ESE 2025
Prelims Solutions

Mechanical Engineering

Set-B

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UPSC ESE Prelims 2025

MECHANICAL ENGINEERING

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Q.1 Consider the following statements regarding diesel cycle:

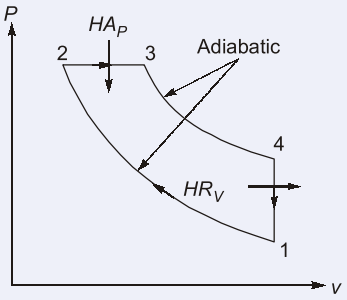
1. Heat is supplied at constant pressure.
2. It has adiabatic expansion process.
3. Rejection of heat is at constant pressure.

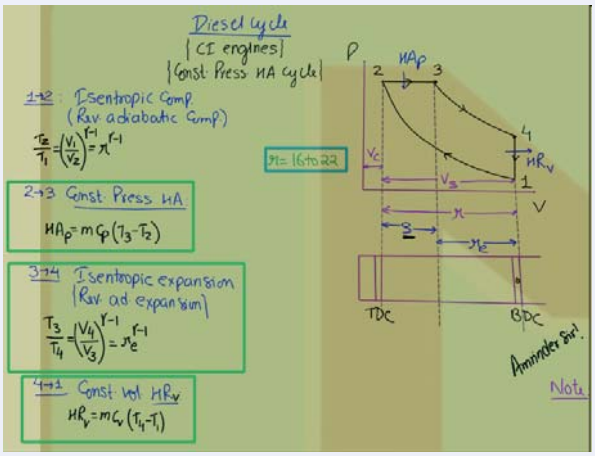
Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (a)

- Heat rejection is at constant volume.
- Heat addition is at constant pressure.





End of Solution

Q.2 Heat is conducted through a material with a temperature gradient of –9000°C/m. The thermal conductivity of the material is 25 W/m-K. If this heat is convected to surroundings at 30°C with a convection coefficient of 345 W/m^2-K, What is the surface temperature?

(a) 957.24°C (b) 1108.61°C
(c) 682.17°C (d) 394.82°C

Ans. (c)

Given : $\frac{dT}{dx} = -9000°C/m$; $k = 25$ w/mK; $h = 345$ w/mK;

$T_o = 30°C$; T_s = Surface temperature

From surface energy balance

Conduction heat transfer = Convection heat transfer

$$-kA\frac{dT}{dx} = hA(T_s - T_\infty)$$

$$-25(-9000) = 345(T_s - 30)$$

$$T_s = 682.174°C$$

End of Solution

Q.3 Consider the following statements regarding convective heat transfer coefficient:

1. It is influenced by viscosity.
2. It is influenced by flow velocity.
3. It is influenced by surface geometry.

Which of the above statements are correct?

(a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

Ans. (d)

The convective heat transfer coefficient (h) is influenced by several factors including.

(i) Viscosity : It affects the development of the boundary layer and flow characteristics, which in turn impact the heat transfer coefficient.

(ii) Flow velocity : Higher velocities usually increase turbulence, which increases heat transfer coefficient.

(iii) Surface geometry : The shape and orientation of the surface influence flow patterns and boundary layer formation, thus affecting the coefficient.

End of Solution

Q.4 If the specific gravity of a fluid is known, then the density of the fluid will be equal to the specific gravity of the fluid multiplied by the density of

(a) air
(b) water
(c) mercury
(d) oxygen

Ans. (b)

Specific gravity is defined as

$$\text{S.G.} = \frac{\text{Density of fluid}}{\text{Density of reference (Standard) fluid}}$$

Unless the fluid is specified a gas the default assumption is that it refers to a liquid. For liquids, the standard reference is water at 4°C (with density ≈ 1000 kg/m^3)

End of Solution

Q.5 Upon cooling, a liquid phase is transformed into the two solid phases α and β at the temperature T_E; the opposite reaction occurs upon heating. This is called

(a) eutectic reaction
(b) eutectoid reaction
(c) peritectic reaction
(d) cementite reaction

Ans. (a)

$L \rightleftharpoons \alpha + \beta$ is Eutectic reaction in partial eutectic system.

COMMON TYPES OF PHASE TRANSFORMATIONS IN BINARY ALLOY SYSTEMS

Type of transformation	Transformation characteristic Dirn. Of cooling--------→ ←----------Dirn. Of heating	Examples
Allotropy	Solid A → solid B	Fe, Sn, Co, Cr, Ti, U, Zr, Mn, Li, Sr
Eutectoid	Solid A → solid B + solid C	Fe-c, Cu-Sn, Cu-Al, Zn-Al
Eutectic	Liquid → solid α + solid β	Fe-C, Al-Si, Bi-Cd, Pb-As, Th-Ti, Cu-Ag, Pb-Sn
Peritectoid	solid A + solid B → Solid C	Ni-Zn, Cu-Sn, Ni-Mo, Fe-Nb
Peritectic	Liquid + solid A → solid B	Fe-C, Cu-Zn, Pt-Ag, Cu-Sn, Al-Ti, Al-Mn
Monotectic	Liquid A → Liquid **B** + solid	Al-Pb, Cu-Pb, Cu-Cr, Zn-Pb, Ag-Ni, Zn--Bi
Order-disorder	Disordered structure --------→ ←----------ordered structure	Cu-Zn, Au-Cu

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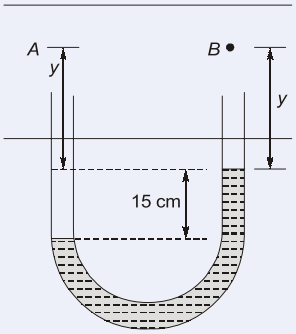
End of Solution

Q.6 A pipe contains an oil of specific gravity 0.9. A differential manometer connected at the two points A and B shows a difference in mercury level as 15 cm. What is the difference of pressures at the two points?

(a) 18789 N/m^2
(b) 18688 N/m^2
(c) 18888 N/m^2
(d) 18989 N/m^2

Ans. (b)

Let P_A be greater than P_B.



$$P_A + 900 \times 9.81 (y + 0.15) - 13600 \times 9.81 \times 0.15 - 900 \times 9.81 \times y = P_B$$

$$P_A - P_B = 18688 \text{ N/m}^2$$

End of Solution

Q.7 Which principle is the basis for differential pressure measuring devices?

(a) Torricelli's (b) Bernoulli's

(c) Euler's (d) Continuity

Ans. (b)

Differential pressure measuring devices, such as orifice meter, venturimeter, pitot tubes are bared on Bernoulli's principle.

End of Solution

Q.8 Consider the following statements regarding floating bodies:

1. During the movement, the volume immersed on both right-hand side and left-hand side increases.
2. The angular displacement of a boat or ship about its longitudinal axis is known as rolling.
3. The angular displacement of a boat or ship about its transverse axis is known as pitching.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only

(c) 1 and 3 only (d) 1, 2 and 3

Ans. (b)

- The angular displacement of a boat or ship about its longitudinal axis is known as rolling and about its transverse axis is known as pitching.
- During the movement, the volume immersed increases on one side and decreases on other.

End of Solution

Q.9 Match the following lists:

List-I	List-II
P. Steady uniform flow	1. Flow at varying rates through a long straight pipe of uniform cross-section
Q. Steady non-uniform flow	2. Flow at constant rate through a duct of uniform cross-section
R. Unsteady uniform flow	3. Flow at varying rates through a duct of non-uniform cross-section
S. Unsteady non-uniform flow	4. Flow at constant rate through a duct of non-uniform cross-section

Select the correct answer using the code given below.

(a)	P	Q	R	S	(b)	P	Q	R	S
	1	2	3	4		2	4	1	3
(c)	P	Q	R	S	(d)	P	Q	R	S
	4	1	2	3		3	4	2	1

Ans. (b)

End of Solution

Q.10 Consider the following statements regarding properties of stream function and potential function:

1. If velocity potential (ϕ) exists, the flow should be rotational.
2. If velocity potential (ϕ) satisfies the Laplace equation, it represents the possible steady incompressible irrotational flow.
3. If stream function (ψ) exists, it is a possible case of fluid flow which may be rotational or irrotational.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (b)

For velocity potential function (ϕ)

- ϕ only exists for irrotational flow.
- if ϕ satisfies the Laplace equation, that means the flow is possible.

For stream function (ψ)

- If ψ exists, the flow is possible.
- If ψ satisfies the Laplace equation, then the flow is irrotational.

End of Solution

Q.11 Match the following lists (where the notations have their usual meanings):

List-I	List-II
P. Orifice meter	1. $Q_{act} = C_d\left(\frac{a_1a_2}{\sqrt{a_1^2 - a_2^2}}\right)\sqrt{2gh}$
Q. Venturi meter	2. $V = C_v\sqrt{2gh}$
R. Pitot tube	3. $Q = \frac{C_d a_0 a_1\sqrt{2gh}}{\sqrt{a_1^2 - a_0^2}}$

Select the correct answer using the code given below.

(a) P Q R (b) P Q R
2 3 1 1 2 3
(c) P Q R (d) P Q R
3 1 2 3 2 1

Ans. (c)

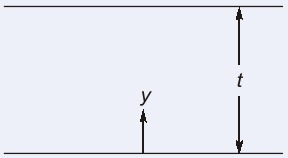
End of Solution

Q.12 What is the pressure gradient along the flow, if the oil viscosity is 0.02 N-s/m^2 flowing between two stationary parallel plates 1 m wide maintained 10 mm apart? (The velocity midway between the plates is 2 m/s)

(a) –3150 N/m^2 per m (b) –3180 N/m^2 per m
(c) –3200 N/m^2 per m (d) –3210 N/m^2 per m

Ans. (c)

Given: $\mu = 0.02$ Ns/m^2, $t = 10$ mm, $V_m = 2$ m/s



We know, $$u = \frac{1}{2\mu}\left(-\frac{\partial f}{\partial x}\right)\left(ty - y^2\right)$$

At mid point, $y = \frac{t}{2}$, $u = 2$

$$2 = \frac{1}{2\times 0.02}\left(-\frac{\partial p}{\partial x}\right)\left(\frac{t^2}{4}\right)$$

Pressure gradient, $\frac{\partial p}{\partial x} = -3200$ N/m^2 per m

End of Solution

Q.13 Which type of glass is used in flat-plate collectors?

(a) Low-iron tempered glass
(b) High-iron tempered glass
(c) Low-iron black glass
(d) High-iron black glass

Ans. (a)

Low Iron content allows better transmission of sunlight, through the panels, which results in higher efficiency for solar cells. Tempared glass is heat treated to make it impact-resistant. If shattered, it breaks, into small pieces, thereby reducing injury and damage to solar cells.

End of Solution

Q.14 Consider the following statements regarding transitional flow:

1. Tollmien and Schlichting predicted that the waves would form and grow in the boundary layer.
2. It has been seen that in the presence of an adverse pressure gradient, at a high Reynolds number, two-dimensional waves appear.
3. The instantaneous velocity profiles produce low shear in the outer region of the boundary layer.

Which of the above statements are correct?

(a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

Ans. (d)

- Tollmien -Schilichting waves are small disturbances in a laminar boundary layer. These waves can grow due to instability, especially in adverse pressure gradients, and lead to transition to turbulence.
- An adverse pressure gradient destabilizes the boundary layer. At high Reynolds numbers, it can lead to the formation of 2D instabilities (T-s waves), aiding transition.
- During transition, the outer region of the boundary layer often retains characteristics of laminar flow longer than the near-wall region. This means the shear (velocity gradient) is relatively low in the outer part, compared to the high shear near the wall in developing turbulence.

End of Solution

Q.15 What type of turbulence is generated by two adjacent layers of fluid in the absence of wall?

(a) Wall turbulence
(b) Free turbulence
(c) Fixed turbulence
(d) Isotropic turbulence

Ans. **(b)**

Free turbulance is generated by two adjacent layers of fluid in the absence of wall.

End of Solution

Q.16 Consider the following statements regarding properties of refrigerants:

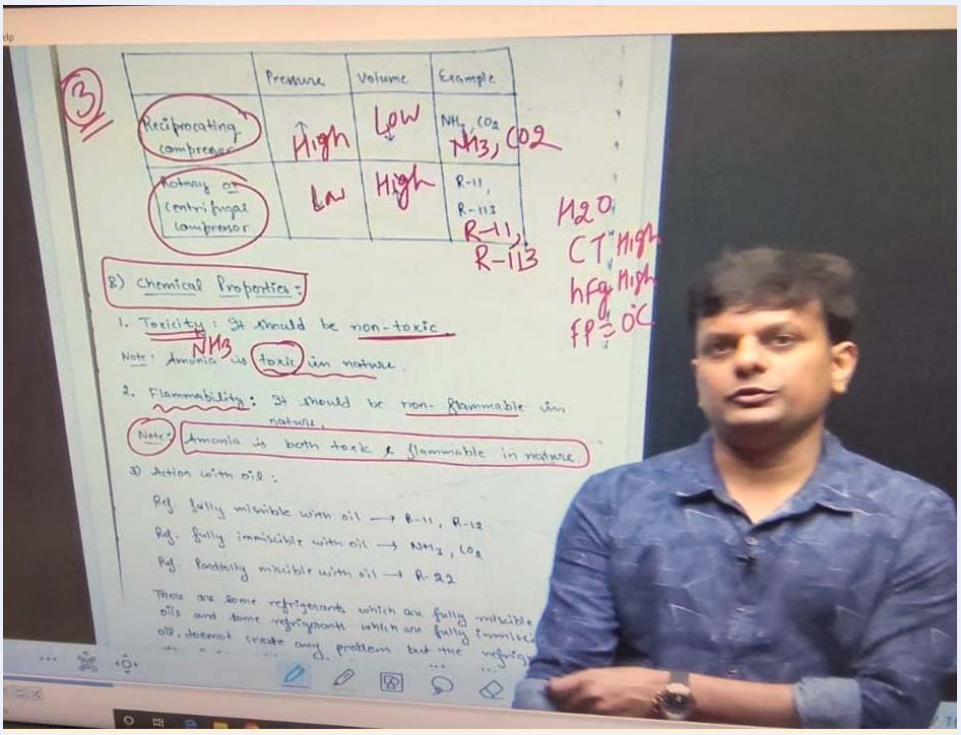
1. Ammonia is highly toxic and highly irritating refrigerant.
2. Carbon refrigerant. dioxide is corrosive
3. Sulphur dioxide is highly toxic refrigerant.

Which of the above statements are correct?

(a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

Ans. **(c)**

- Ammonia and sulphur dioxide both are highly toxic refrigerants.
- Carbon dioxide is a non-corrosive and non toxic refrigerant.



End of Solution

Q.17 Consider the following statements regarding vapour absorption cycle:

1. Absorbent should have negligible vapour pressure at generator temperature compared to refrigerant.
2. Absorbent should have low specific heat.
3. Lithium bromide is a hygroscopic salt with low affinity for water.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (a)

Lithium bromide (LiBr) is a hygroscopic salt, but it has a high affinity for water, this high affinity makes it ideal as an absorbent in LiBr-water absorption systems.

End of Solution

Q.18 Consider the following statements regarding properties of moist air:

1. Percentage saturation is defined as the ratio of specific humidities, saturated versus actual at a given temperature.
2. Specific humidity is defined as the mass of water vapour in kilograms which is associated with one kilogram of dry air-water vapour mixture.
3. Relative humidity is the ratio of actual water vapour pressure in the air to the vapour pressure which would exist in a saturated mixture at the temperature of the air.

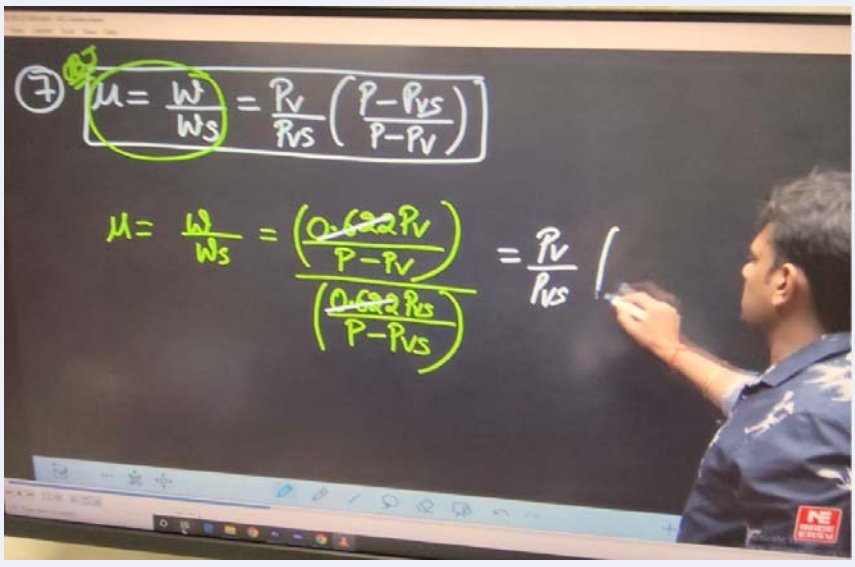
Which of the above statements are correct?

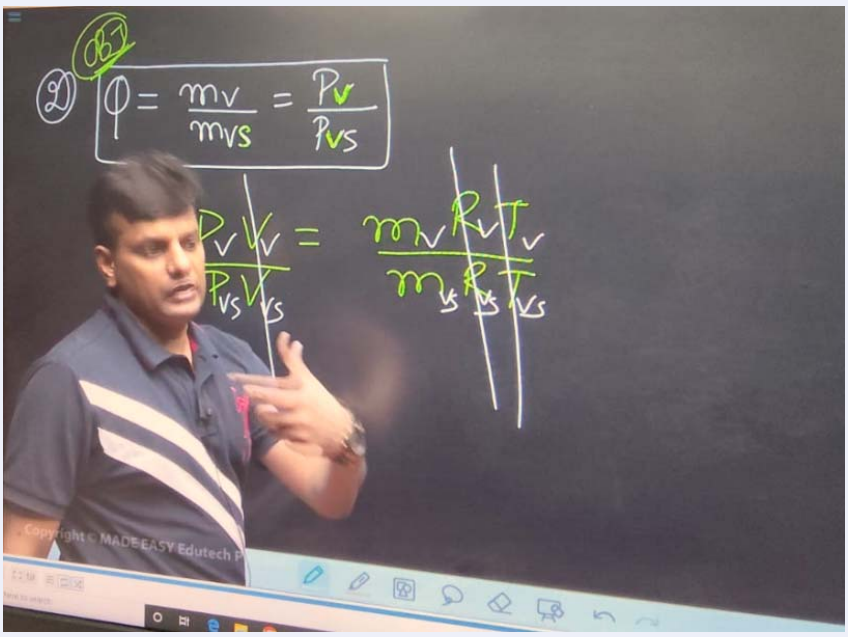
(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

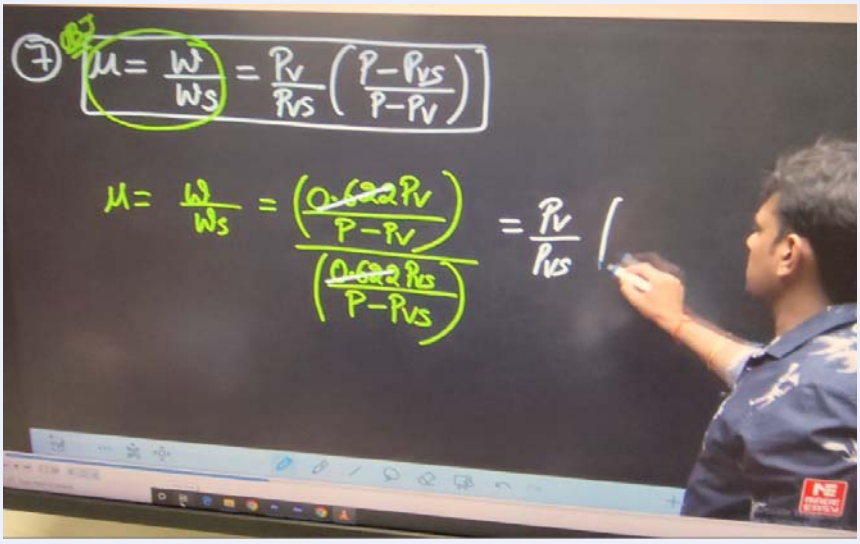
Ans. (b)

Percentage saturation is defined as the ratio actual specific humidity to specific humidity at saturation.

$$\mu = \frac{W}{W_s}$$







End of Solution

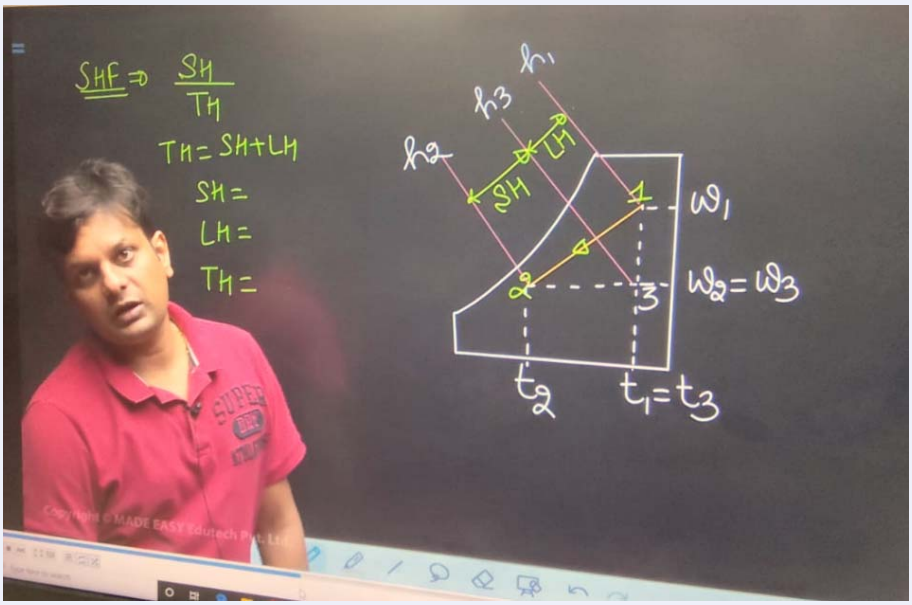
Q.19 The sensible heat gain of a room is 4.8 kW and its latent heat gain is 1.4 kW. What is the sensible heat ratio?

(a) 0.98
(b) 0.77
(c) 0.59
(d) 0.65

Ans. **(b)**

Given : S.H = 4.8 kW; L.H = 1.4 kW

$$\text{Sensible heat factor} = \frac{SH}{SH+LH} = \frac{4.8}{4.8+1.4} = 0.774$$



End of Solution

Q.20 Consider the following statements regarding psychrometry:

1. Dry-bulb temperature is the temperature of the air measured with an ordinary thermometer.
2. Dew-point temperature is the temperature at which water vapour in the air is saturated.
3. Sensible heat is necessary to produce a change of state of a material at a constant temperature.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (a)

- Sensible heat changes the temperatures of a substance.
- Latent heat is required to change the phase (e.g. liquid to vapour) at constant temperature.

End of Solution

Q.21 Consider the following statements regarding thermodynamic systems:

1. Close system is that system which exchanges neither energy nor matter with any other system or with environment.
2. A system which consists of two phases is called a heterogeneous system.
3. A phase is a quantity of matter which is homogeneous throughout in chemical composition and physical structure.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (b)

Close system is that system which can exchange energy but not matter with its surroundings.

End of Solution

Q.22 Consider the following statements regarding pure substance:

1. It is homogeneous in composition.
2. It is homogeneous in chemical aggregation.
3. It is variable is chemical aggregation.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (a)

Pure substance is homogeneous in composition and in chemical aggregation.

End of Solution

Q.23 Consider the following statements regarding phase change of a pure substance:

1. The difference between super-heated temperature and saturation temperature at the given pressure is called the degree of superheat.
2. The amount of heat required to convert liquid water completely into vapour is called the heat of sublimation.
3. If the temperature of liquid water on cooling becomes lower than the saturation temperature for the given pressure, the liquid water is called a subcooled liquid.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (c)

The amount of heat required to convert liquid water completely into vapour is called latent heat of vaporization.

End of Solution

Q.24 Consider the following statements regarding thermometer and thermo-metric property:

1. Constant volume gas thermometer is used to measure resistance.
2. Thermocouple is used to measure electromotive force.
3. Pyrometer is used to measure intensity of radiation.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (b)

The thermometric property that is measured by constant volume gas thermometer is pressure.

