatrix} \hat{i} & \hat{j} & \hat{k} \\ u & v & w \\ dx & dy & dz \end{bmatrix} = 0\hat{i} + 0\hat{j} + 0\hat{k}$$

$\hat{j}(vdz - wdy) - \hat{j}(udz - wdx) + \hat{k}(udy - vdx)$

$= 0\hat{i} + 0\hat{j} + 0\hat{k}$

comparing both side unit vector

$\frac{dx}{u} = \frac{dy}{v} = \frac{dz}{w}$ (stream-line eq^n in 3D flow)

$\frac{dx}{u} = \frac{dy}{v}$ (stream line eq^n in 2D flow)

■ Slope of steam line in x-y plane $\boxed{\frac{dy}{dx} = \frac{v}{u}}$

Boundary Layer Theory

179. Vapour pressure is primarily associated with which phenomenon?

(a) Capillarity (b) Cavitation
(c) Surging (d) Water hammering

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Ans. (b) : Cavitation– The formation, growth and collapse of vapour filled cavities or bubbles in a flowing liquid due to local fall in fluid pressure is called cavitation.

- Vapour pressure is primarily associated with cavitation phenomenon.
- The cavitation in a hydraulic machine affects in the following ways–

(i) It causes noise and vibration of various parts.
(ii) It makes surface rough
(iii) It reduces the discharge of a turbine.
(iv) It causes sudden drop in power output and efficiency.

180. What is the hydraulic radius for a circular pipe running full?

(a) d (b) 0.25d
(c) 0.5d (d) 0.75d

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