End of Solution

Q.25 Consider the following statements regarding first law of thermodynamics:
1. The first law applies to reversible as well as irreversible transformations.
2. It is impossible to construct a perpetual motion machine of first kind.
3. It is observed that when a system is made to undergo a complete cycle, then net work is done on or by the system.

Which of the above statements are correct?
(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (d)

End of Solution

Q.26 Consider the following statements regarding reversible processes:
1. Frictionless adiabatic expansion is an ideal reversible process.
2. Condensation and boiling of liquids are ideal reversible processes.
3. Mixing of two fluids is an ideal reversible process.

Which of the above statements are correct?
(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (a)
Mixing of two fluids is an irreversible process.

End of Solution

Q.27 Consider the following statements regarding perpetual motion machine (PMM):
1. Machine which would continuously absorb heat from a single thermal reservoir and would convert this heat completely into work is called the PMM of the second kind.
2. Machine which violates the first law of thermodynamics is called the PMM of the first kind.
3. The PMM of the second kind does not violate the second law of thermodynamics.

Which of the above statements are correct?
(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (a)
- The PMM of first kind voilates the first law of thermodynamics.
- the PMM of second kind voilates the second law of thermodynamics.

End of Solution

Q.28 Consider the following statements regarding Carnot cycle:
1. It cannot be performed in practice because it is impossible to perform a frictionless process.
2. Compression and expansion are non-reversible.
3. Working medium is a perfect gas and has constant specific heat.

Which of the above statements are correct?
(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (c)

In Carnot cycle both compression and expansion are isentropic.

End of Solution

Q.29 A cyclic heat engine operates between a source temperature of 1000°C and a sink temperature of 40 °C. Find the least rate of heat rejection per kW net output of the engine.

(a) 0.758 kW
(b) 0.543 kW
(c) 0.326 kW
(d) 0.917 kW

Ans. (c)

Given: $T_H = 1000°C$, $T_L = 40°C$, $W = 1$ kW

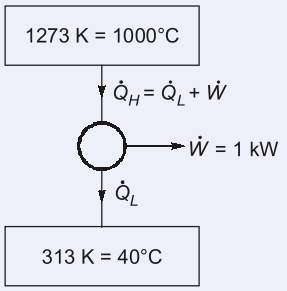
$$\eta_{max} = \frac{\dot{W}}{\dot{Q}_H = \dot{Q}_L + \dot{W}}$$

$$1 - \frac{313}{1273} = \frac{1}{\dot{Q}_L + 1}$$

$$0.7541(\dot{Q}_L + 1) = 1$$

$$\dot{Q}_L + 1 = 1.3261$$

$$\dot{Q}_L = 0.3261 \text{ kW}$$



End of Solution

Q.30 The efficiency of an Otto cycle is 60% and the ratio of specific heats is 1.5. What is the compression ratio?

(a) 6.25
(b) 4.26
(c) 9.85
(d) 8.15

Ans. (a)

Given: $\gamma = 1.5$, $\eta_o = 60\%$.

$$\eta_o = 1 - \frac{1}{r^{\gamma - 1}}$$

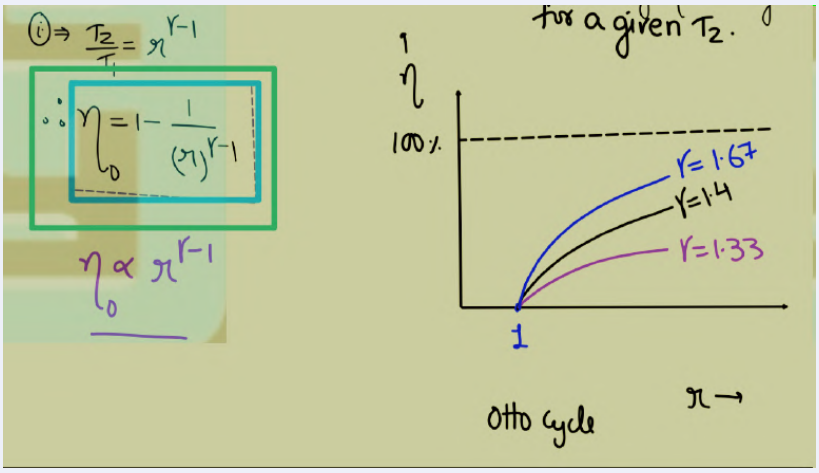
$$0.6 = 1 - \frac{1}{(r)^{1.5-1}}$$

$$\frac{1}{(r)^{0.5}} = 0.4$$

$$r^{0.4} = \frac{1}{0.4} = 0.5$$

$$r = (0.5)^{1/0.5}$$

$$r = (2.5)^2 = 6.25$$



End of Solution

Q.31 Consider the following statements regarding reheating in Rankine cycle:

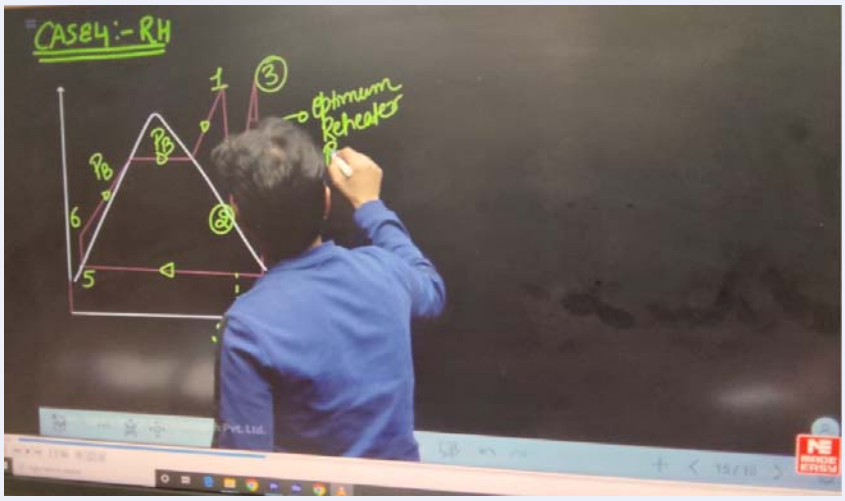
1. The reheater may be heated by a coil carrying high-pressure superheated steam.
2. Reheating should be done at optimum pressure.
3. A large proportion of the heat supplied in the reheating process will be thrown to waste in the condenser.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (a)

- In a Rankine cycle with reheat, the reheater is typically heated by high-pressure steam or directly by the combustion gases in a boiler.
- Reheating should be done at optimum pressure because if reheat is too high or low, it might not yield maximum efficiency.



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Q.32 In case of a steam turbine working on Rankine cycle, the work done per kg of steam flowing through the turbine and the amount of total heat supplied during the processes are 1080 kJ/kg and 3076.1 kJ/kg respectively. What is the thermal efficiency of the cycle?

(a) 23.7% (b) 29.3%

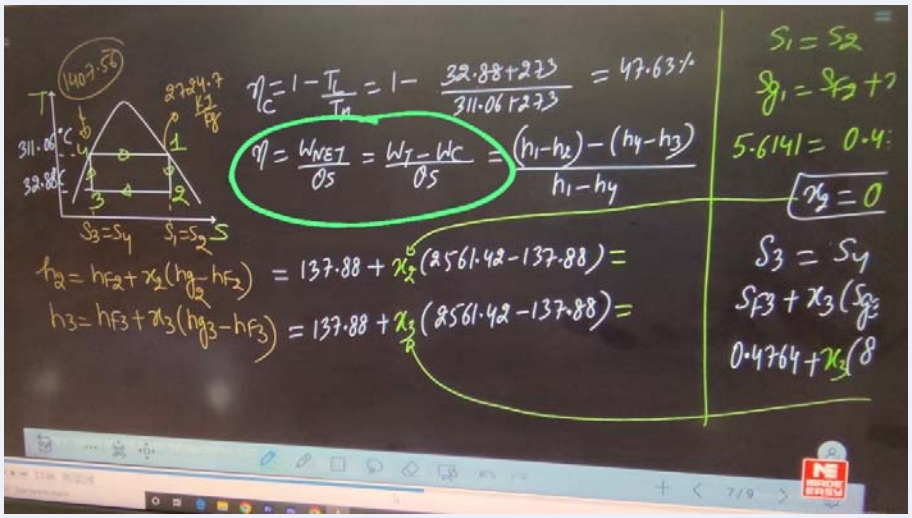
(c) 35.1% (d) 41.4%

Ans. (c)

Given : w_{net} = 1080 kJ/kg; Q_s = 3076.1 kJ/kg

$$\text{Efficiency, } \eta = \frac{\text{Workdone}}{\text{Heat supplied}} = \frac{W_{net}}{Q_s} = \frac{1080}{3076.1} \times 100$$

$$\eta = 35.1\%$$



End of Solution

Q.33 Consider the following statements regarding advantages of regenerative cycle over simple Rankine cycle:

1. The heating process in the boiler tends to become reversible.
2. Heat rate is increased.
3. A small size condenser is required.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only

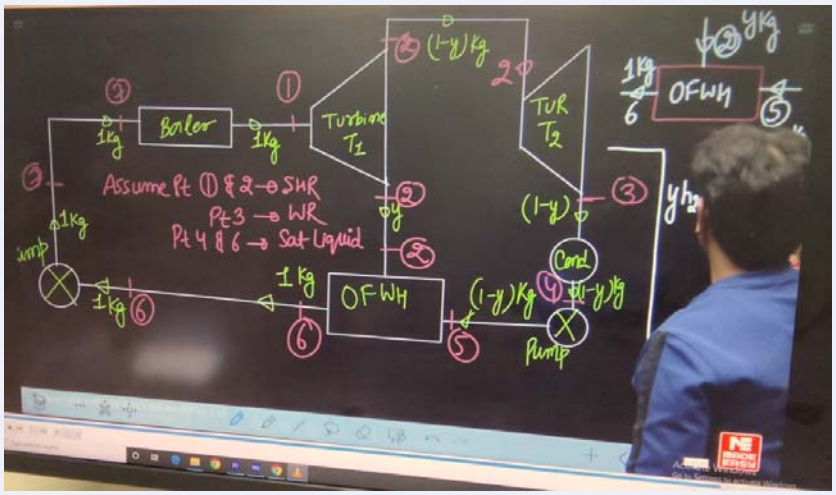
(c) 2 and 3 only (d) 1, 2 and 3

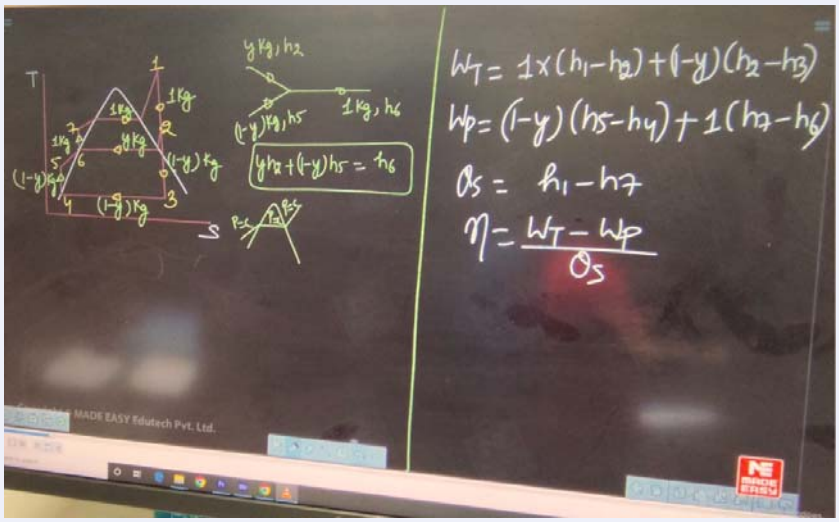
Ans. (b)

In case of regeneration the efficiency of the cycle increases

and $\text{efficiency} = \frac{1}{\text{Heat rate}}$

If efficiency increases than heat rate will decrease.





End of Solution

Q.34 A grade written as "5-10 cm, 500-A8-F24-S1.6" indicates the coal as having

1. a size of 5-10 cm
2. heating value of 5000 kcal/kg
3. 8 to 10% ash

Which of the above are correct?

(a) 1 and 2 only
(b) 1 and 3 only
(c) 2 and 3 only
(d) 1, 2 and 3

Ans. (d)

5 - 10 cm : Refers to the size of coal pieces
500 : Typically refer to heating value, so
(500 × 10 = 5000 kcal/kg)
A8 : This refers to ash content = 8%

End of Solution

Q.35 A boiler generates 360 kg of steam per hour. The quantity of heat supplied per kg of steam is 2560.6 kJ/kg. The calorific value of coal is 29245.4 kJ/kg. If the hourly rate of burning is 60 kg. what is the boiler efficiency?

(a) 21.41% (b) 34.87%
(c) 52.53% (d) 65.86%

Ans. (c)

Given : Qs = 2560.6; CV = 29245.4; m_s = 360 kg/hour; m_f = 60 kg/hour

$$\eta_b = \frac{Q_s m_s}{m_f \times CV} \times 100 = \frac{2560.6 \times 360}{60 \times 29245.4} \times 100$$

$$= 52.53\%$$

End of Solution

Q.36 Consider the following statements regarding locomotive boiler:

1. It consists of a cylindrical barrel with a rectangular firebox at one end and a smoke box at the other end.
2. The hot gases which are generated due to burning of coal are deflected by an arch of firebricks.
3. The fire tubes are placed inside the smoke box.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (a)

- Fire tubes run through the cylindrical barrel of the boiler between the firebox and the smoke box, not inside the smoke box.
- The smoke box only collects the hot gases after they have passed through the tubes.

End of Solution

Q.37 Consider the following statements regarding Babcock and Wilcox boiler:

1. It is a fire tube boiler.
2. It may be designed for stationary or marine purposes.
3. It consists of a drum connected to a series of front-end and rear-end headers by short riser tubes.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (c)

- The Babcock and Wilcox boiler is a water tube boiler, not a fire-tube boiler.
- In this type water flows inside the tubes and hot gases flow outside.

End of Solution

Q.38 The ratio of heat received by 1 kg of water under working conditions to received by 1 kg of water evaporated from and at 100 °C is known as

(a) factor of evaporation
(b) boiler efficiency
(c) overall efficiency
(d) evaporation efficiency

Ans. (a)

The ratio of heat received by 1 kg of water under working conditions to that received by 1 kg of water evaporated from and at 100°C is known as factor of evaporation.

End of Solution

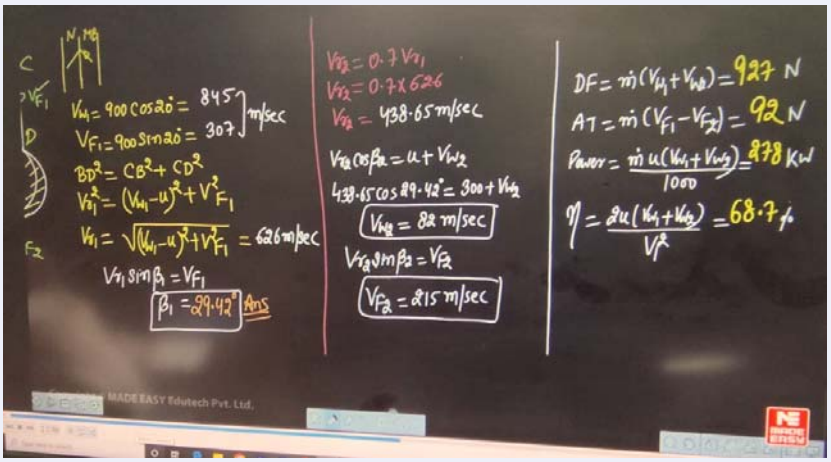
Q.39 In a reaction turbine, the fixed blades and moving blades are of the same shape but reversed in direction. The work done per pair of blades per kg of steam is 7600 N-m. If the heat drop per pair is 10-04 kJ/kg, what is the efficiency of the pair?

(a) 57.1%
(b) 68.4%
(c) 75.7%
(d) 81.3%

Ans. (c)

Given : W = 7600 Nm/kg = 7.6 kJ/kg; Q = 10.04 kJ/kg

$$\eta = \frac{W}{Q} = \frac{7.6}{10.4} = 75.69\%$$



End of Solution

Q.40 Consider the following statements regarding air leakage in condenser:

1. The leakage air in the condenser results in decrease in back pressure on the prime mover.
2. The leaked air in the condenser lowers the partial pressure of steam.
3. The air has poor thermal conductivity; hence the leaked air reduces the rate of heat transfer from vapour.

Which of the above statements are correct?

(a) 1 and 2 only
(b) 1 and 3 only
(c) 2 and 3 only
(d) 1, 2 and 3

Ans. (b)

The leaked air in the condenser increases the partial pressure of steam.

End of Solution

Q.41 Consider the following statements regarding centrifugal pumps:

1. The speed ratio varies from 0.95 to 1.25.
2. The flow ratio varies from 0-1 to 0.25.
3. For low-to-medium specific speed pumps, the number of vanes varies from 15 to 25.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (a)

For low to medium specific speed pumps, the number of vanes varies 9 to 12.

End of Solution

Q.42 A centrifugal pump has an impeller of 30 cm outer diameter. The vane tips are radial at the outlet. For a rotative speed of 1450 r.p.m., what is the manometric head developed? (Assume a manometric efficiency of 82%)

(a) 17.82 m (b) 23.34 m
(c) 29.82 m (d) 43.38 m

Ans. (d)

Given: $d_2 = 0.3$ m, $\phi = 90°$, $N = 1450$ rpm, $\eta_{mano} = 82\%$.

$$\eta_{mano} = \frac{W.P.}{I.P.} = \frac{gH_m}{V_{w2}u_2}$$

For radial vane, $V_{w2} = u_2$

$$\eta_{mano} = \frac{gH_m}{u_2^2}$$

$$u_2 = \frac{\pi d_2 N}{60} = \frac{\pi \times 0.3 \times 1450}{60}$$

$$u_2 = 22.77 \text{ m/s}$$

$$\therefore \quad \eta_{mano} = \frac{9.81 \times H_m}{22.77^2} = 0.82$$

$$H_m = 43.33 \text{ m}$$

End of Solution

Q.43 A discharge of 0.4 m^3/s of water is needed to be pumped to a total head of 240 m. How many pumps connected in series and each having a specific speed of 35 and running at a speed of 1500 r.p.m. would be needed for the job? (The dynamic head in the system can be neglected)

(a) 1 pump (b) 5 pumps
(c) 3 pumps (d) 4 pumps

Ans. (c)

Given: $Q = 0.4$ m^3/sec, $H_m = 240$ m, $N_s = 35$, $N = 1500$ rpm.

For series, Q = Constant = 0.4 m^3/sec.

$$\text{Total } H_m = 240 \text{ m} = n \times (H_m)_{\text{Each pump}}$$

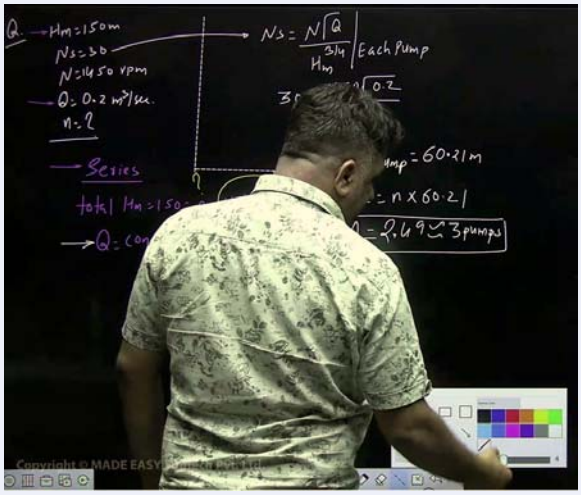
$$(N_s)_{\text{each pumps}} = \left(\frac{N\sqrt{Q}}{H_m^{3/4}}\right)_{\text{each pump}}$$

$$35 = \frac{1500\sqrt{0.4}}{H_m^{3/4}} \Rightarrow (H_m)_{\text{each pump}}$$

$$(H_m)_{\text{each pumps}} = 81.42 \text{ m}$$

$$\text{Total } H_m = 240 = n \times 81.42$$

$$n = 2.94 \approx 3 \text{ pumps in series}$$



End of Solution

Q.44 Consider the following statements regarding reciprocating pumps:

1. The ratio of theoretical discharge to actual discharge is known as coefficient of discharge.
2. The difference between theoretical discharge and actual discharge is called the slip of the pump.
3. In a double-acting pump, both sides of the piston will be displacing the liquid.

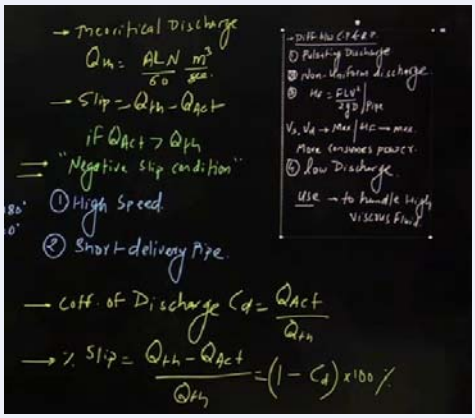
Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

Ans. (c)

The ratio of actual discharge to theoretical discharge in known as coefficient of discharge.



End of Solution

Q.45 Consider the following statements regarding advantages of air vessels in suction pipe:

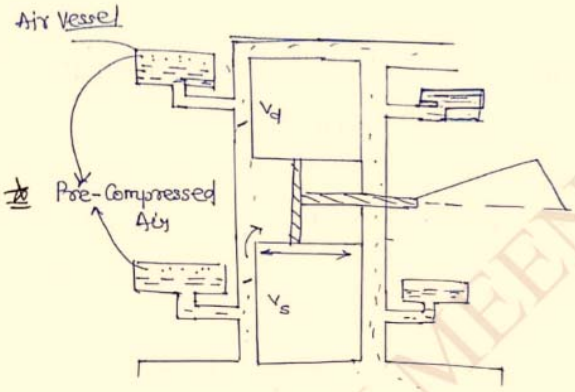
1. Power expended in pumping will reduce.
2. Frictional losses will reduce.
3. For a given speed, there will be increase in the cavitation susceptibility.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (a)

→ Air Vessel



it is the reservior of water placed Near to pump in suction and delivery pipe.

Advantages:

~~In suction and delivery pipe~~

① To maintain constant & continuous discharge.
② To reduce the power input to pump.
③ it also helps to increase discharge.

* Single cylinder Double acting reciprocating pump.

$Q_{th} = \frac{2LN}{60}$ $m^3/sec.$

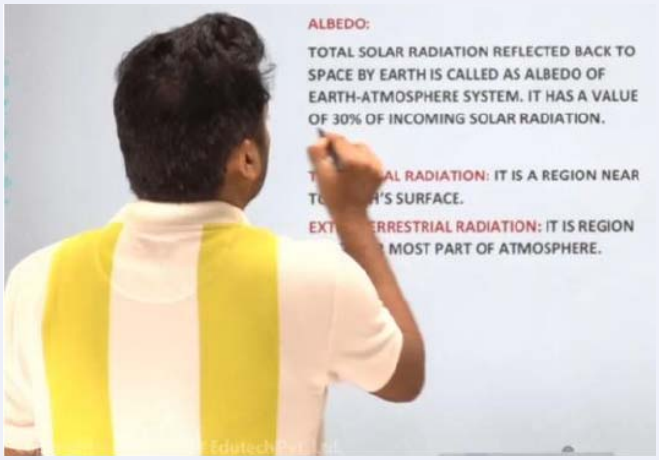
End of Solution

Q.46 The percentage of incoming radiation energy reflected back to space by the earth is about

(a) 10% (b) 20%
(c) 30% (d) 40%

Ans. (c)

The incoming radiation energy reflected back to space by earth is called the albedo of the earth-atmosphere system and has a value of about 30% of the incoming solar radiation for the earth as a whole.



End of Solution

Q.47 Consider the following statements regarding flat-plate collector:

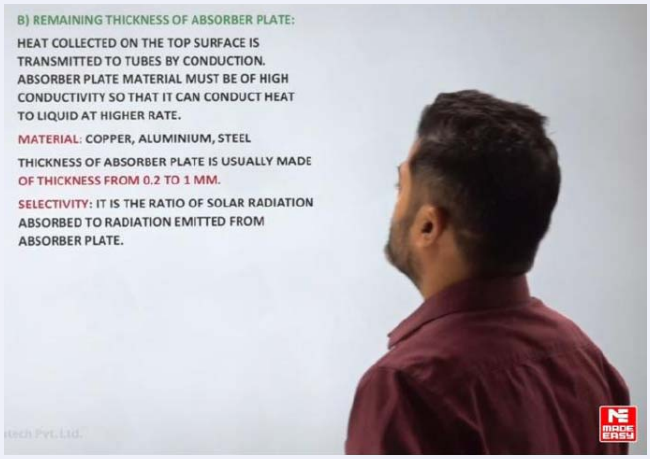
1. One of the desirable characteristics of thermal insulating material is low thermal conductivity.
2. Copper is often chosen for absorber plates due to its high thermal conductivity and good corrosion resistance.
3. Absorber plate material should have low thermal conductivity.

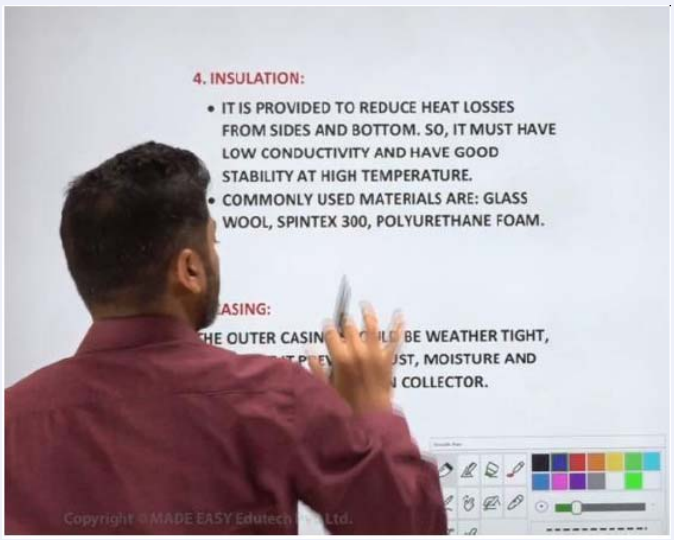
Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (a)

Absorber plate material should have high thermal conductivity because whatever heat is collected on the absorber plate that has to be conducted to the tubes.





End of Solution

Q.48 Consider the following statements regarding performance indices of a solar collector:

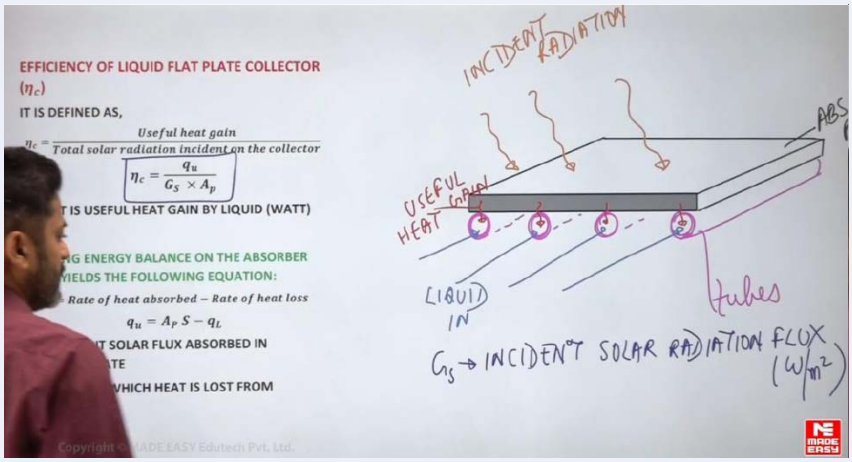
1. Temperature range is the range of temperature to which the heat transporting fluid is heated up by the collector.
2. Collector efficiency is defined as the ratio of the energy actually absorbed and transferred to heat transporting fluid by the collector to the energy incident on the collector.
3. Concentration ratio is defined as the ratio of the area of the receiver to the area of aperture of the system.

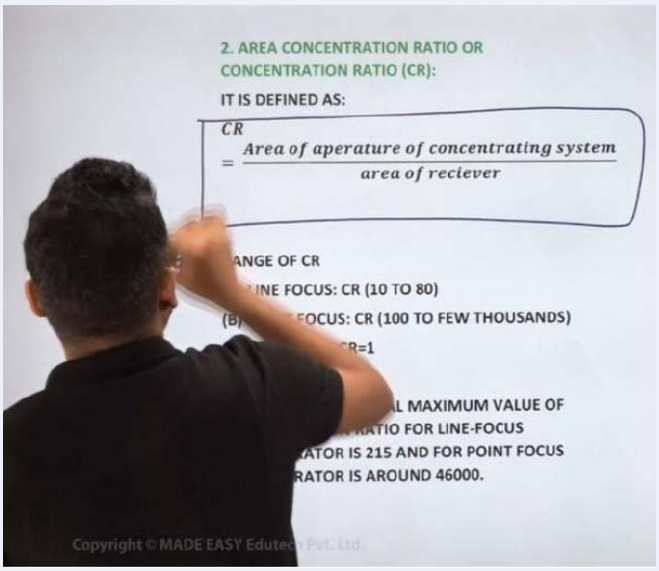
Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (a)

Concentration ratio (CR) is defined as the ratio of the area of the aperture of the system to the area of the receiver. The aperture of the system is the projected area of the collector facing (normal) the beam.





End of Solution

Q.49 Consider the following statements regarding solar thermal systems:

1. In cold climate regions, large amount of low-grade thermal energy is required for heating air for comfort.
2. Solar energy is best suited for low-grade thermal applications.
3. Solar thermal energy is not utilized in drying industries.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (a)

We know that the solar energy can be utilized directly by two technologies namely solar thermal and solar photovoltaic. Solar thermal system provide thermal energy for various processes. In region of cold climates a large amount of low grade thermal energy is required to heat air for comfort and hot water for washing, cleaning and other domestic and industrial needs. Various industrial surveys show that upto 24% of all industrial heat is consumed for heating fluids to a moderate temperature. Thus, solar energy is best suited for low grade thermal applications. Even in high temperature heating applications, a significant amount of fuel can be saved by suing solar energy for preheating (upto about 180°C). Solar thermal energy is utilized in drying industries.

End of Solution

Q.50 Consider the following statements regarding chemical energy storage:

1. The chemical energy in hydrogen can be converted into thermal energy.
2. Hydrogen-fired steam turbine may also be used to obtain mechanical energy.
3. Electrical energy may also be obtained more efficiently directly from hydrogen by means of fuel cell.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (d)

The chemical energy in hydrogen can be converted into the thermal, mechanical or electrical energy, one possibility is to burn hydrogen in air, in a manner similar to natural gas, to produce thermal energy for use in home or industry. Hydrogen can also serve as fuel in place of gasoline in automobiles, to obtain mechanical energy.

Hydrogen fired steam turbines may also be used to obtain mechanical energy. Electrical energy can then be generated from mechanical energy thus obtained by using a generator. Electrical energy may also be obtained more efficiently (at about 55 to 60% conversion efficiency) directly from hydrogen by means of a fuel cell.

End of Solution

Q.51 Consider the following statements regarding solar space heating system:

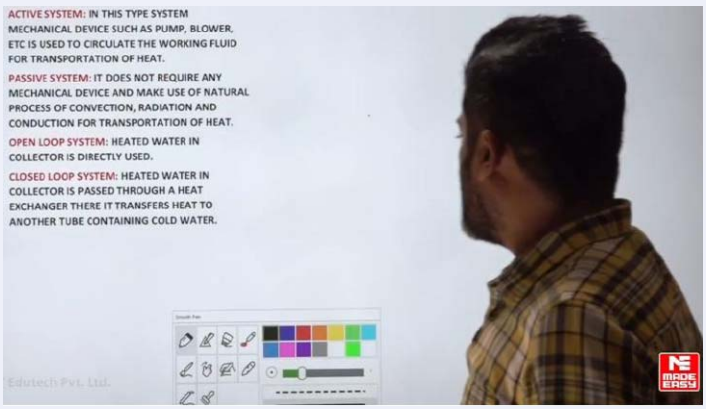
1. Passive systems do not require any mechanical device and make use of natural process of convection, radiation and conduction for transport of heat.
2. Uses of active heating systems put restrictions on the building design to make possible the flow of heat naturally.
3. Active heating systems employ mechanical devices to circulate the working fluid for transportation of heat.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (c)

Use of passive heating/cooling system put restrictions on the building design to make possible the flow of heat naturally. Such a specially designed building is called a solar house.



End of Solution

Q.52 Consider the following statements regarding solar refrigeration and air-conditioning systems:

1. In absorption cycle cooling systems, two working fluids-a refrigerant and an absorbent-refrigerant solution are used.
2. The absorbent-refrigerant combination is so chosen that the absorbent has low affinity for the refrigerant.
3. The absorbent cooling is based on the principle that the refrigerant can be bound by a liquid or solid solvent, known as absorbent, to release heat during absorption.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only

(c) 1 and 3 only (d) 1, 2 and 3

Ans. (c)

The absorbent-refrigerant combination is so chosen that the absorbent has high affinity for the refrigerant.

End of Solution

Q.53 Consider the following statements regarding solar greenhouse

1. The design of a greenhouse depends on local climatic conditions.
2. Greenhouses for arid zone are designed to conserve water resources.
3. In tropical countries, the solar insolation and ambient temperatures are quite high and therefore, winter greenhouses' are used to maintain low temperatures inside and allow just sufficient sunlight for photosynthesis.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only

(c) 1 and only (d) 1, 2 and 3

Ans. (a)

In tropical countries, the solar insolation and ambient temperatures are quite high and therefore summer Greenhouses are used to maintain low temperature inside and allow just sufficient sunlight for photosynthesis.

End of Solution

Q.54 Consider the following statements regarding solar distillation:

1. Distillation is the process to convert fresh water saline water into
2. About 20 percent of water available on the earth is brackish.
3. Only 30 percent of water available on the earth is fresh.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only

(c) 1 and 3 only (d) 1, 2 and 3

Ans. (a)

Fresh water available on the earth is about 1%.

End of Solution

Q.55 Consider the following statements regarding wind energy

1. A generator coupled to wind turbine is known as aerogenerator.
2. Australians were probably the first to introduce the horizontal axis windmill around 12th century.
3. The electric power generation through wind was first proposed in Denmark in 1890.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

Ans. (b)

Europeans imported the technology from the east and were probably the first to introduce the horizontal axis windmill around the 12th century, and by 1750.

End of Solution

Q.56 Consider the following statements regarding ocean tidal energy conversion schemes:

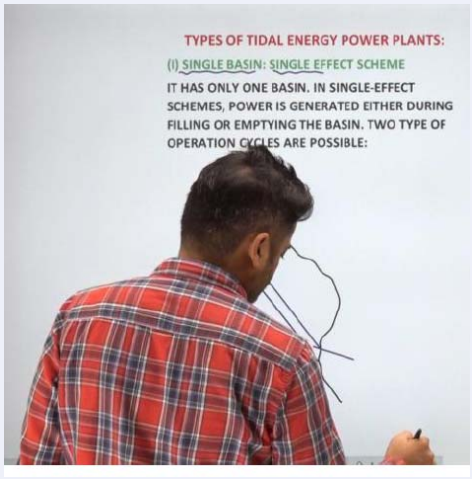
1. In single-basin, double-effect scheme, power is generated on both flood and ebb.
2. Linked basin scheme consists of two basins, one topped up at high tide and the other emptied at low tide.
3. In single-effect scheme, power is not generated during either filling or emptying the basin.

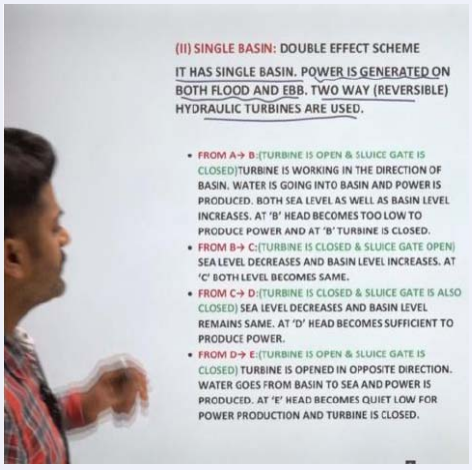
Which of the above statements are correct?

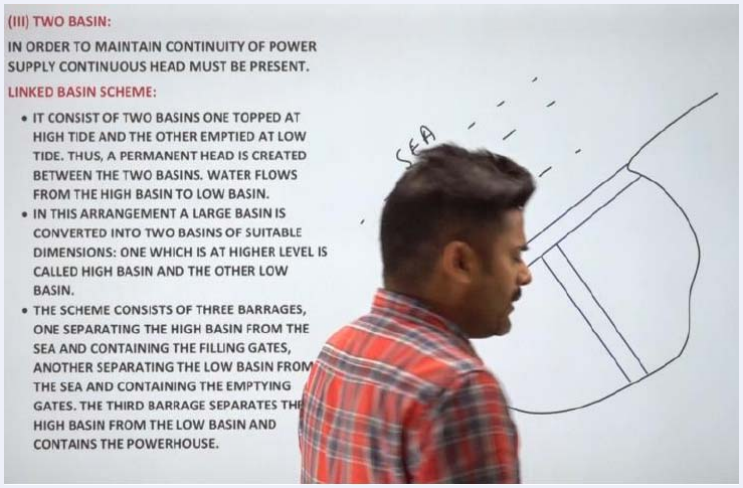
(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (a)

In single effect scheme, power is generated during either filling or emptying the basin.







End of Solution

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Q.57 Consider the following statements regarding biomass energy:

1. Pelletization is a process in which waste wood is pulverized, dried and forced under pressure through an extrusion device.
2. Biomass briquettes are made from woody matter.
3. Concentrated vegetable oils may be obtained from certain agro-products but cannot be used as fuel in diesel engines.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (a)

Concentrated vegetable oils may be obtained from certain agro products and may be used as fuel in diesel engines. However, difficulties arise with direct use of plant oil due to high viscosity and combustion deposits.

End of Solution

Q.58 Consider the following statements regarding fuel cell:

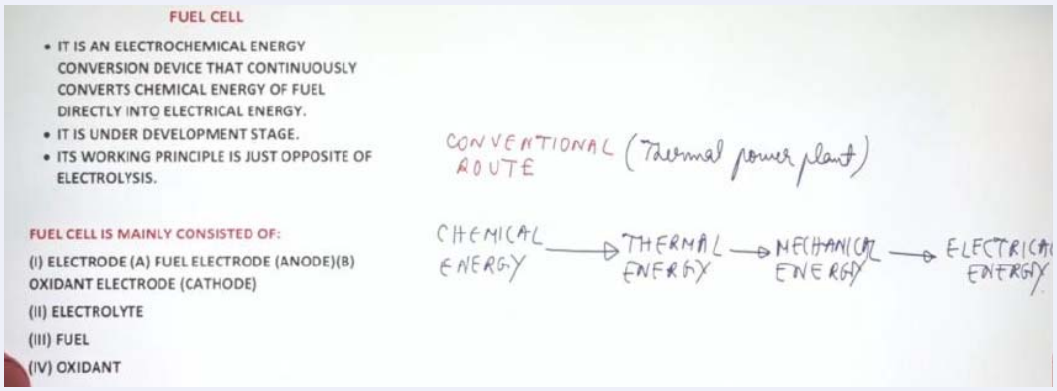
1. A fuel cell continuously converts mechanical energy directly into electrical energy.
2. Fuel cell is a conversion device. static power
3. The only exhaust of a fuel cell, if pure hydrogen is used as fuel and pure oxygen as oxidant, is water vapour.

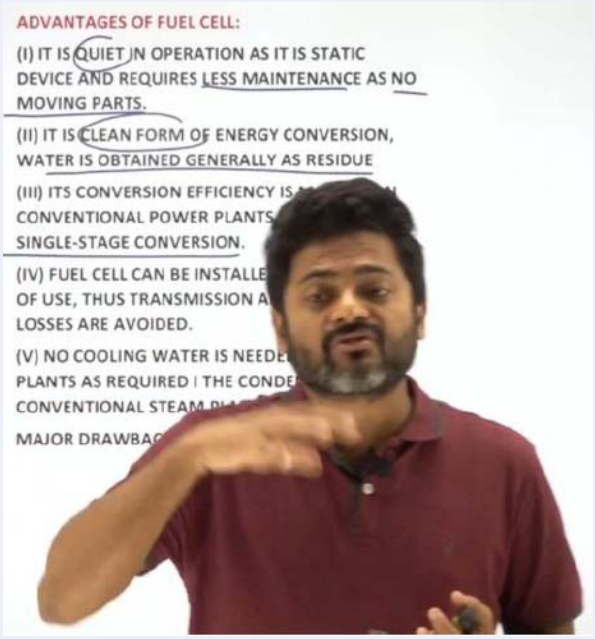
Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (c)

A fuel cell is an electrochemical energy conversion device that continuously converts chemical energy of a fuel directly into electrical energy.





End of Solution

Q.59 Consider the following statements regarding reheating in Rankine cycle:

1. Erosion and corrosion problems in the steam turbine are eliminated.
2. Final dryness fraction of steam is improved.
3. There is decrease in the nozzle and blade efficiencies.

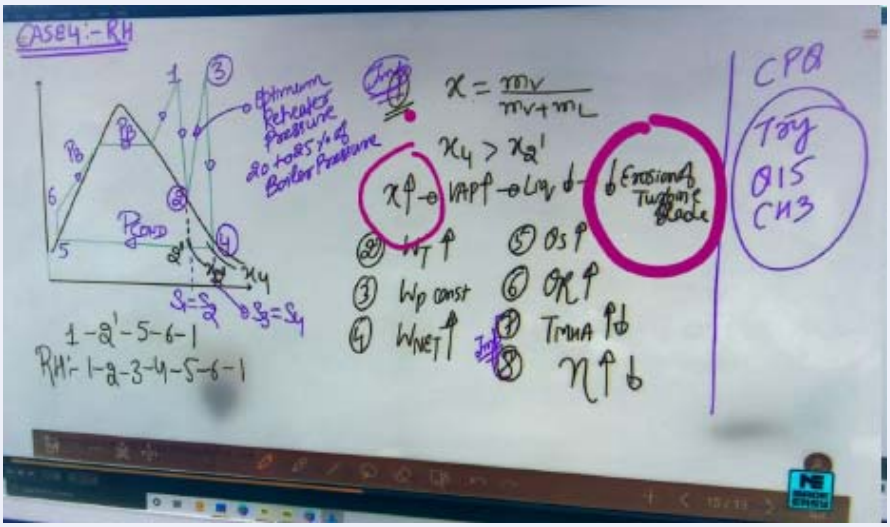
Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

Ans. (a)

- Reheating improves the dryness fraction of the steam eliminating erosion and corrosion problems in the steam turbine.
- Reheating generally improves the efficiency of the turbine.



End of Solution

Q.60 What is the primary purpose of superheating steam and supplying it to the prime movers?

(a) To decrease the power plant efficiency

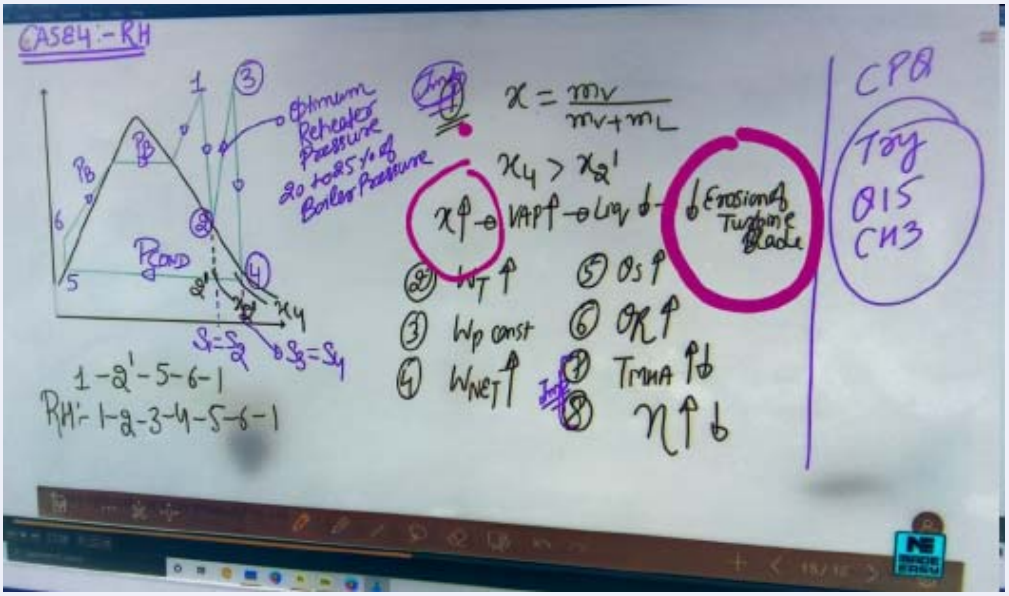
(b) To avoid too much wetness at the end of expansion.

(c) To increase the initial condensation losses in steam engines

(d) To make the steam visible

Ans. (b)

The main purpose of superheating before it enters the turbine or prime mover is to prevent the steam from becoming too wet during expansion.



End of Solution

Q.61 Which one of the following statements correctly distinguishes gas turbine plants from steam turbine plants?

(a) Gas turbine plants operate at lower inlet gas temperatures and higher pressures.

(b) Gas turbine plants and steam turbine plants operate at the same inlet gas temperatures and pressures.

(c) Gas turbine plants operate at higher inlet gas temperatures and lower pressures.

(d) Gas turbine plants operate at higher inlet gas temperatures and higher pressures.

Ans. (c)

Gas turbine power plants operate at higher inlet gas temperature and lower pressures.

End of Solution

Q.62 Consider the following statements regarding effects of increasing the initial steam pressure in a steam turbine plant:

1. Increase in the initial steam pressure gives a higher saturation temperature of steam below the critical value.
2. The gains in thermal efficiency obtained by a large increase in the initial steam pressure in the higher ranges are of the order of 5% or more.
3. The wet steam in the larger part of the turbine would give lower turbine stage efficiencies.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

Ans. (d)

End of Solution

Q.63 If a Kaplan turbine produces 6.5 MW of power at a head of 15 m under a speed of 150 r.p.m., what is the specific speed?

(a) 450 (b) 510

(c) 410 (d) 360

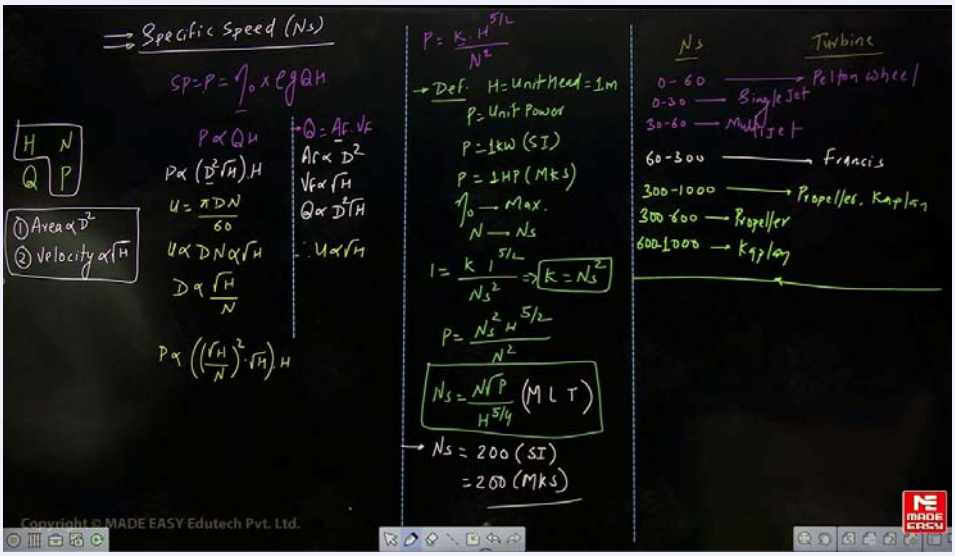
Ans. (c)

Given: SP = 6.5 MW = 6500 kW, H = 15 m, N = 150 rpm, N_s = ?

$$\Rightarrow \quad N_s = \frac{N\sqrt{P}}{H^{5/4}} = \frac{150\sqrt{6500}}{15^{5/4}} = 409.66$$

$$N_s = 409.66$$

$$N_s \approx 410$$



End of Solution

Q.64 Consider the following statements about a ramjet engine:

1. A ramjet engine does not have a compressor and turbine.
2. Ramjet engine is ideal for hypersonic aircraft.
3. Test shows that a subsonic flow system is right choice for a ramjet engine.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (a)

- Ramjet engine uses the forward motion of the aircraft to compress incoming air. Hence no compressor or turbine is present.
- Ramjets require supersonic speeds to operate efficiently.

End of Solution

Q.65 Consider the following statements about advantages of a pulsejet engine:

1. A pulsejet engine can be mass produced in a short time due to its simple construction and low cost.
2. It is suitable for one-time military use.
3. It has turbine and compressor, allowing it to employ low temperature.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (a)

- Pulsejets do not have turbines or compressors.
- Air enters the engine due to pulsing pressure waves and momentum, not through compression by rotating machinery.

End of Solution

Q.66 Consider the following statements about advantages of a turbojet engine:
1. It is suitable for long-distance flight at higher speed and altitudes.
2. Reheat can be employed to increase thrust.
3. Pressure rise through inlet diffuser is significant.

Which of the above statements are correct?
(a) 1 and only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (d)

End of Solution

Q.67 Consider the following statements regarding compressor:
1. A centrifugal compressor like a pump is a head-producing device.
2. The centrifugal type of compressor is suitable for low specific speed and higher pressure ratio applications.
3. The centrifugal compressor is less efficient than the axial type,

Which of the above statements are correct?
(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (d)

End of Solution

Q.68 In axial compressor stages, the ratio of 'actual change of enthalpy in the rotor' to 'actual change of enthalpy in the stage' is known as
(a) degree of reaction (b) degree of enthalpy
(c) enthalpy ratio (d) rotor efficiency

Ans. (a)

The ratio of actual change of enthalpy in the rotor to actual change of enthalpy in the stage is known as degree of reaction.

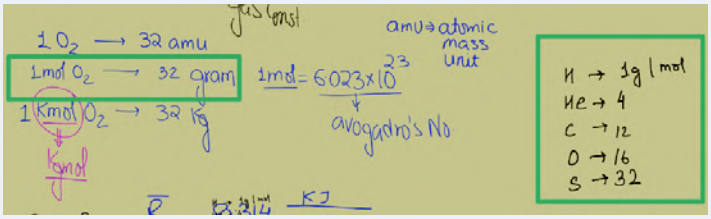
End of Solution

Q.69 Consider the following statements regarding molecular weight:
1. The molecular weight of air is 28.97 g/mole.
2. The molecular weight of argon is 39.95 g/mole.
3. The molecular weight of carbon monoxide is 20.42 g/mole.

Which of the above statements are correct?
(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (a)

Molecular weight of carbon monoxide is 28.01 g/mol.
Molecular weight of air is 28.96 g/mol.
Molecualar weight of Argon is 39.95 g/mol.



End of Solution

Q.70 Consider the following statements regarding engine operating characteristics:

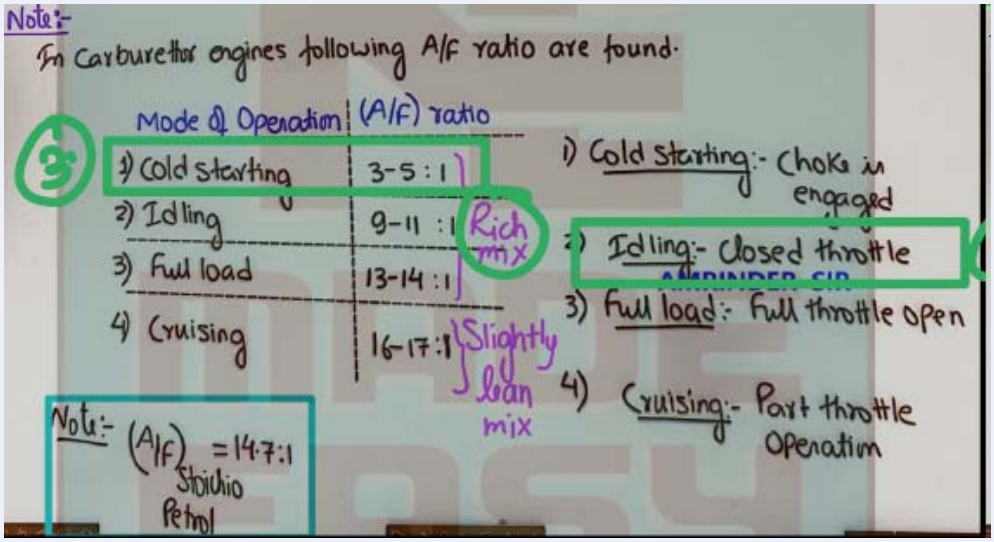
1. At very low engine speeds, the throttle will be almost closed, resulting in a high vacuum in the intake manifold.
2. When quick deceleration is desired and the throttle is closed at high engine speed, a very large vacuum is created in the intake system.
3. When a cold engine is started, an over-rich supply of fuel must be supplied to assure enough fuel vapour to create a combustible gas mixture.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (d)

All three are correct.



End of Solution

Q.71 Consider the following statements regarding compression ignition engines:

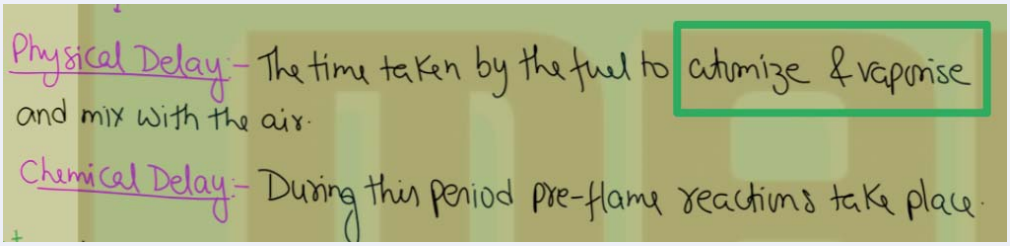
1. In atomization process, fuel drops break into very small droplets.
2. In vaporization process, the small droplets of liquid fuel evaporate to vapour.
3. The smaller the fuel drop size emitted by the injector, the less efficient will process. be atomization

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (c)

Smaller fuel droplet size increases the efficiency of atomization and leads to better mixing and faster vaporization thus improving combustion efficiency.



End of Solution

Q.72 Consider the following statements regarding combustion in internal combustion engines:

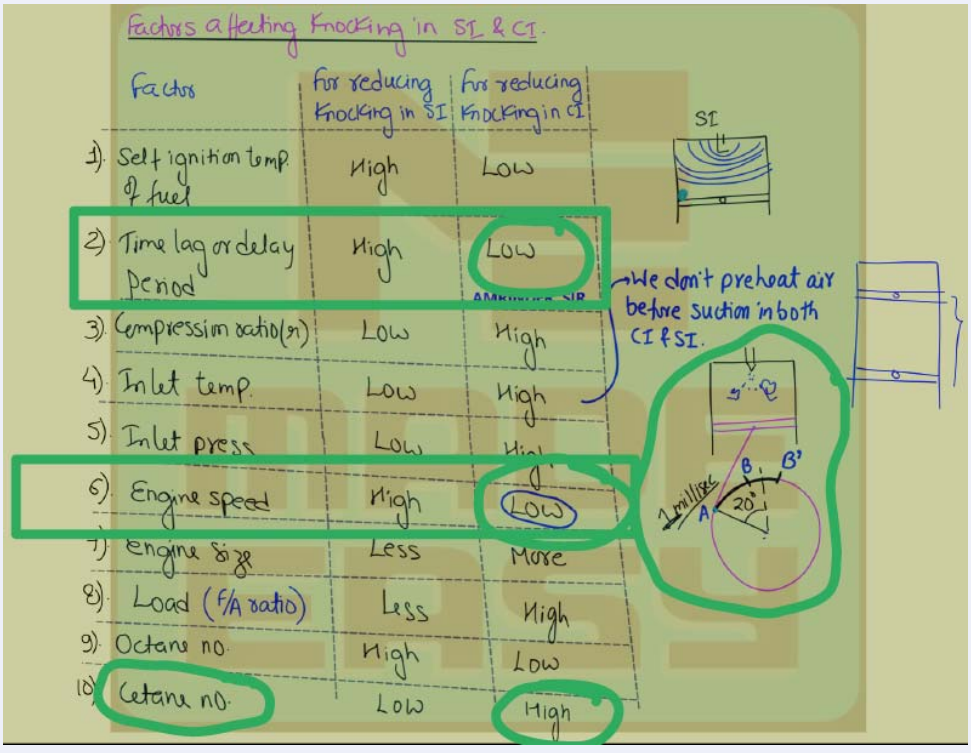
1. At higher engine speeds, ignition delay is decreased in real time.
2. If injection is too early, ignition delay time will decrease.
3. If the cetane number is low, ignition delay will be too long.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (c)

If injection in early then due to combustion chamber not being very hot it may take more time for combustion to begin.



End of Solution

Q.73 Consider the following statements regarding emissions and air pollution of two-stroke cycle SI engines:

1. Addition of hydrocarbon emissions to the exhaust during scavenging process takes place.
2. The air-fuel intake mixture is used to push exhaust residual out of the open exhaust port.
3. Lubricating oil is fully combustible as readily as fuel.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

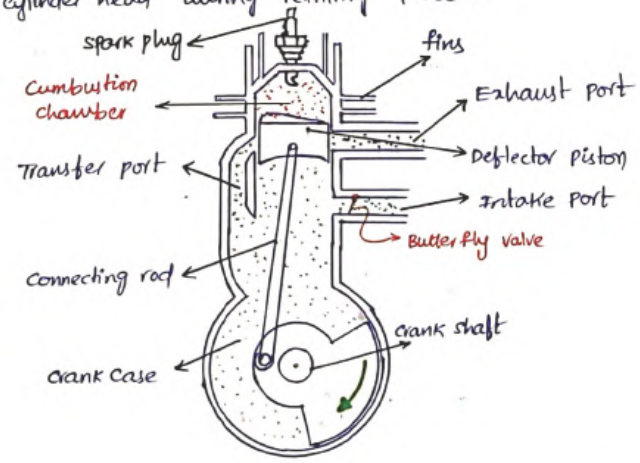
Ans. **(a)**

Even though lubricating oil is mixed in fuel it does not burn as smoothly as fuel.

2-stroke engines

Scavanging: It is the process of cleaning of the engine of exhaust gases. In 2-stroke engines, the fresh air-fuel mixture refilling in the cylinder helps in scavanging of the exhaust gases.

* The efficiency of the 2-stroke is less than that of the 4-stroke engine. Because, some of the fresh air-fuel is lost during scavanging.
* The deflector on the piston is used to direct the fresh-air fuel mixture towards the cylinder head during refilling process.



I. Mist type: (It is used in 2-stroke engines.)

* The lubricating oil is mixed with the fuel and is sent in the crank case. The vapours of the lubricating oil forms mist.
* When the engine is running at the closed throttle, the lubricating oil entering the engine is very less, and there is a chance of engine damage. This may happen when the vehicle moves down hill.

End of Solution

Q.74 Consider the following statements regarding vapour compression refrigeration cycle:

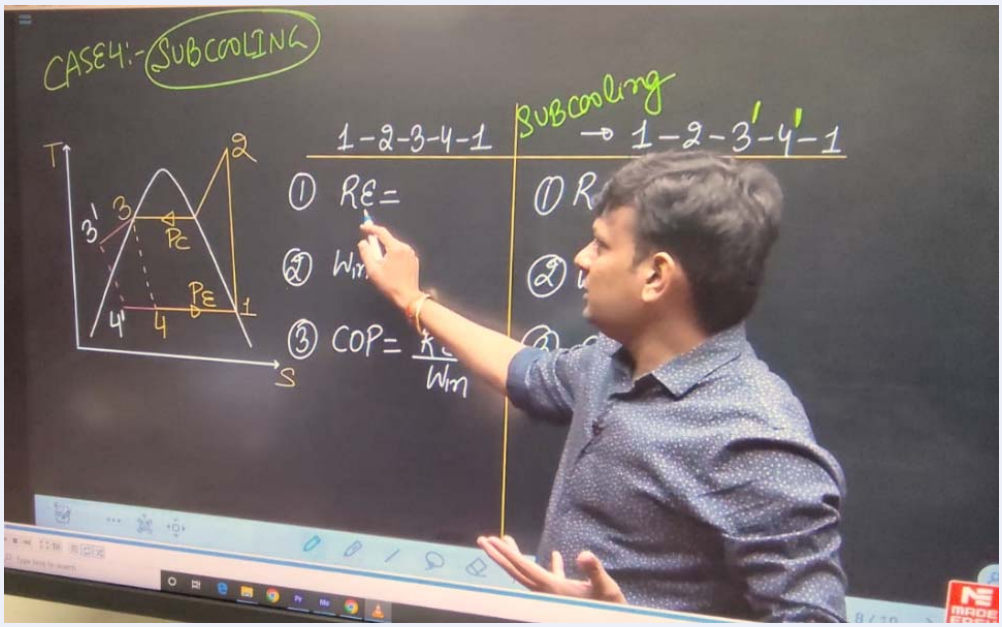
1. Normally in the practical cycles, the temperature of the liquid refrigerant leaving the condenser is lower than the saturation temperature.
2. Subcooling ensures that no vapour enters the expansion valve and furthermore, it increases the refrigerating effect.
3. The refrigerant is also subcooled before leaving the evaporator to make sure that only the wet vapour will enter the compressor.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (a)

The refrigerant leaving the evaporator should be superheated, ensuring that only vapour (not liquid or wet vapour) enters the compressor. Liquid or wet vapour in the compressor can cause mechanical damage.



End of Solution

Q.75 Consider the following statements regarding critical temperature of various refrigerants:

1. The critical temperature of CO_2 is 30.98°C.
2. The critical temperature of CH_4 is 94.47°C.
3. The critical temperature of NH_3 is 132.22°C.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (c)

End of Solution

76. Match the following lists:

List-I	List-II
P. Isotropy	1. Physical properties are not dependent upon the direction in the body along which they are measured
Q. Anisotropy	2. Property of a material which governs its ability to be deformed in processes
R. Ductility	3. Variation of physical property with the direction in a body along which the property is measured

Select the correct answer using the code given below.

(a)	P	Q	R
	2	3	1
(b)	P	Q	R
	1	3	2
(c)	P	Q	R
	3	1	2
(d)	P	Q	R
	1	2	3

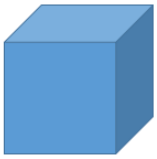
Ans. (b)

Isotropy denotes that physical properties are not dependent upon direction, along which they are measured. Anisotropy refers to variation in properties, in a body, along the direction in which they are measured. Ductility is the property of a material, which denotes its ability to deform in manufacturing processes.

ENGINEERING MATERIALS – CLASSIFICATION, PROPERTIES & APPLICATIONS

- CRYSTALLINE MATERIALS
- Materials which exhibit 3-D, long range, periodicity of arrangement of atoms/ ions/ molecules in the internal structure.
- A crystalline material may have different periodic arrangements in different directions, the physical properties vary with direction and hence, they are called anisotropic substances; whereas, amorphous materials, having random arrangement of atoms/ions/molecules in different directions, have isotropic properties, that are direction independent.

a, b, c = lattice parameters
α, β, γ= Inter-axial angles

Unit cell 

DR. Ch. S. R. Sastry, Faculty of Mech. Engg., MADE EASY

DUCTILITY: Ability to exhibit extensive permanent deformation under applied tensile loads.

It is indicated by % elongation in length=

$= \{ (l_f - l_0)/ l_0 \} \times 100$

Ductility of Materials in increasing order:

Zn, Sn, Ni, Al,Cu, MS, Pt, Ag, Au

- **MALLEABILITY:** Ability to exhibit extensive permanent deformation under applied compressive loads.

  It is indicated by % reduction in area of cross section=$\{ (A_0 - A_f)/A_0 \} \times 100$

  Malleability of metals in decreasing order:

  Au , Ag, Al, Cu, Sn, Pb, Zn, Fe

End of Solution

77. What is the relation between K and E?

(a) $K = \dfrac{E}{3(1-2\nu)}$ (b) $K = \dfrac{E}{2(1-2\nu)}$

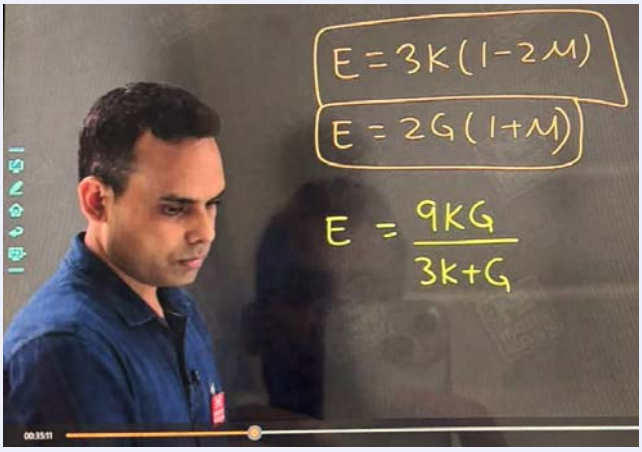
(c) $K = \dfrac{E(1+\nu)}{2}$ (d) $K = \dfrac{E(1-\nu)}{2}$

where ν = Poisson's ratio, K = bulk modulus and E = Young's modulus of elasticity.

Ans. **(a)**

As we know, $E = 3K(1 - 2\nu)$

$\therefore$ $K = \dfrac{E}{3(1-2\nu)}$



End of Solution

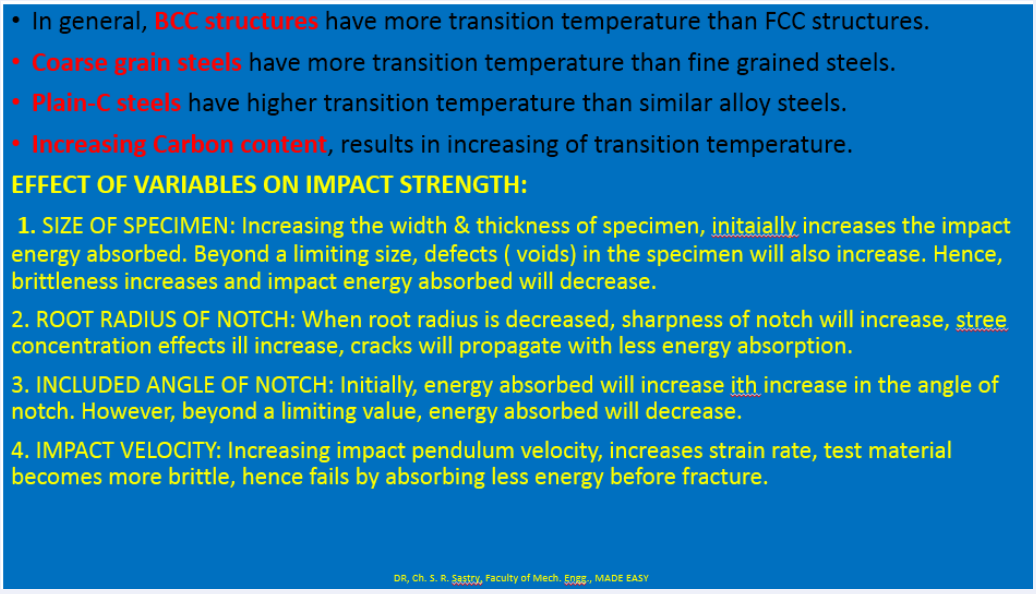
78. Consider the following statements regarding impact strength of a material:
1. Impact strength increases if the dimensions of the specimen are increased.
2. When the sharpness of the notch increases, the impact strength of the material required to cause failure also increases.
3. The angle of notch also improves impact strength after values. certain

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (c)

In impact test, specimen dimensions show effect on impact strength. Initially, by increasing the width and depth of specimen, impact energy, absorbed will increase. However, beyond a certain limit, the internal imperfections will increase by increasing specimen dimensions. Due to this, brittleness will increase and impact strength will decrease similarly, by increasing the notch angle upto about 60°, impact strength will increase. But beyond this value, it will decrease.



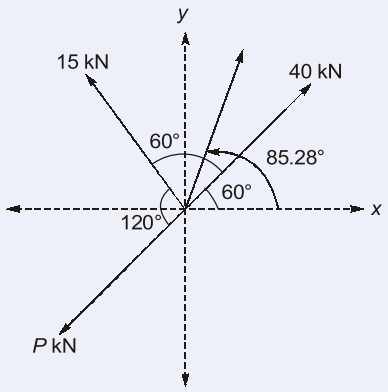
End of Solution

79. What is the magnitude of the third force P, if three forces of magnitudes 40 kN, 15 kN and P kN are acting at a point O. The angles made by 40 kN, 15 kN and P kN forces with X-axis are 60° 120° and 240° respectively, and the magnitude and direction of the resultant force are 30.41 kN and 85.28°? (Take cos85.28° = 0.8229)

(a) 18 kN (b) 19 kN
(c) 20 kN (d) 21 kN

Ans. (c)

Given: $F_R = 30.41$ kN, $Q = 85.28°$



Net force in horizontal direction = Component of resultant force in horizontal direction.

$40 \cos 60° + 15 \cos 40° = 30.41 \cos 85.28$

$P \cos 240° = -10$

$$P = \frac{-10}{-0.5}$$

$P = 20$ kN

End of Solution

80. Consider the following statements regarding laws of friction:

1. The limiting frictional force bears a constant ratio to the normal reaction between two surfaces.
2. The ratio between limiting friction and normal reaction is always greater when the two surfaces are in motion.
3. The limiting frictional force does not depend upon the shape and areas of the surfaces in contact.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only

(c) 1 and 3 only (d) 1, 2 and 3

Ans. (c)

Let limiting frictional force = $(f_s)_{max}$

We know, $\frac{(f_s)_{max}}{N} = \mu_s$

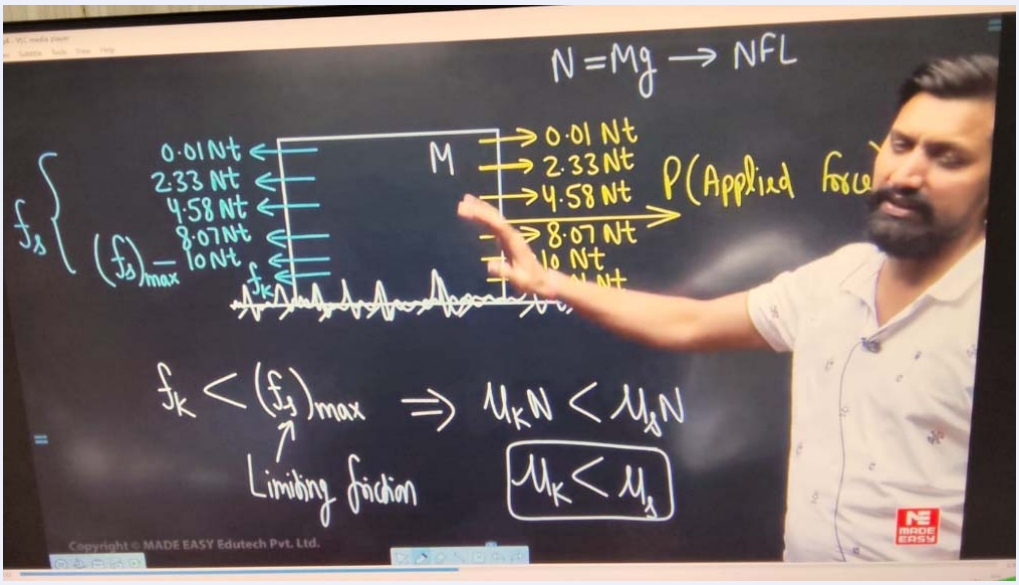
Therefore the limiting force bears a constant ratio to the normal reaction between two surfaces.

When two surface are in motion.

$$\frac{(f_s)}{N} = \mu_k$$

Therefore the ratio between limiting and normal reaction is always smaller when the two surfaces are in motion.

The limiting frictional force does not depend upon the shape and areas of the surfaces in contact.



End of Solution

81. Match the following lists:

List-I (Shape)	List-II (Centroid ($\bar{y}$))
P. Semicircular area	1. h / 3
Q. Triangular area	2. $3b$ / 8
R. Rectangular area	3. $4r$ / (3π)
S. Parabolic area	4. h / 2

Select the correct answer using the code given below.

(a)	P	Q	R	S	(b)	P	Q	R	S
	1	2	3	4		2	1	4	3
(c)	P	Q	R	S	(d)	P	Q	R	S
	4	3	2	1		3	1	4	2

Ans. (d)

Shape	Centroid
Semicircular area	$\frac{4r}{3\pi}$
Triangular area	$\frac{h}{3}$
Rectangular area	$\frac{h}{2}$
Parabolic area	$\frac{3b}{8}$

End of Solution

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82. What is the time required for a particle to reach a velocity of 72 m/s from its initial condition at $t = 0$, if the position coordinate of the particle which is confined to move along a straight line is given by $s = 2t^3 - 24t + 6$, where s is measured in metres from a convenient origin and t is in seconds?

(a) 4 s (b) 6 s
(c) 8 s (d) 2 s

Ans. (a)

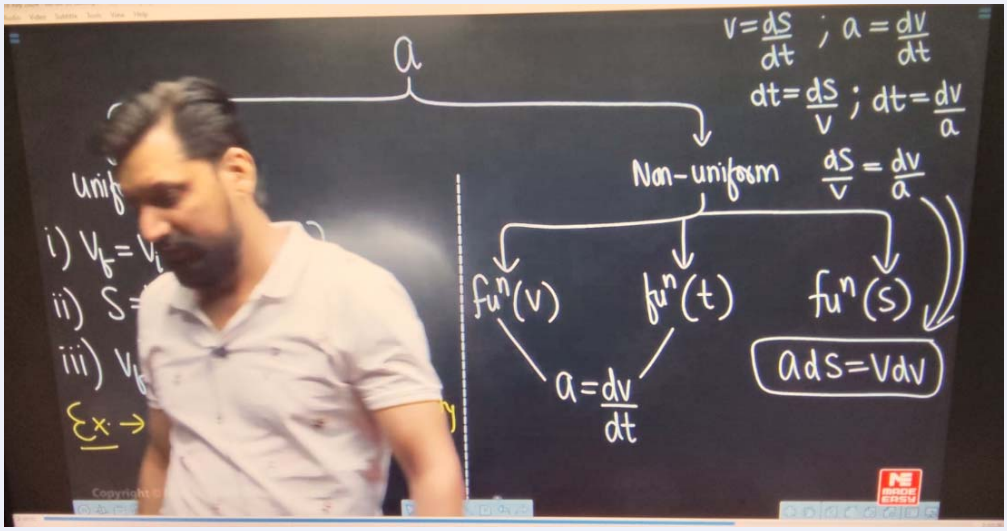
Given: Position coordinate, $S = 2t^3 - 24t + 6$, $t_o = 0$, $V = 72$ m/s.

We know, $\text{Velocity} = \frac{ds}{dt} = 6t^2 - 24$

$72 = 6t^2 - 24$

$6t^2 = 96$

$t = 4s$



End of Solution

83. Match the following lists:

List-I (Name)	List-II (Symbol)
P. Tensile strain	1. τ
Q. Tensile stress	2. ϕ
R. Shear strain	3. e
S. Shear stress	4. σ

Select the correct answer using the code given below.

(a) P Q R S
1 2 3 4

(b) P Q R S
2 1 4 3

(c) P Q R S
3 4 2 1

(d) P Q R S
3 1 4 2

Ans. (c)

End of Solution

84. A rod 150 cm long and of diameter 2.0 cm is subjected to an axial pull of 20 kN. If the modulus of elasticity of the material of the rod is 2×10^5 N/mm^2, What is the elongation of the rod?

(a) $1.5/\pi$ mm (b) $1.6/\pi$ mm
(c) $1.4/\pi$ mm (d) $1.8/\pi$ mm

Ans. (a)

Given : L = 150 cm; d = 2 cm; P = 20 kN = 20×10^3 N; $E = 2 \times 10^5$ N/mm^2; δL = ?

Elongation of the road, $\delta L = \dfrac{PL}{AE}$

$$= \frac{20\times10^3\times150\times10}{\frac{\pi}{4}\times(20)^2\times2\times10^5} = \frac{1.5}{\pi}\text{mm}$$

End of Solution

85. The planes on which the shear stress is zero are known as

(a) normal planes (b) tangential planes
(c) orthogonal planes (d) principal planes

Ans. (d)

The planes on which the shear stress is zero are known as principal planes.

Principal stress :- It is the maximum or minimum normal stress acting on any plane. In 3D stress system, there may be three principal plane which always carry, zero shear stress.

End of Solution

86. What is the expression for normal stress when two perpendicular stresses are acting accompanied with a state of simple shear?

(a) $p_1\cos^2\theta + p_2\sin^2\theta + q\sin2\theta$ (b) $\left\{\dfrac{(p_1+p_2)}{2}\right\}\sin2\theta + q\cos\theta$

(c) $p_1\sin^2\theta + p_2\cos^2\theta + q\sin2\theta$ (d) $\left\{\dfrac{(p_1+p_2)}{2}\right\}\cos2\theta + q\sin2\theta$

where symbols have their usual meanings.

Ans. (a)

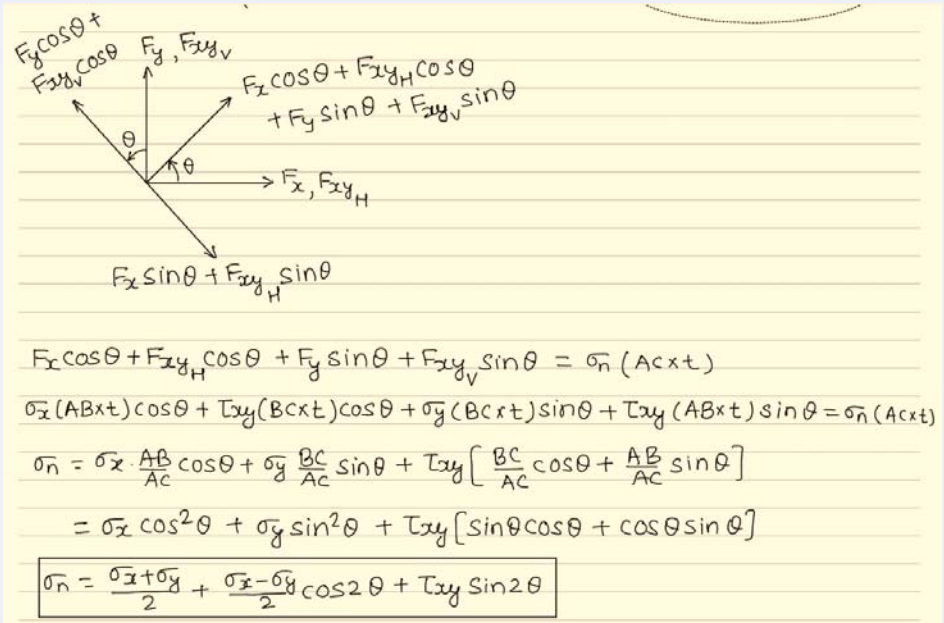
Given : $\sigma_x = p_1$, $\sigma_y = p_2$, $\tau_{xy} = q$

As we know, $\sigma_n = \dfrac{1}{2}(\sigma_x+\sigma_y)+\dfrac{1}{2}(\sigma_x-\sigma_y)\cos2\theta+\tau_{xy}\sin2\theta$

On simplifying, $\sigma_n = \sigma_x\cos^2\theta+\sigma_y\sin^2\theta+\tau_{xy}\sin2\theta$

On putting $\sigma_x = p_1$, $\sigma_y = p_2$, $\tau_{xy} = q$

We get, $\sigma_n = p_1\cos^2\theta + p_2\sin^2\theta + q\sin2\theta$



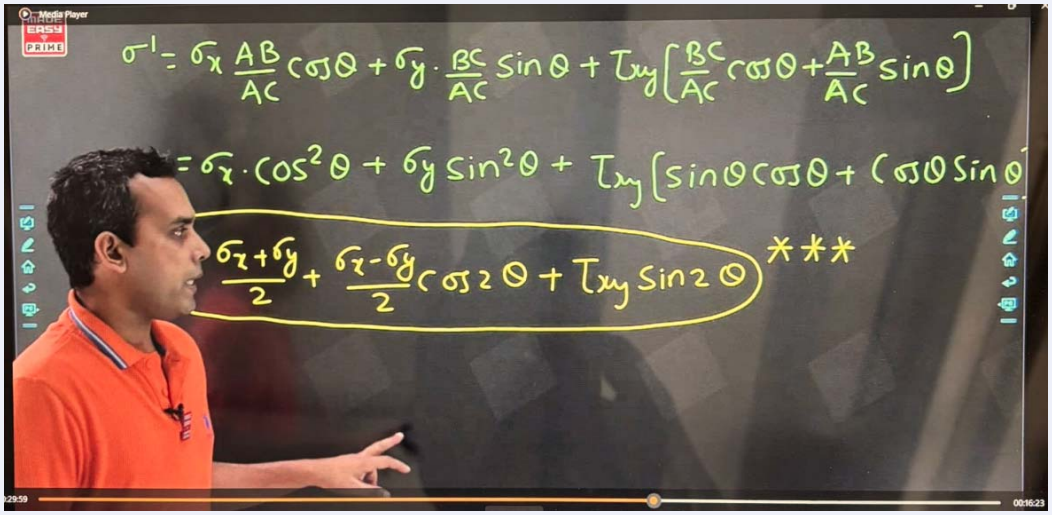
$$F_x\cos\theta + F_{xy_H}\cos\theta + F_y\sin\theta + F_{xy_V}\sin\theta = \sigma_n (A_c \times t)$$

$$\sigma_x (AB \times t)\cos\theta + \tau_{xy}(BC \times t)\cos\theta + \sigma_y (BC \times t)\sin\theta + \tau_{xy}(AB \times t)\sin\theta = \sigma_n (A_c \times t)$$

$$\sigma_n = \sigma_x \frac{AB}{AC}\cos\theta + \sigma_y \frac{BC}{AC}\sin\theta + \tau_{xy}\left[\frac{BC}{AC}\cos\theta + \frac{AB}{AC}\sin\theta\right]$$

$$= \sigma_x \cos^2\theta + \sigma_y \sin^2\theta + \tau_{xy}[\sin\theta\cos\theta + \cos\theta\sin\theta]$$

$$\boxed{\sigma_n = \frac{\sigma_x+\sigma_y}{2} + \frac{\sigma_x-\sigma_y}{2}\cos 2\theta + \tau_{xy}\sin 2\theta}$$



End of Solution

87. The equation commonly used for finding loss of head due to friction in pipes is
(a) Darcy-Weisbach equation (b) Reynolds equation.
(c) Navier-Stokes equation (d) Hagen-Poiseuille equation

Ans. (a)

Darcy-Weisbach equation is commonly used for finding loss of head due to friction in pipes.

End of Solution

88. Consider the following statements regarding shear force and bending moment diagrams:
1. The shear force between any two vertical loads will be constant and hence the shear force diagram between two vertical loads will be horizontal.
2. The bending moment at the two supports of a simply supported beam and at the free end of a cantilever will be zero. But at the fixed end of the cantilever, there will be bending moment for fixing moment).
3. The positive values of shear force and bending moment are plotted above the baseline, and negative values below the baseline.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only.
(c) 1 and 3 only (d) 1,2 and 3

Ans. (d)

Note :-
① For point load (Concentrated force) SFD will be rectangular (uniform) and BMD will be triangular (linear).
② For UDL, SFD will be linear and BMD will be parabolic (2^{nd} order)
③ For UVL, SFD will be parabolic and BMD will be cubic (3^{rd} order)

order of load	order of SFD	order of BMD
0° (UDL)	1°	2°
1° (UVL)	2°	3°
2° (Parabolic)	3°	4°
n°	$(n+1)^\circ$	$(n+2)^\circ$

End of Solution

89. A steel wire of 10 mm diameter is bent into a circular arc of 20 metres radius. What is the maximum stress induced in it? (Take $E = 2 \times 10^5$ N/mm^2)

(a) 40 N/mm^2 (b) 45 N/mm^2
(c) 50 N/mm^2 (d) 55 N/mm^2

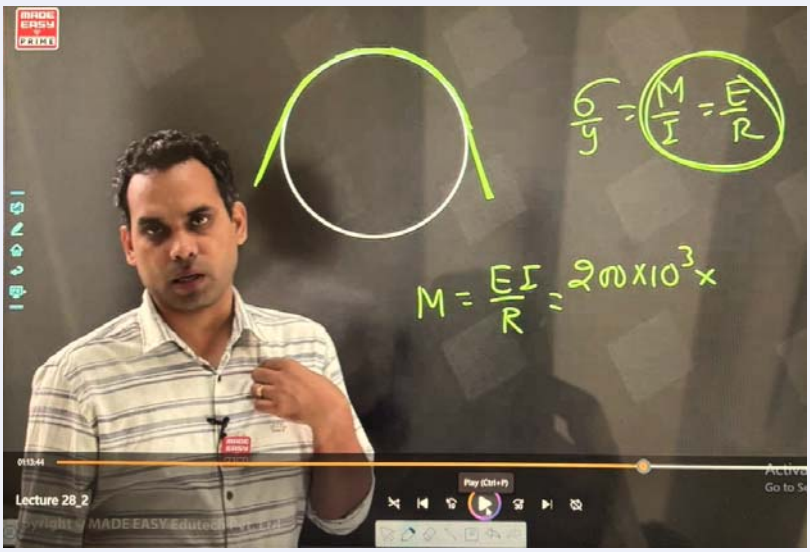
Ans. (c)

Given : $d = 10$ mm; $R = 20$ m; $E = 2 \times 10^5$ N/mm^2

As we know, $$(\sigma_b)_{max} = \frac{Ey_{max}}{R} = \frac{E \times \frac{d}{2}}{\frac{D}{2}} = \frac{Ed}{D}$$

$$(\sigma_b)_{max} = \frac{2 \times 10^5 \times 10}{2 \times 20 \times 1000}$$

$$(\sigma_b)_{max} = 50 \text{ N/mm}^2$$



End of Solution

90. The sum of pressure head and potential head is termed as

(a) datum head
(b) velocity head
(c) piezometric head
(d) static head

Ans. (c)

$$\text{Piezometric head} = \frac{P}{\rho g} + Z$$

$$\text{Stagnation head} = \frac{P}{\rho g} + \frac{V^2}{2g}$$

where, $\frac{P}{\rho g}$ is pressure head

Z is potential head and $\frac{V^2}{2g}$ is kinetic head.

End of Solution

91. Consider the following statements regarding instantaneous centres:

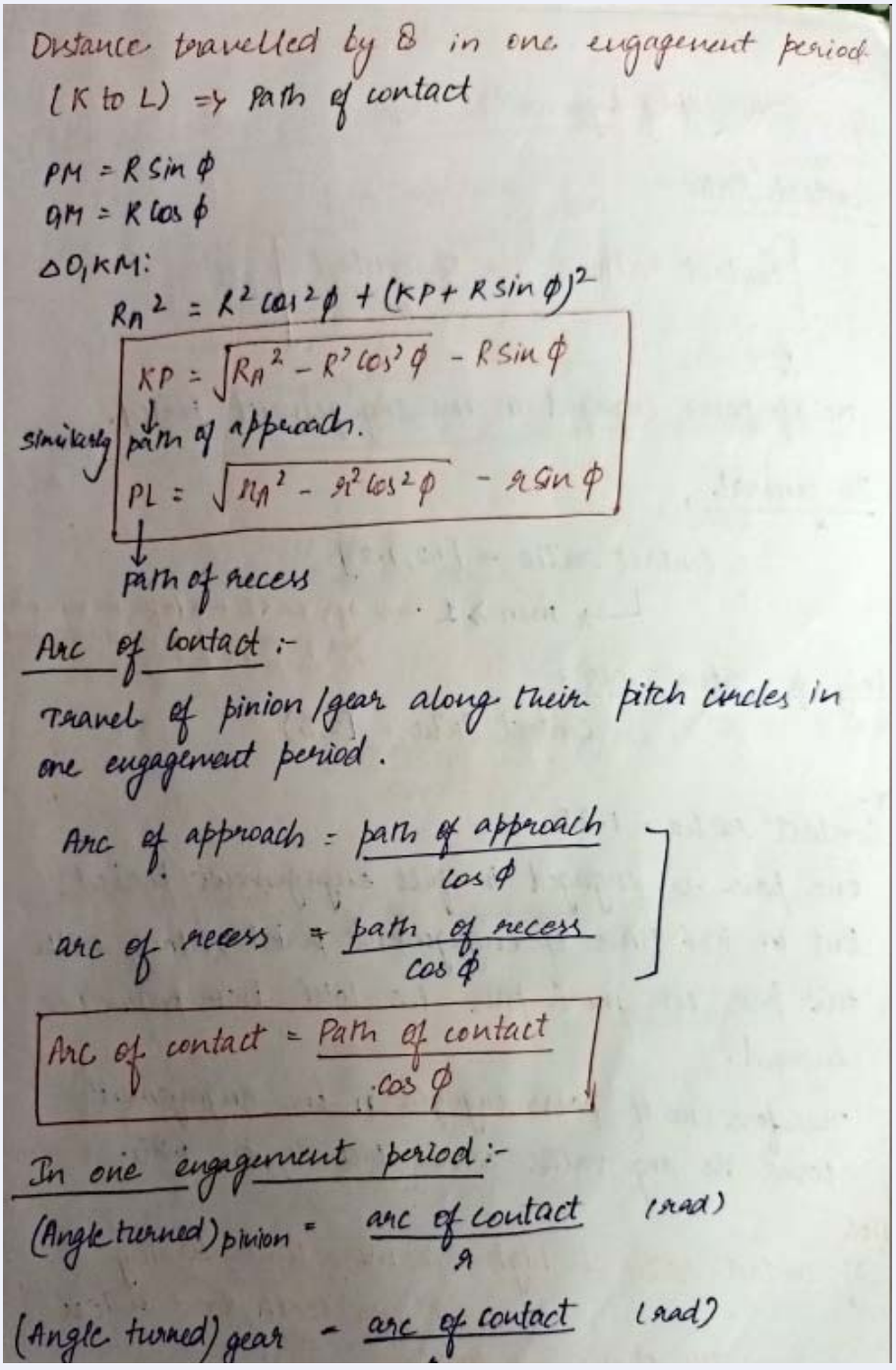
1. The angle of approach is defined as the angle through which a gear rotates from the instant a pair of teeth comes into contact until the teeth are in contact at the pitch point.
2. The angle of recess is the angle through which a gear rotates from the instant the teeth are in contact at the pitch point until the contact is broken.
3. In general, the angle of approach is equal to the angle of recess.

Which of the above statements are correct?

(a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

Ans. (a)

Approach and recess angles are not necessarily always equal, it depends on design of gear,



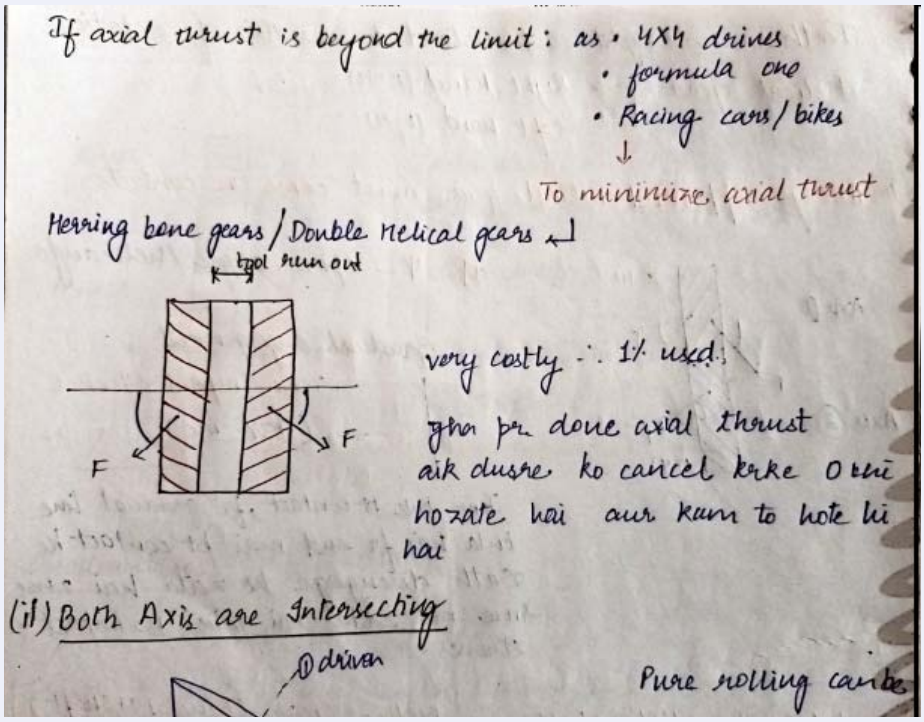
End of Solution

92. What is the name of the gear, half of whose width is cut with a tooth helix in one direction and the other half in the opposite direction?

(a) Bevel gear
(b) Spiral gear
(c) Herringbone gear
(d) Roger gear

Ans. (c)

A Herringbone gear consists of two helical gears with opposite helix angles placed side by side. This design helps to cancel out axial thrust, making them suitable for high-power transmission.



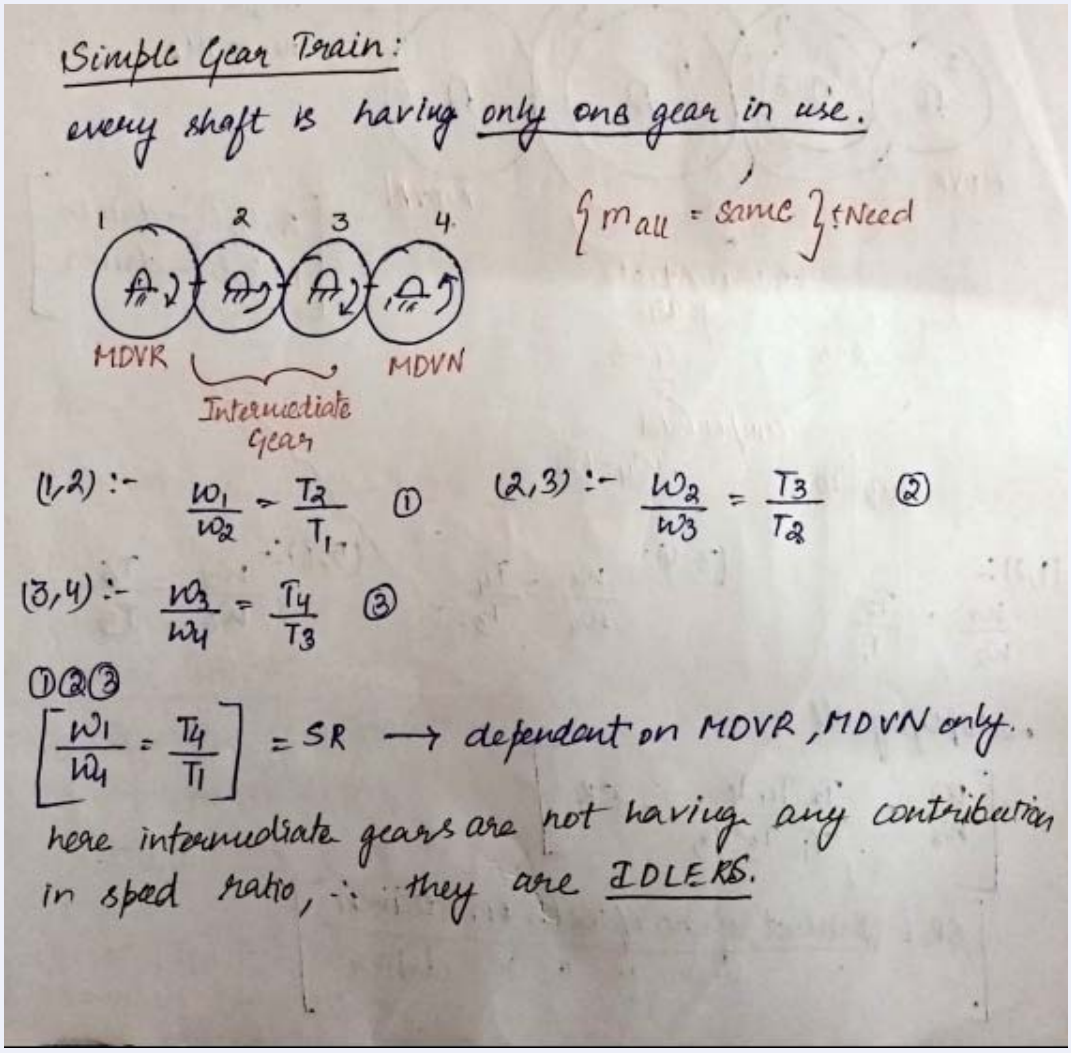
End of Solution

93. Which gears do not in anyway affect the velocity ratio in simple gear train?

(a) First gears
(b) Intermediate gears
(c) Last gears
(d) One-tenth gears

Ans. (b)

In simple gear train, intermediate gears only change the direction of rotation, and do not affect the overall velocity ratio.



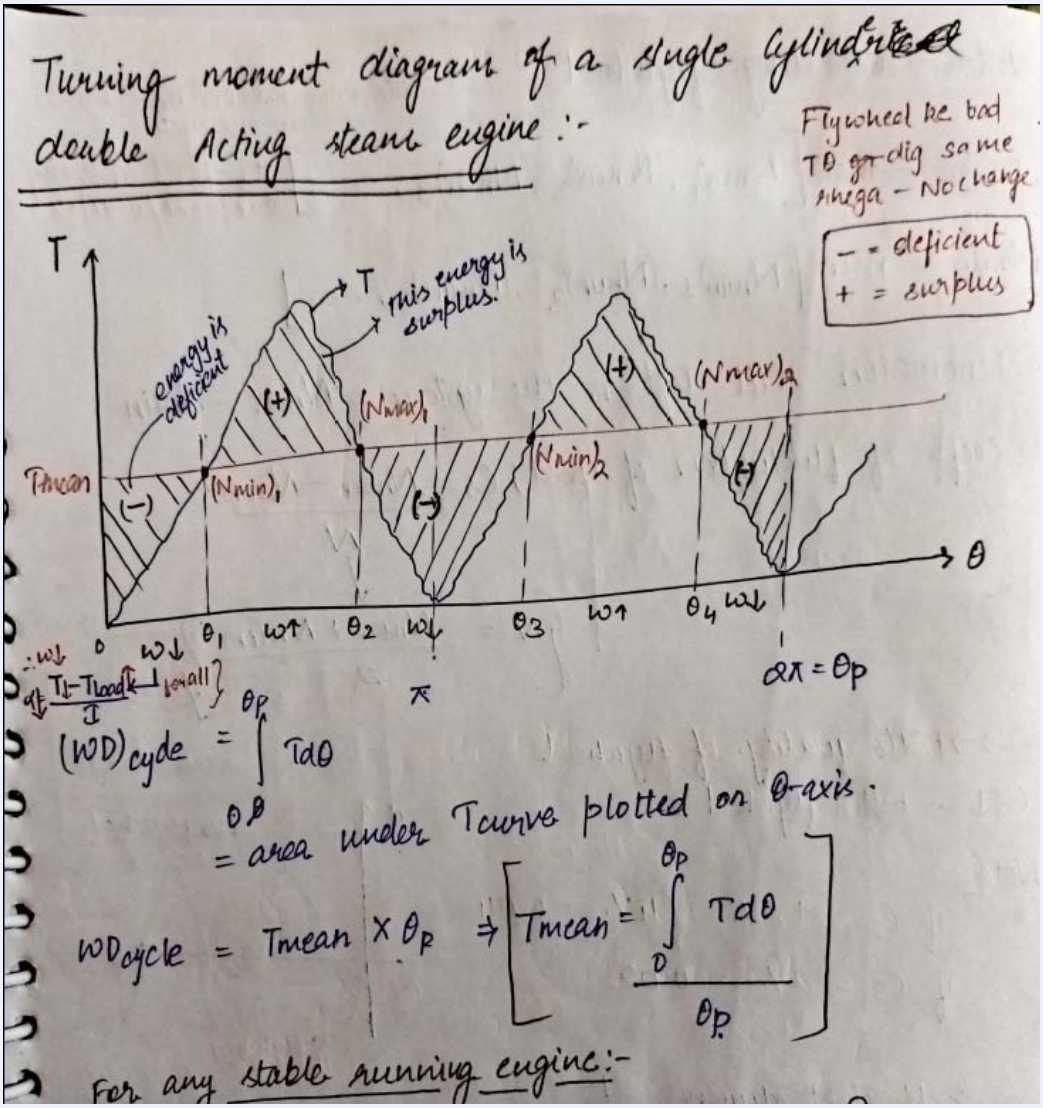
End of Solution

94. Consider the following statements regarding use of turning moment diagram:
1. The area under the turning moment diagram represents work done per cycle.
2. Dividing the area of the turning moment diagram with the length of the base gives the mean turning moment.
3. The maximum ordinate of the turning moment diagram gives the maximum torque to which the crankshaft is subjected to.

Which of the above statements are correct?

(a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

Ans. (d)



End of Solution

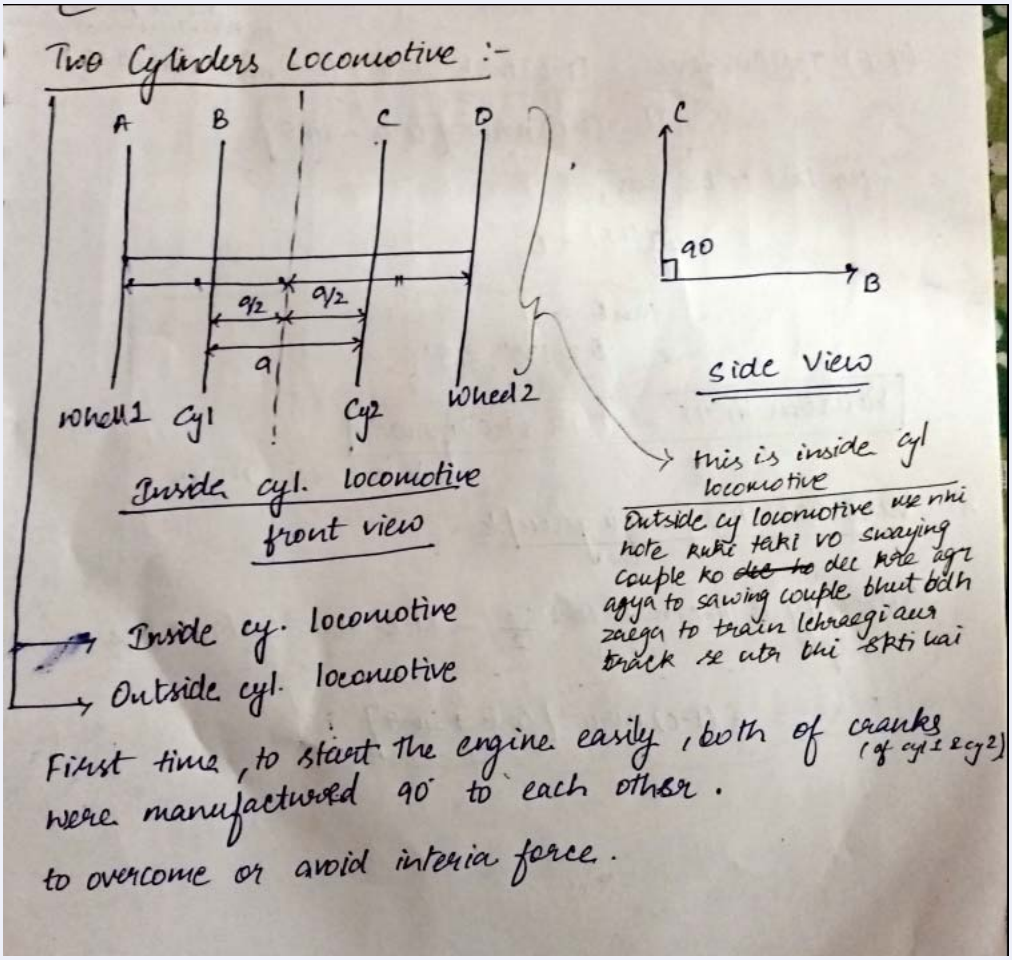
95. At how many degrees, the cranks of the two cylinders are set to each other so that the engine can be started easily after stopping in any position?

(a) 45° (b) 75°

(c) 90° (d) 120°

Ans. (c)

In two-cylinder engines, the crankshafts are often set 90° apart, so that when one piston is at top dead centre (TDC), the other is about to reach TDC, this ensures that there's always one piston in favourable position for power stroke. This makes it easier to start the engine from any position.



End of Solution

96. For the FCC crystal structure, total how many whole atoms may be assigned to a given unit cell, if there are eight corner atoms ($N_c = 8$), six face atoms ($N_f = 6$) , and no interior atoms ($N_i = 0$)?

(a) 5 (b) 4

(c) 6 (d) 3

Ans. **(b)**

Number of whole atoms in a unit cell, refers to average number of atoms or effective number of atoms (N_{av})

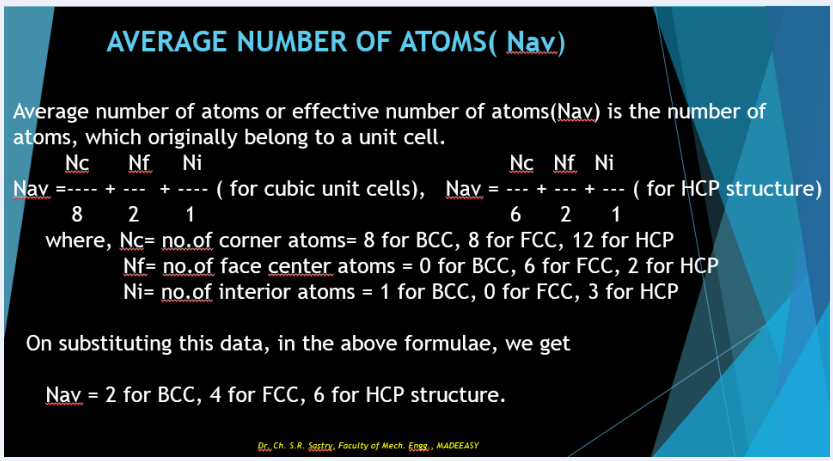
$$\because \quad N_{av} = \frac{N_C}{8} + \frac{N_f}{2} + \frac{Ni}{1}$$

$\because$ N_C = Number of corner atoms = 8 (given)

N_f = Number of face center atoms = 6 (given)

N_i = Number of interior atoms = 0 (given)

$$\therefore \quad N_{av} = \frac{8}{8} + \frac{6}{2} + \frac{0}{1} = 4$$



End of Solution

97. Match the following lists:

List-I (Crystal systems)	List-II (Interaxial angles)
P. Hexagonal	1. $\alpha = \gamma = 90° \neq \beta$
Q. Cubic	2. $\alpha = \beta = 90°, \gamma = 120°$
R. Monoclinic	3. $\alpha = \beta = \gamma = 90°$

Select the correct answer using the code given below.

(a) P Q R — 2 3 1
(b) P Q R — 1 3 2
(c) P Q R — 3 1 2
(d) P Q R — 3 2 1

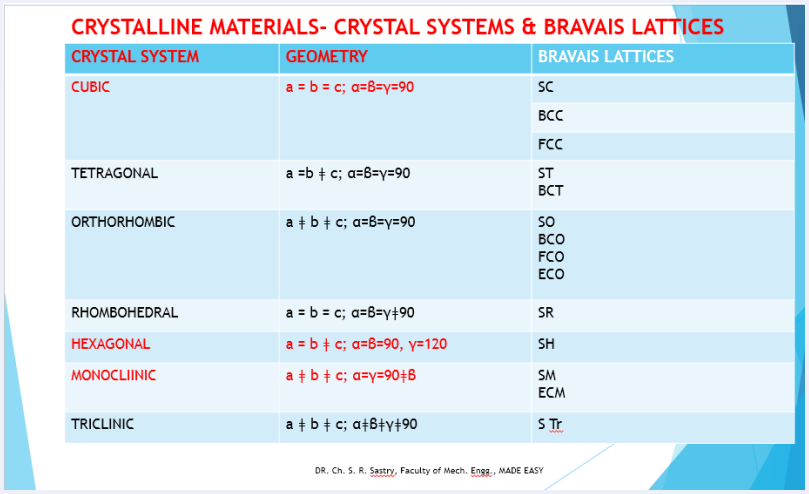
Ans. **(a)**

The crystal geometrices are:

Cubic: $a = b = c, \alpha = \beta = \gamma = 90°$

Hexagonal: $a = b \neq c, \alpha = \beta = 90°, \gamma = 120°$

Monoclinic: $a \neq b \neq c, \alpha = \gamma = 90° \neq \beta$



CRYSTALLINE MATERIALS- CRYSTAL SYSTEMS & BRAVAIS LATTICES

CRYSTAL SYSTEM	GEOMETRY	BRAVAIS LATTICES
CUBIC	a = b = c; α=β=γ=90	SC
		BCC
		FCC
TETRAGONAL	a =b ≠ c; α=β=γ=90	ST BCT
ORTHORHOMBIC	a ≠ b ≠ c; α=β=γ=90	SO BCO FCO ECO
RHOMBOHEDRAL	a = b = c; α=β=γ≠90	SR
HEXAGONAL	a = b ≠ c; α=β=90, γ=120	SH
MONOCLIINIC	a ≠ b ≠ c; α=γ=90≠β	SM ECM
TRICLINIC	a ≠ b ≠ c; α≠β≠γ≠90	S Tr

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End of Solution

98. Which one of the following is an indication of negatively charged ionized gas molecules that travel from discharge electrodes to grounded collection electrodes?

(a) Corona (b) Condenser
(c) Ejector (d) Precipitator

Ans. (a)

In an electrostatic precipitator (ESP), a high voltage is applied to create a corona discharge. This discharge ionizes the gas molecules-negatively charged ions are produced near the discharge electrode, these negatively charged ions then migrate towards the grounded electrodes, carrying dust particle with them.

End of Solution

99. The eutectic copper-silver and lead-tin phase diagrams have only two solid phases α and β these are sometimes. termed as

(a) intermediate solid solutions (b) terminal solid solutions
(c) intermetallic compound solutions (d) co-terminal solid solutions

Ans. (b)

The Ag-Cu, Pb-Sn alloys belong to partial Eutectic phase diagram. In this phase diagram, α and β are called 'Terminal solid solutions', because their compositions are very close to pure metals.

TYPE-III: PARTIAL EUTECTIC SYSTEM

- In this system, the two elements added will exhibit complete solubility in liquid state and partial solubility in solid state.
- Ex: Ag-Cu, Pb-Sn, Sn-Bi, Pb-Sb, Cd-Zn and Al-Si alloys.
- At Eutectic point, three phases are in equilibrium, namely, Liquid, α, and ß. Hence, application of Gibb's phase rule results in 3+ F = 2 + 1, this implies F=0.

In this diagram, α, and ß are known as terminal solid solutions, because their compositions are close to pure metals A and B.

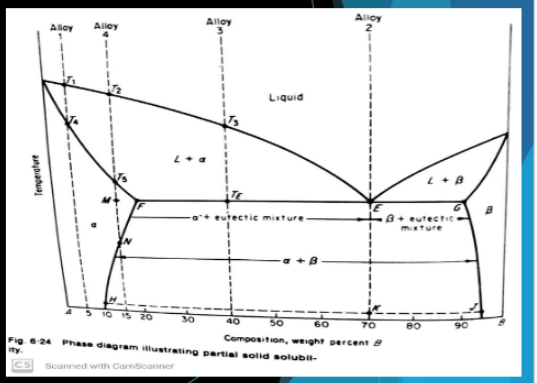

Fig. 6-24 Phase diagram illustrating partial solid solubility.

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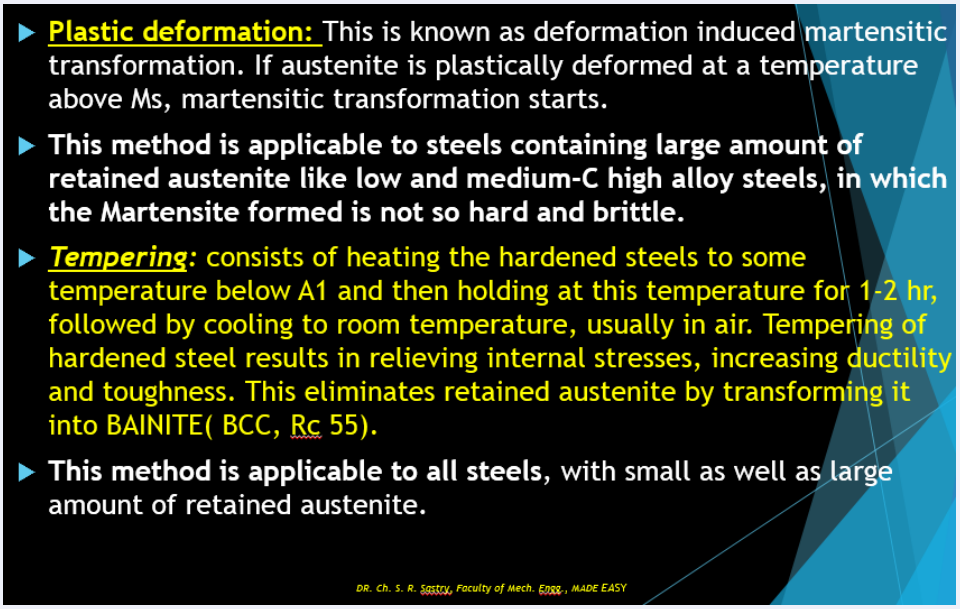
End of Solution

100. What properties of martensite may be enhanced and the internal stresses relieved by a heat treatment known as tempering?

(a) Ductility and toughness (b) Brittleness and strength
(c) Ductility and malleability (d) Ductility and hardness

Ans. (a)

When hardened steels containing martensite are subjected to tempering, internal stresses are relieved, ductility is increased, retained austenite is transformed into Bainite (having BCC structure and hardness less than martensite) and toughness is increased.



End of Solution

101. Consider the following statements regarding ferrous alloys:

1. Ferrous alloys are those in which iron is the prime constituent.
2. Stainless steel is a low-alloy ferrous alloy.
3. Ferrous alloys are extremely versatile, in that they may be tailored to have a wide range of mechanical and physical properties.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (c)

Ferrous alloys are those in which primary constituent is Iron, stainless steels are of two types- namely, low aloy stainless steels and high alloy stainless steels. Ferrous alloys are extremely versatile, in the sense that they can be tailored to have a wide range of mechanical and physical properties, for different applications.

End of Solution

102. Match the following lists:

List-I	List-II
P. Gray iron	1. General engineering service at normal and elevated temperature
Q. Ductile (nodular) iron	2. Miscellaneous soft iron castings in which strength is not a primary consideration
R. Malleable iron	3. Diesel engine blocks, exhaust manifolds, brake discs for high-speed train
S. Compacted graphite iron	4. Pressure-containing parts such as valve and pump bodies

Select the correct answer using the code given below.

(a)	P	Q	R	S	(b)	P	Q	R	S
	1	2	3	4		2	1	4	3
(c)	P	Q	R	S	(d)	P	Q	R	S
	3	4	2	1		3	1	4	2

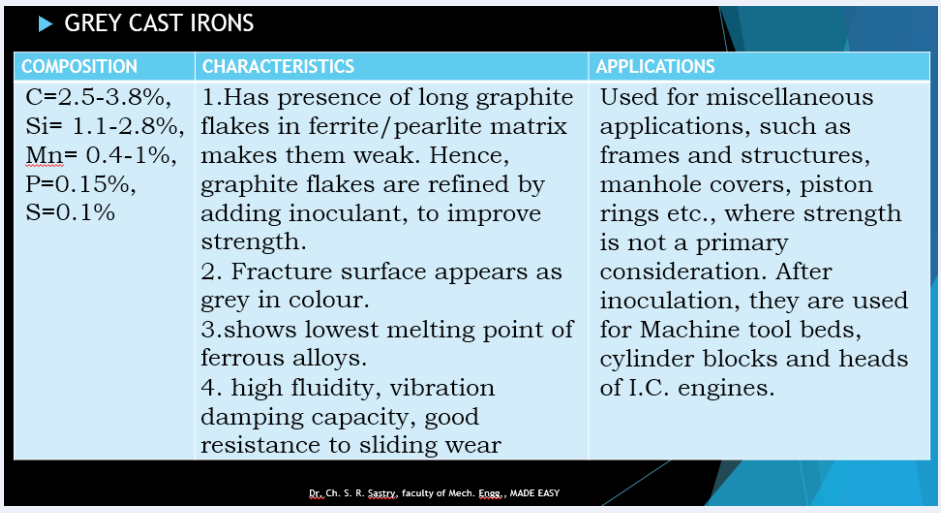
Ans. (a)

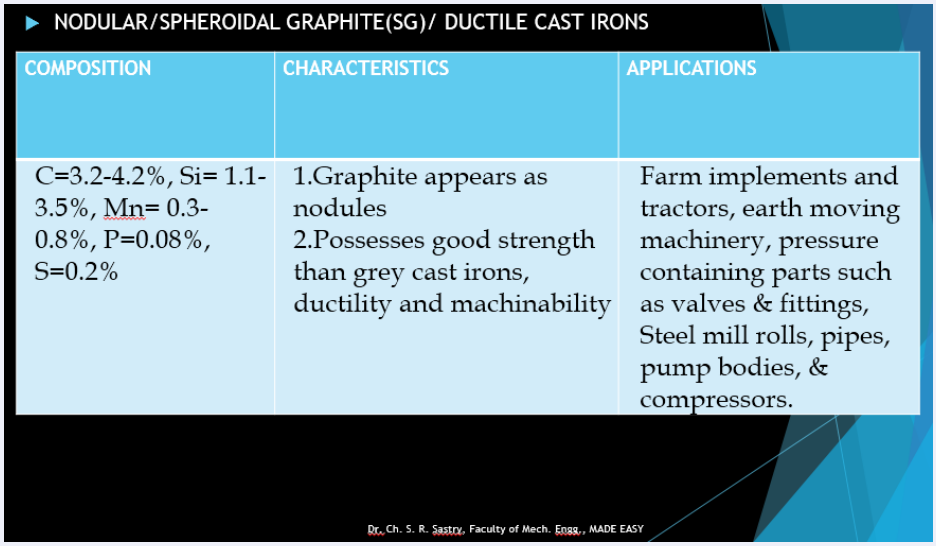
Grey cast-iron is used for Miscellaneous soft Iron castings in which strength is not a primary consideration presence of graphite flakes, makes them weak.

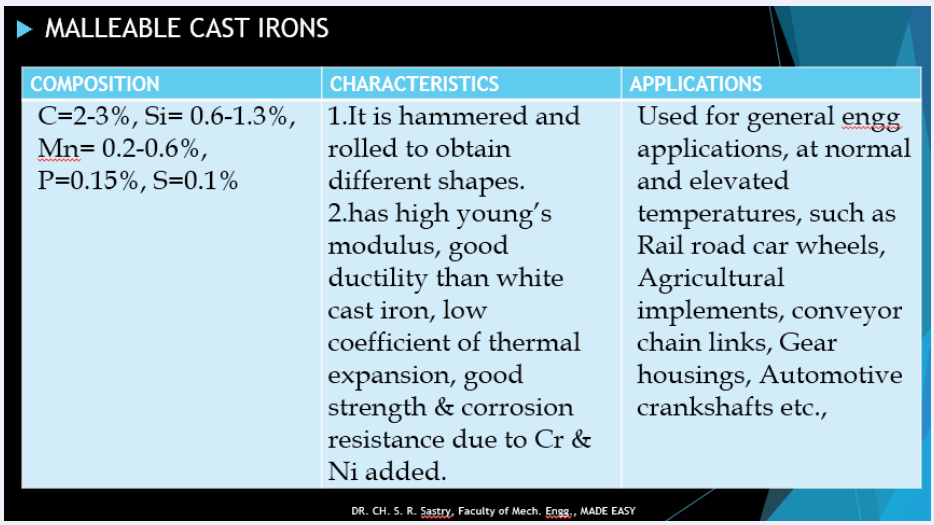
Ductile Iron-(Nodular cast irons) are used for pressure containing parts such as valve and pump bodies, due to good strength than grey cast irons.

Malleable Iron is used for general engineering service at normal and elevated temperatures, due to high ductility, toughness and machinability.

Compacted graphite Iron is used for diesel engine blocks, exhaust manifolds, brakes discs for high speed trains, due to superior strength and wear resistance.







End of Solution

103. Consider the following statements regarding non-ferrous alloys:
1. Molybdenum alloys are used for extrusion dies and structural parts in space vehicles.
2. Tantalum is immune to chemical attack by virtually all environments at temperatures below 150°C and is frequently used in applications requiring such resistant material. a corrosion.
3. Super alloys are used in aircraft turbine components, which must withstand exposure to severely oxidizing environments and high temperatures for reasonable time periods.

Which of the above statements are correct?

(a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

Ans. (d)

Molybdenum is used for high strength, high temperature resistance applications, such as extrusion dies. Tantalum is immune to corrosion in all environments, due to naturally occurring surface oxide film. Superalloys are used in air craft turbine components to resist high stresses, high temperatures and oxidation tendencies.

End of Solution

104. Consider the following statements regarding nanostructured materials :

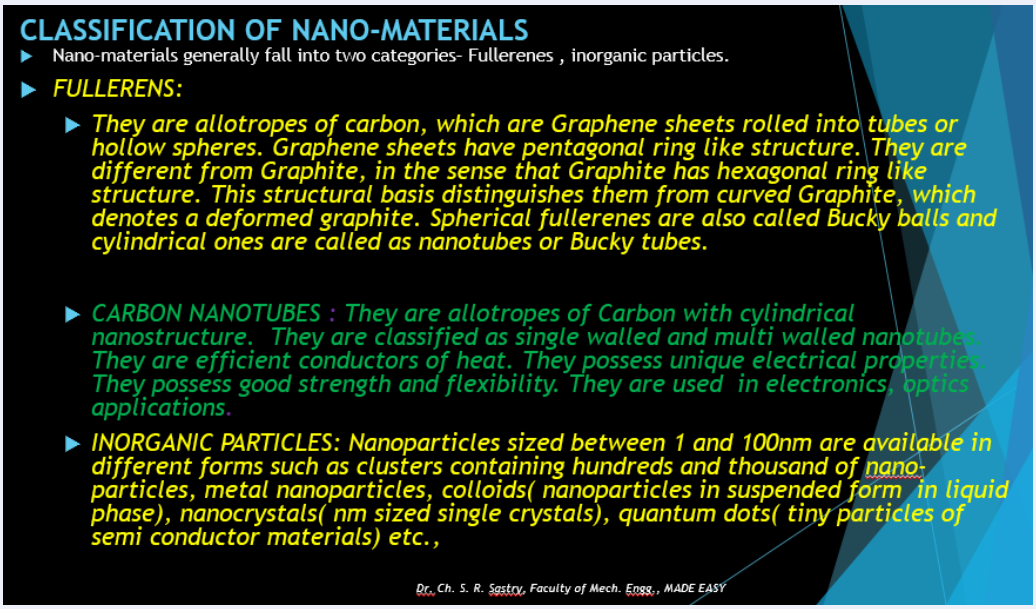
1. Nanostructured materials may be defined as those materials whose structural crystallites elements-clusters, molecules have or dimensions in the 1 nm to 100 nm range.
2. Clusters of atoms consisting of typically hundreds to thousands on nanometre (nm) scale are commonly called as nanoclusters.
3. Fullerenes and carbon nanotubes cannot be seen as curved pieces of graphite.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (d)

Nanostructured materials are materials consisting of particles in the size range of 1-100 nm. "Clusters of atoms" consist of hundreds to thousands of nanoparticles. They are called nano-clusters, curved graphite only denotes simply deformed graphite sheet. Fullerenes and carbon nanotubes are formed from a network of atoms in graphene.



End of Solution

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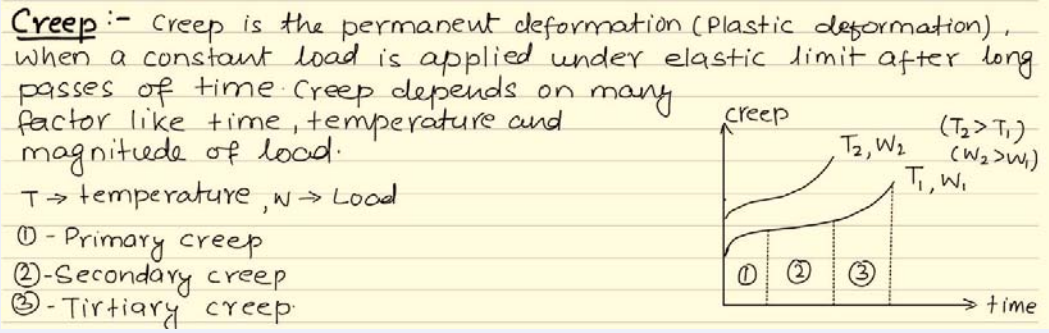
105. Which one of the following tests is used to determine the continuing changes in the deformation of materials at elevated temperatures when stresses are below the yield point?

(a) Tensile test
(b) Hardness test
(c) Impact test
(d) Creep test

Ans. (d)

Creep test is used to determine the progressive deformation of materials at temperature approximately equal to 0.4 T_m.



End of Solution

106. What is the property developed by the cutting tools due to addition of tungsten and molybdenum to high-carbon steel?

(a) Hardness
(b) White hardness
(c) Red hardness
(d) None of the above

Ans. (c)

In high-Carbon steel tool materials tungsten and molybdenum promote hot hardness/ red hardness.

Manganese	• Increases tensile strength and hardness • HADFIELD- Mn STEELS • Promotes quench cracking tendency
Nickel	• Increases tensile strength and toughness without decreasing ductility • Increases corrosion resistance but decreases coefficient of thermal expansion
W, Cr, V, Mo	• W- predominantly increases hot hardness • Cr- predominantly increases corrosion resistance • V- predominantly increases endurance strength/ fatigue strength • Mo- predominantly increases creep resistance i.e., strength and hardness at high temperatures.

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End of Solution

107. Match the following lists:

List-I	List-II
P. Clearance fit	1. The largest permissible diameter of the shaft is smaller than the diameter of the smallest hole
Q. Interference fit	2. The diameter of the largest permissible hole is greater than the diameter of the smallest shaft, and the diameter of the smallest hole is smaller than the diameter of the largest shaft
R. Transition fit	3. The minimum permissible diameter of the shaft exceeds the maximum allowable diameter of the hole

Select the correct answer using the code given below.

(a)	P	Q	R	(b)	P	Q	R
	2	3	1		1	3	2
(c)	P	Q	R	(d)	P	Q	R
	3	1	2		3	2	1

Ans. (b)

End of Solution

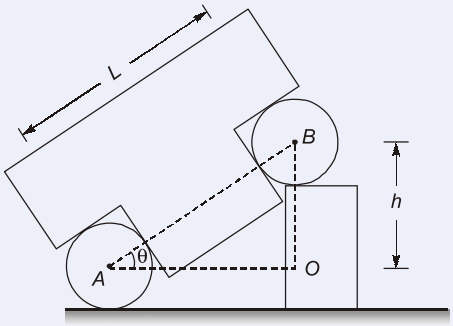
108. The formula for sine of angle (θ) formed between the upper surface of a sine bar and the surface plate (datum) is

(a) L / h (b) h / L

(c) $2h / L$ (d) $2L / h$

where L = the distance between the centres of the rollers and h = the height difference between the two rollers.

Ans. (b)



For sine bar,

In ΔAOB

$$\sin\theta = \frac{OB}{AB}$$

$$\sin\theta = \frac{h}{L}$$

or $$\theta = \sin^{-1}\left(\frac{h}{L}\right)$$

End of Solution

109. Match the following lists:

List-I (Layout configuration)	List-II (Typical material handling system)
P. In-line layout	1. In-floor towline carts
Q. Loop layout	2. Rail-guided vehicle system
R. Robot-centred layout	3. Industrial robot

Select the correct answer using the code given below.

(a) P Q R
2 1 3

(b) P Q R
1 3 2

(c) P Q R
3 1 2

(d) P Q R
1 2 3

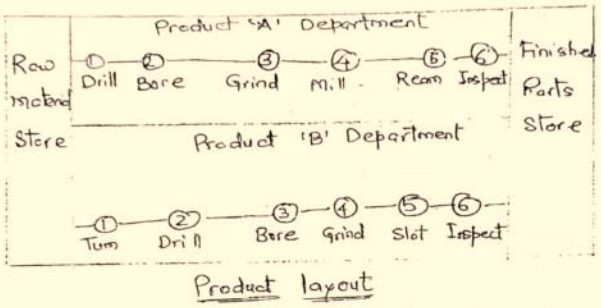
Ans. (a)

Layout configuration	Typical Material
Inline layout	Rail guided vehicle system
Loop layout	In-floor towline carts
Robot-centered layout	Industrial robot

b). Product or line layout :- If the machines and processing equipments are arranged according to the sequence of operation of a product, the layout is called product layout. This type of layout is done to manufacture one type of product in large quantity. Special purpose machines are used which

(9)

perform the required function quickly and reliably. Separate layouts are necessary for different types of products.



Product layout

End of Solution

110. Consider the following statements regarding material requirements planning (MRP) :

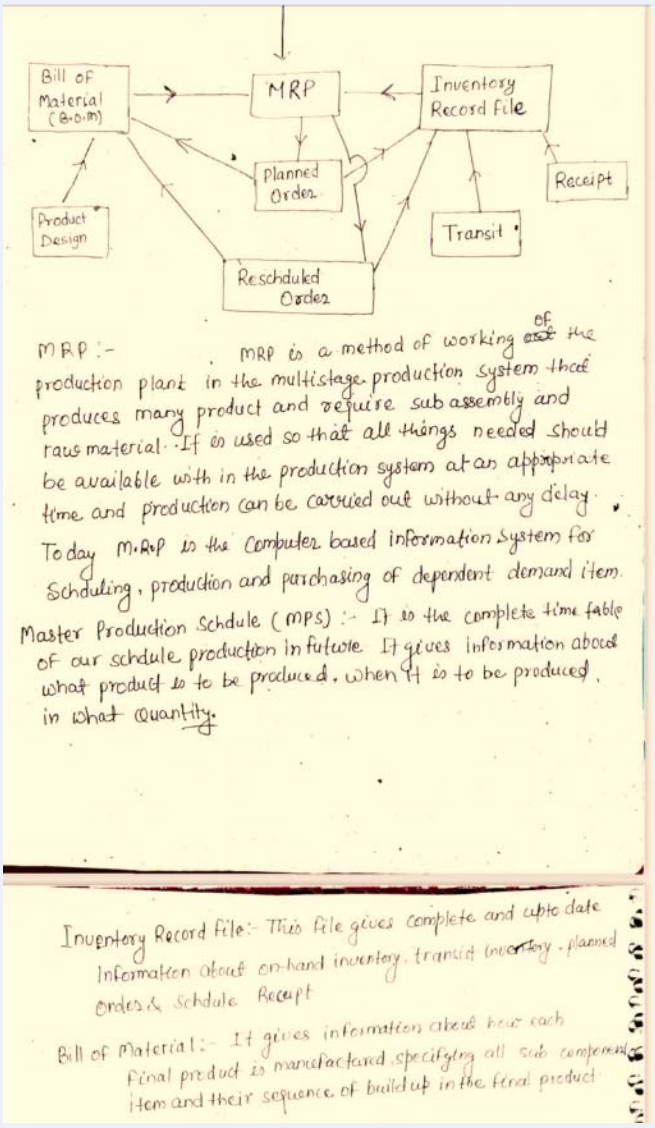
1. MRP is a computational technique that converts the master schedule for end products into a detailed schedule for the raw materials and components used in the end products.
2. MRP is often thought of as a method of inventory control.
3. The distinction between independent demand and dependent demand is important in MRP.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (d)

All statements are correct.



End of Solution

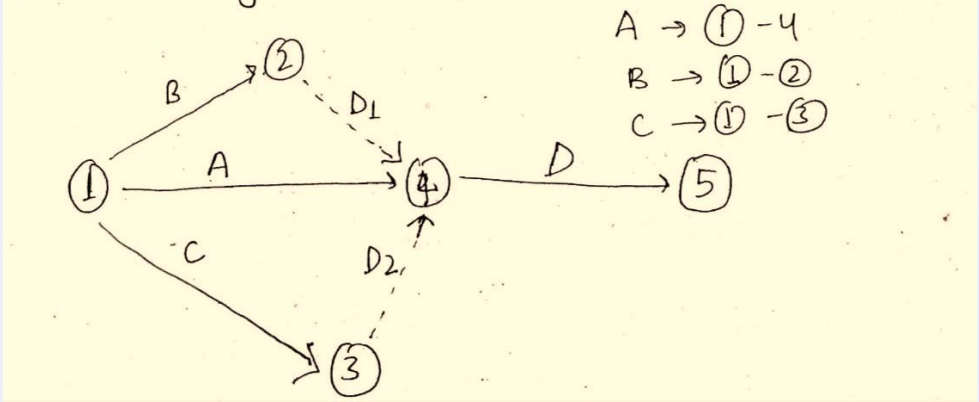
111. Which activity simply shows the logical relationship and does not consume any resource?

(a) Dummy
(b) Tail
(c) Head
(d) Cross

Ans. (a)

Dummy activity does not consume any resources, it is only used to show the dependency relation of one activity over the other.

Dummy Activity :- An activity which is used to show the logic, dependancy or relationship of one activity over the other, but does not consume any time or Resources for its completion is termed as Dummy Activity. It is represented by dotted line arrow.



End of Solution

112. Match the following lists:

List-I (Selective control technique)	List-II (Basis of classification)
P. ABC	1. Criticality of item
Q. VED	2. Value of items in storage
R. XYZ	3. Annual consumption value

Select the correct answer using the code given below.

(a) P Q R
2 1 3

(b) P Q R
1 3 2

(c) P Q R
3 1 2

(d) P Q R
3 2 1

Ans. (c)

ABC → Annual consumption value
VED → Criticality of item
XYZ → Value of items in storage

In ABC Control, Inventory items are classified into A, B and C categories depending upon their usage value. For A category items inventory is kept almost nill and Frequent review is done. On the other hands for C-categories items large amount of inventories is kept and it is reviewed after a long period.

Pare to Laws or 80-20 Laws:-

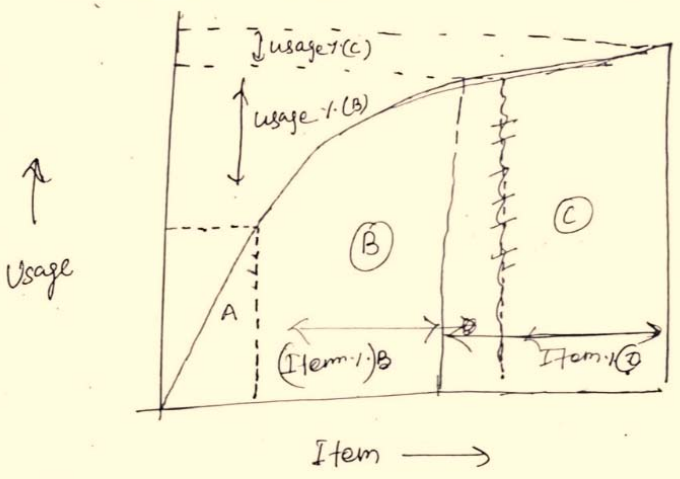


Fig:- ABC Curve.

Essential and Desirable

Inventory are classified on the basis of importance of inventory item for the production system.

End of Solution

113. Consider the following statements regarding reliability theory:

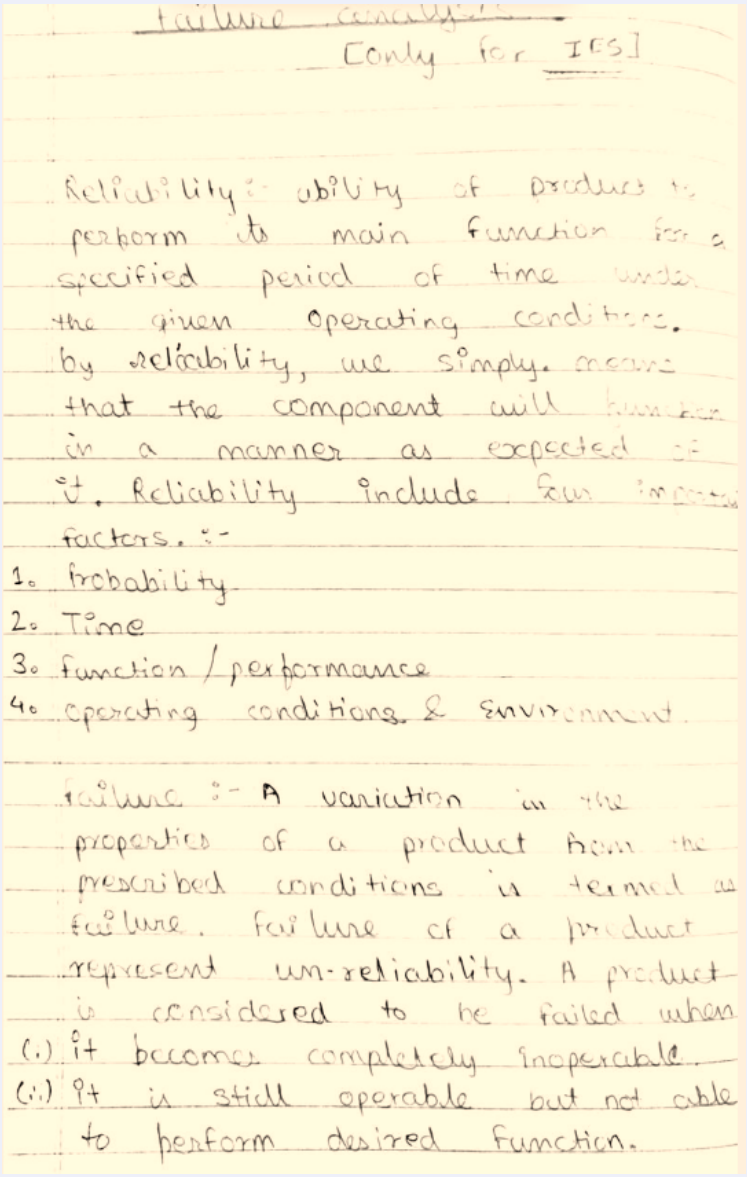
1. Reliability analysis can be divided into two broad categories-(i) qualitative and (ii) quantitative.
2. Reliability engineering deals with the design and construction of systems and products, taking into account the reliability of their parts and components.
3. Reliability management deals with the various management issues in the context of managing the design, manufacture, and/or operation of reliable products and systems.

Which of the above statements are correct?

(a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

Ans. (d)

All the statements are correct.



Reliability :- ability of product to perform its main function for a specified period of time under the given operating conditions. by reliability, we simply means that the component will function in a manner as expected of it. Reliability include four important factors. :-

1. Probability
2. Time
3. function / performance
4. operating conditions & environment.

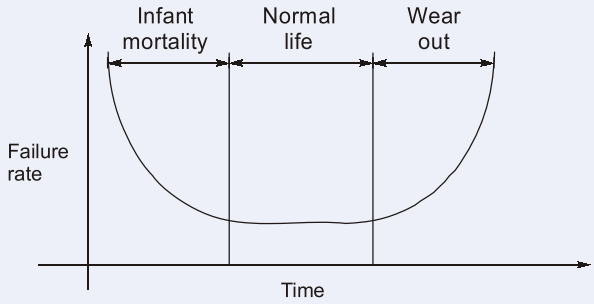
failure :- A variation in the properties of a product from the prescribed conditions is termed as failure. failure of a product represent un-reliability. A product is considered to be failed when
(i) it becomes completely inoperable.
(ii) it is still operable but not able to perform desired function.

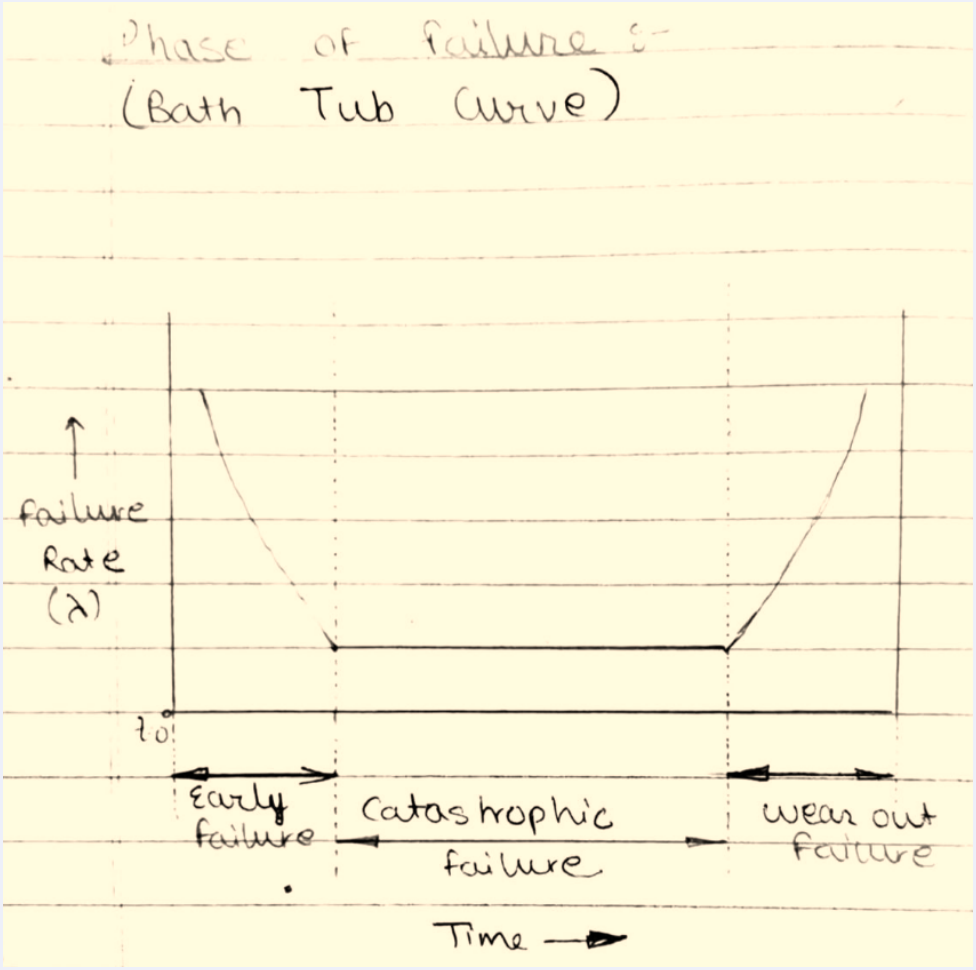
End of Solution

114. The failure rate function can have many different shapes. What type of shape it is where, in region A (decreasing failure rate), the failure is due to manufacturing and/or assembly errors (often referred to as teething problems), in region B (constant failure rate), the failure is purely due to chance (and is not affected by age), and in the final region C (increasing failure rate), failure is due to the aging effect?

(a) FMEA
(b) FTA
(c) Bathtub
(d) RBD

Ans. (c)





End of Solution

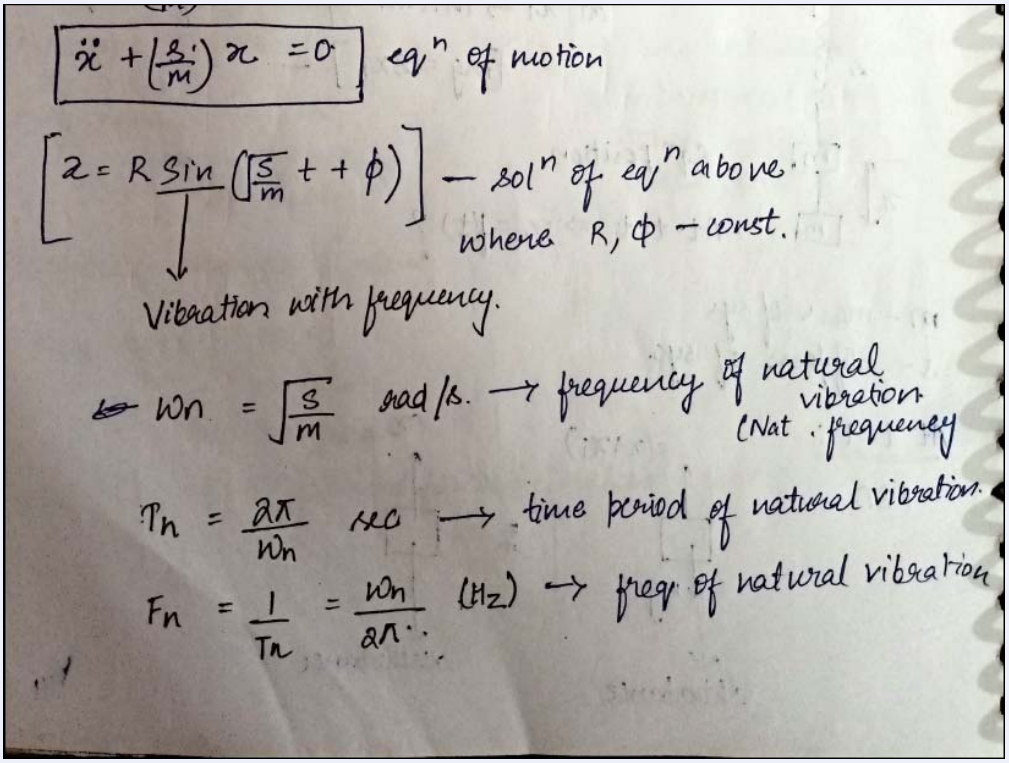
115. In which domains, the signals generated by vibration may be analyzed?

(a) Distance or time
(b) Time or frequency
(c) Speed or time
(d) Time or velocity

Ans. (b)

Vibration analysis is typically performed in the time domain and frequency domain.

- Time domain gives information like amplitude, duration, etc.
- Frequency domain, using fourier transform to understand how much of signal lies in each frequency band.



End of Solution

116. Consider the following statements regarding functions of machine elements:

1. Bearing is used to support the rotating shaft and confine its motion.
2. Key is used to transmit the torque between the shafts.
3. Power screw is used to store and release the energy.

Which of the above statements are correct?

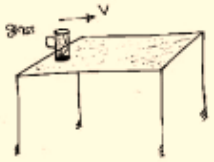
(a) 1 and 2 only
(b) 1 and 3 only
(c) 2 and 3 only
(d) 1, 2 and 3

Ans. (a)

Power screw is not a storing device it is used to transmit the power.

BEARING

• Bearing →
whenever relative motion occurs b|w two machine element the machine element which is stationary supporting the moving machine element is referred as bearing.



• Bearing (According to the Shaft):
" Bearing is a define as a machine element which is used to Provide support for the Rotating element Shaft or Axle, To guide, To ~~alone~~ allign and confined it's motion while Preventing the motion into the dir" of Applied load."

• Shaft	Axle
→ It is a device which is used to transmit the Power.	→ Used to Provide the support to the wheels.
→ They are subjected to twisting as well as Bending.	→ Subjected to only Bending.
→ Intermediate devices like Pulley, gear, Flywheel are Present.	→ Are absent
→ It is a rotating member.	→ Generally a stationary member except train Axle
→ Shafts are designed on the basis of strength, Rigidity and fatigue.	→ Axles are designed on the basis of Bending only.

End of Solution

117. Consider the following statements regarding ergonomics:
1. Ergonomics is defined as the relationship between man and machine.
2. Ergonomics means the natural laws of work.
3. Ergonomists have not carried out experiments to determine the best dimensions of a driver's seat.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (a)

- Ergonomics studies the interaction between humans and machines.
- Ergon means work and nomos means law, so it means "Natural laws of work".
- Ergonomists have extensively studied drives seat dimensions, posture, reach and comfort to optimize vehicle design.

End of Solution

118. Two plates, subjected to a tensile force of 50 kN, are fixed together by means of three rivets. The plates and rivets are made of plain carbon steel 10C4. The permissible shear stress for rivets is 50 N/mm^2. Neglecting stress concentration, determine the diameter of the rivets.

(a) 14.75 mm (b) 20.60 mm
(c) 24.38 mm (d) 29.52 mm

Ans. **(b)**

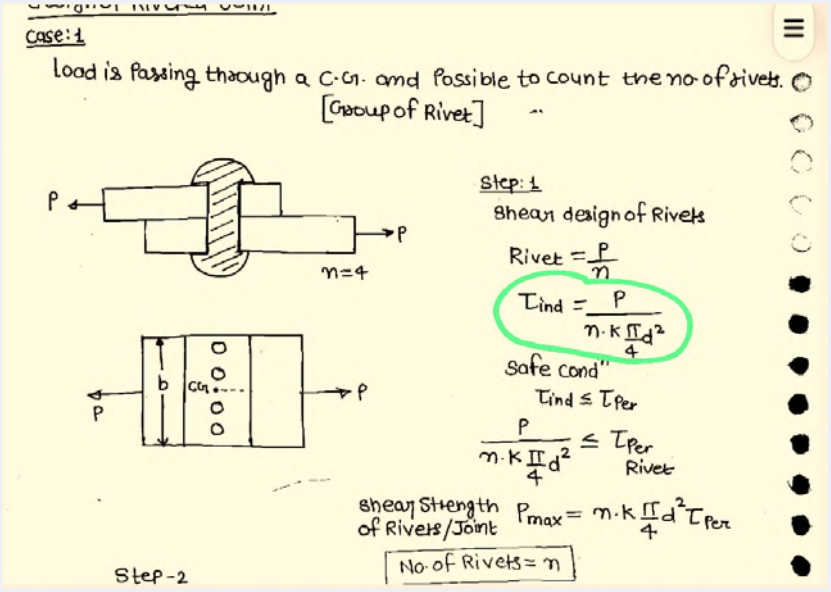
Given : $P = 50$ kN; $n = 3$; $\tau_{per} = 50$ N/mm^2

$$\text{Load per rivet} = \frac{P}{n} = \frac{50 \times 1000}{3} \text{N}$$

Also, $\dfrac{P}{n \times \frac{\pi}{4} \times d^2} \le \tau_{per}$ [Assuming lap joint as diagram is not given]

$$\frac{50 \times 1000 \times 4}{3 \times \pi \times d^2} \le 50$$

$$d \ge 20.60 \text{ mm}$$



End of Solution

119. Consider the following statements regarding mechanical properties of engineering materials:

1. Strength is defined as the ability of the material to resist, without rupture.
2. Elasticity is defined as the ability of the material to regain its original shape and size after the deformation.
3. Plasticity is defined as the ability of the material to retain the deformation produced under the load on a permanent basis.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (d)

Elasticity :- It is that property of the materials by which specimen can regain its original dimension after the removal of load. If loading is done beyound elastic limit, unloading curve will be parallel to initial stress-strain curve. In case of cyclic loading beyound elastic limit, in every cycle some fraction of strain energy stored in the specimen which is utilized for plastic strain and in the next cycle its yield limit increases. Such increase in yield limit is known as strain hardening.

End of Solution

120. Which theory states that the failure of the mechanical component subjected to biaxial or triaxial stresses occurs when the maximum principal stress reaches the ultimate strength of the material?
(a) Rankine's theory
(b) Coulomb, Tresca and Guest's theory
(c) Huber, von Mises and Hencky's theory
(d) Haigh's theory

Ans. (a)

Rankine's theory state that the failure of the mechanical component. Projected to biaxial or triaxial stresses occurs when the maximum principal stress reaches the ultimate strength of the material.

① **Maximum Principal Stress theory (Rankine theory)** :-

According to this theory, maximum principal stress should be less than or equal to yield stress in uniaxial loading.

$$\sigma_1 \le \sigma_y$$

$$\sigma_1 \le \frac{\sigma_y}{FOS}$$

End of Solution

121. Consider the following statements regarding mechatronics and robots :
1. Mechatronics is the synergistic combination of precision mechanical engineering, electronic control and systems thinking in the design of products and manufacturing processes.
2. All robots are not mechatronic systems, but all mechatronic systems are robots.
3. All machines that do not have any kind of autonomy in their behaviour, because they simply automatically act according to the inputs they receive from humans, are strictly pure mechatronic systems.

Which of the above statements are correct?
(a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

Ans. (c)

A robot is commonly considered as a typical mechatronic system, which integrates software, control, electronics, and mechanical designs in a synergistic manner. Robotics can be considered as a part of mechatronics, i.e., all robots are mechatronics systems, but not all the mechatronic systems are robots.

End of Solution

122. How much voltage can be produced by a typical cell at full rated load?

(a) 0.2 V to 0.3 V
(b) 0.4 V to 0.5 V
(c) 0.6 V to 0.7 V
(d) 0.9 V to 1 V

Ans. (c)

The average cell voltage is typically about 0.7V (on rated load) and several cells may by connected in series to increase the voltage.

End of Solution

123. Consider the following statements regarding graph theory and consensus:

1. Graphs are often exploited for modelling the communication between robots in multi-robot systems.
2. Consensus problem is a well-known and widely studied problem in the field of decentralized control of multi-robot systems.
3. Rendezvous is the problem of controlling the robots in such a way that based on locally available quantities, their positions converge to a common value.

Which of the above statements are correct?

(a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

Ans. (d)

Graph Theory of consensus: Graphs are often exploited for modeling the communication between robots in multi-robot systems, and for this reason, they are also called communication graphs. A vertex i represents a robot, and the presence of an edge between vertices i and j means that robots i and j can exchange information.

The consensus problem is a well-known and widely studied problem in the field of decentralized control of multi-robot systems. Rendezvous is the problem of controlling the robots in such a way that based on locally available quantities, their positions converge to a common value.

End of Solution

124. Consider the following statements regarding Microsoft Robotics Developer Studio (MRDS):

1. MRDS was a freely available .NET-based programming environment for building robotic applications.
2. MRDS can be used by professional developers.
3. MRDS can be used by non-professional developers.

Which of the above statements are correct?

(a) 1 and 2 only
(b) 1 and 3 only
(c) 2 and 3 only
(d) 1, 2 and 3

Ans. (d)

Microsoft Robotics Developer Studio (MRDS) was a freely available .NET-based programming environment for building robotic applications, for professional as well as non-professional developers and even for hobbyists. It included a light-weight REST-style service-oriented run-time, a set of visual programming and simulation tools, as well as lots of tutorials. However, due to the vendor lock-in, it never gained widespread acceptance within the robotics research community.

End of Solution

125. For software component model, the link between component internal ports (dashed interface) and component external ports (solid interface) is realized via

(a) communication patterns
(b) SmartSoft model software component
(c) agnostic model
(d) hidden dotted model

Ans. (a)

For software component model, the link between the component internal ports (dashed interface) and the component external ports (solid interface) is realized via communication patterns. In general, a publish/subscribe and a request/response communication pattern would be sufficient to cover all needs.

End of Solution

126. Consider the following statements regarding actuators :

1. The use of multiple extra actuators requires the development of new control strategies to cope with the diverse interactions that may arise compared with standard systems with a single actuator.
2. Two-degree-of-freedom actuators can also be designed to combine two motions, like the roto-translational direct drive motor.
3. Their response time is tens to hundreds of milliseconds, but they can be profitably used in many mechatronic applications.

Which of the above statements are correct?

(a) 1 and 2 only
(b) 1 and 3 only
(c) 2 and 3 only
(d) 1, 2 and 3

Ans. (d)

Actuators : The use of multiple extra actuators, however, requires the development of new control strategies to cope with the diverse interaction that may arise compared with standard systems with a single actuator. Two-degrees of freedom (d.o.f) actuators can also be designed in order to combine two motions, like the roto-translational direct drive motor presented in Tanaka et al. Actuators can also be tailored to the specific application, and they can be designed either to move along a specific path in space or to provide a variable compliance in order to increase the safety of all mechatronic devices that directly interact with the user. Finally, among all possible actuator technologies available for a mechatronic application, the designer must account for the cost/performance trade-off. For some inexpensive, ultra-low-cost applications, such as those for consumer devices, a new type of actuator makes use of shape memory alloy (SMA) wires, which contract and relax according to their operating temperature. Their response time is in the order of tens to hundreds of milliseconds, but they can be profitably used in many mechatronic applications.

End of Solution

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127. Consider the following statements regarding intrinsic tactile sensing:
1. It consists of one strain gauge detecting vertical force and derives both vertical force and position of centre of pressure.
2. Intrinsic sensing is based on a force/torque sensor placed within the mechanical structure of the sensing system.
3. Extrinsic sensing is based on sensors, which are often arranged in arrays that are mounted at or near the contact interface.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (c)

Intrinsic Tectile Sensing : It consists of four strain gauges detecting the vertical force and derives both the vertical force and the position of center of pressure. Intrinsic sensing is based on a force/torque sensor placed within the mechanical structure of the sensing system. The system with intrinsic sensing derives the contact information, like magnitude of force or contact location, using the force/torque sensor. Extrinsic sensing is based on sensors, which are often arranged in arrays that are mounted at or near the contact interface.

End of Solution

128. Consider the following statements regarding simple electroencephalo-graphy (EEG):
1. A subjective index is obtained by a questionnaire, whereas an objective index is determined by a biosignal.
2. EEG is one of the biosignals used as indexes for determining preference.
3. Visualization of the mind status cannot be done by using EEG.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (a)

Electroencephalography (EEG) : A subjective index is obtained by a questionnaire, whereas an objective index is determined by a bio-signal. In addition, an objective index can be quantified, which enables an objective and engineered approach. Incidentally, there have been many propositions regarding the relationship between an EEG signal and the preference determined by KANSEI in the analysis of a bio-signal. The propositions are based on the idea that "the state of the brain should change if the state of the person changes because " the brain governs the mind, consciousness, recognition, and senses" as well as other ideas. EEG is one of the bio-signals used as indexes for determining preference in the present study. Based on our study, we propose various preference measurement systems for the olfactory sense, acoustic sense, haptic sense, taste sense, and visual sense (generally referred to as the five senses) as well as for a combination of the acoustic and visual senses. A sample application of the developed preference measurement systems, namely "Visualization of the mid status using EEG".

End of Solution

129. Consider the following statements regarding next-generation motion control:
1. Next-generation motion systems are inherently multi-variable since the flexible dynamical behaviour is generally not aligned with the motion DOFs.
2. Next-generation motion systems are envisaged to be designed with many actuators and sensors to actively control flexible dynamical behaviour, whereas traditionally, the number of inputs and outputs equals the number of motions DOFs.
3. A model-based design provides a systematic control design procedure for multi-variable systems.

Which of the above statements are correct?
(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (d)

Next-Generation motion control: The presence of flexible dynamical behavior within the control bandwidth has significant implications for motion control design in comparison to the traditional situation:
(i) Next-generation motion systems are inherently multivariable, since the flexible dynamical behavior is generally not aligned with the motion DOFs.
(ii) Next-generation motion systems are envisaged to be designed with many actuators and sensors to actively control flexible dynamical behavior, whereas traditionally, the number of inputs and outputs equals the number of motion DOFs.
(iii) A dynamical relation exists between measured and performance variables, since the sensors generally measure at the edge of the wafer stage system, while the performance is required on the spot of exposure on the wafer itself. In contrast, the flexible dynamical behavior is often neglected in traditional motion systems, leading to an assumed static geometric relation between measured and performance variables.

These implications of lightweight motion systems on the control design motivate a model-based control design, since:
(i) A model-based design provides a systematic control design procedure for multivariable systems.
(ii) A model is essential to investigate and achieve the limits of performance. Specifically, fundamental performance limitations are well-established for nominal models, and robust control provides a transparent trade-off between performance and robustness.
(iii) A model-based design procedure enables the estimation of unmeasured performance variables from the measured variables through the use of a model.

End of Solution

130. Consider the following statements regarding next-generation impedance control:
1. A mechanical impedance at an interaction port can be defined as a dynamic operator that determines an output force in response to an input velocity at the same port.
2. A mechanical admittance is a dynamic operator that determines an output velocity in response to an input force.
3. For linear systems, admittance is proportional to impedance, and both can be represented as transfer functions in Laplace domain.

Which of the above statements are correct?
(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (a)

Next Generation Impedence Control : In this perspective, a mechanical impedance at an interaction port can be defined as a dynamic operator that determines an output force in response to an input velocity at the same port. Vice versa, a mechanical admittance is a dynamic operator that determines an output velocity in response to an input force.

For linear systems, admittance is the inverse of impedance, and both can be represented as transfer functions in Laplace domain. Moreover, impedance (admittance) is analogous to electrical impedance (admittance) if we replace force with voltage and velocity with current.

End of Solution

131. Consider the following statements regarding component-based software engineering (CBSE) :

1. It shifts the emphasis in system building from traditional requirements analysis, system design, and implementation to composing software systems from a mixture of reusable off-the-shelf and custom-built components.
2. CBSE is based on the explication of all relevant information about a component to make it usable by other software elements without the need to get in contact with the component provider.
3. Software components explicitly cannot consider reusable pieces of software.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (a)

Component-based software engineering (CBSE) : It is an approach that has arisen in the software engineering community in the last decade. It shifts the emphasis in system-building from traditional requirements analysis, system design, and implementation to composing software systems from a mixture of reusable off-the-shelf and custom-built components. Software components explicitly consider reusable pieces of software, including notions of independence and late composition. Composition can take place during different stages of the life-cycle of components; that is, during the design phase (design and implementation), the deployment phase (system integration), and even the run-time phase (dynamic wiring of data flow according to situation and context). CBSE is based on the explication of all relevant information of a component to make it usable by other software elements without the need to get in contact with the component provider. The key properties of encapsulation and composability result in the following seven criteria that make a good component: (i) may be used by other

software elements (clients), (ii) may be used by clients without the intervention of the component's developers, (iii) includes a specification of all dependencies (hardware and software platform, versions, other components), (iv) includes a precise specification of the functionalities it offers, (v) is usable on the sole basis of that specification, (vi) is composable with other components, and (vii) can be integrated into a system quickly and smoothly.

End of Solution

132. Consider the following statements regarding service-oriented architectures (SOAS):

1. SOAs are the policies, practices, and frameworks that enable application functionality to be provided and consumed as sets of services published at a granularity relevant to the service consumers.
2. Services are the key entities performing communication between providers and consumers.
3. SOA is not related to policy, practice and frameworks.

Which of the above statements is/are correct?

(a) 1 and 2 only (b) 1 only

(c) 3 only (d) 1, 2 and 3

Ans. (a)

Service-oriented architectures (SOA) are the policies, practices, and frameworks that enable application functionality to be provided and consumed as sets of services published at a granularity relevant to the service consumers. Services can be invoked, published, discovered, and abstracted away from the implementation using a single, standards-based form of interface. In component models, services are represented as ports. This view puts the focus on the question of a proper level of abstraction of offered functionalities. Services combine information and behavior, hide the internal workings from outside intrusion, and present a relatively simple interface to the rest of the program. Services are the key entities performing communication between providers and consumers. SOA is all about style (policy, practice, and frameworks), which makes process matters an essential consideration. A SOA has to ensure that services are not get reduced to the status of interfaces; rather, they have an identity of their own.

End of Solution

133. Consider the following statements regarding simultaneous localization and mapping (SLAM):

1. SLAM forms the backbone of mobile robotics, as it is a prerequisite for higher-level tasks such as path planning and navigation.
2. SLAM has received a lot of attention in the robotics community, and many algorithms that address different aspects of the problem have been proposed over the years.

3. The architecture of a SLAM algorithm can be divided into two main parts-the front-end and the back-end.

Which of the above statements are correct?

(a) 1 and 2 only
(b) 1 and 3 only
(c) 2 and 3 only
(d) 1, 2 and 3

Ans. (d)

SLAM forms the back-bone of mobile robotics, as it is a prerequisite for higher-level tasks such as path planning and navigation. It takes the raw measurements from on-board sensors and creates a coherent representation of the environment that can then be used not only to localize the robot but to plan and navigate. SLAM has received a lot of attention in the robotics community, and many algorithms that address different aspects of the problem have been proposed over the years.

The architecture of a SLAM algorithm can be divided into two main parts: the front-end, which handles on-board sensors and is responsible for sensor-dependent tasks such as data association and loop closure detection, and the back-end, which takes the information generated by the front-end and provides an updated map estimate using an estimation algorithm.

End of Solution

134. Match the following lists:

List-I	List-II
P. Refractoriness	1. Ability of sand to stick to other bodies
Q. Permeability	2. Ability of sand grains to stick together
R. Cohesiveness	3. Ability to allow gases, water vapour and air to pass through it
S. Adhesiveness	4. It should be able to withstand high temperatures

Select the correct answer using the code given below.

(a) P Q R S
4 3 2 1

(b) P Q R S
1 2 3 4

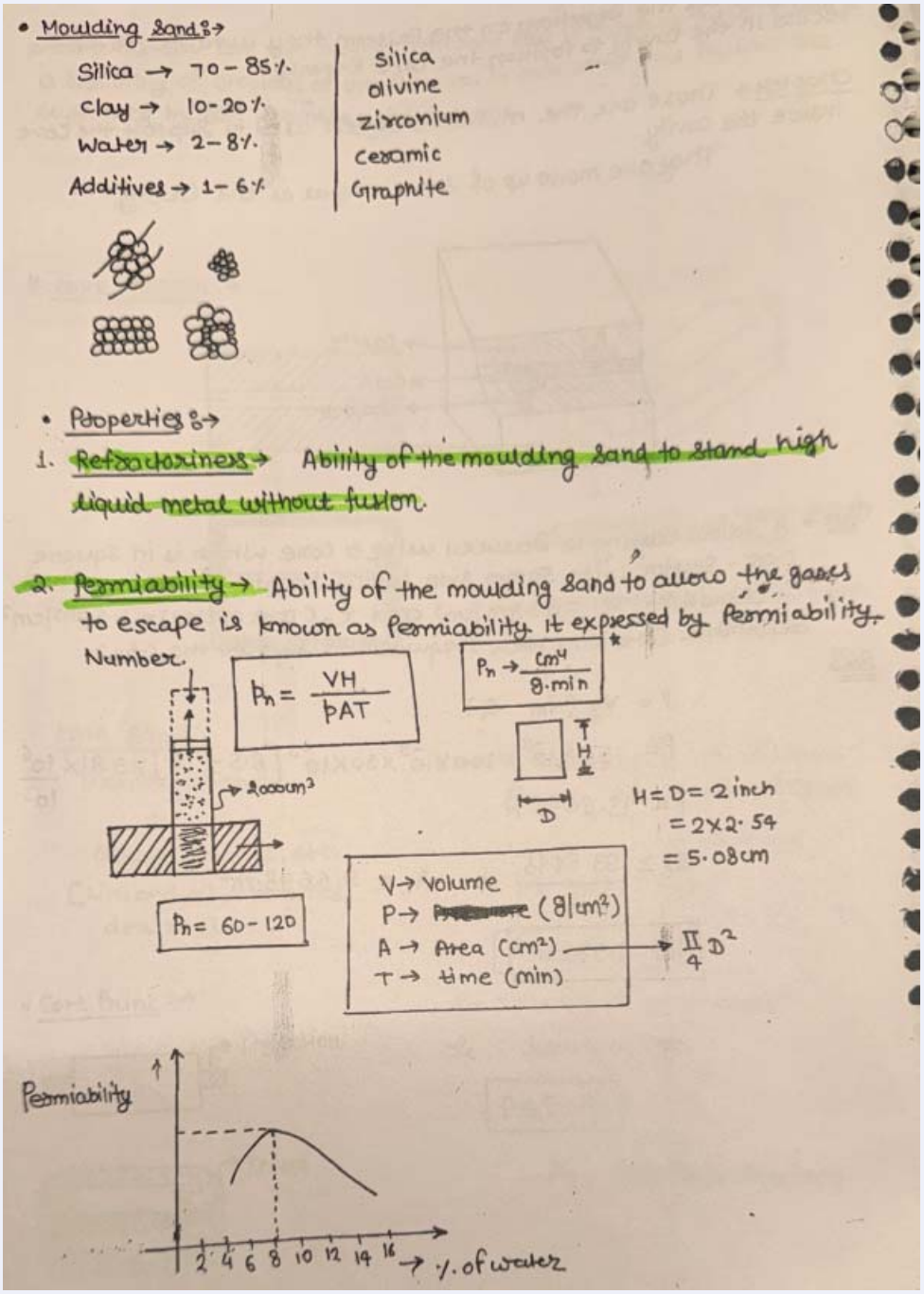
(c) P Q R S
3 1 4 2

(d) P Q R S
4 1 2 3

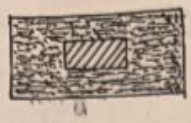
Ans. (a)

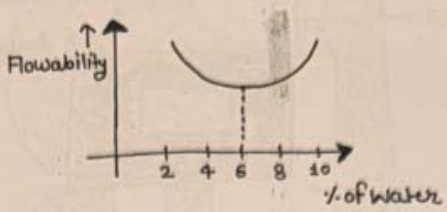
- **Refractoriness** is the ability of the moulding sand to withstand high temperature of the liquid metal without fusion.
- **Permeability** is the ability of moulding sand to allow the gases and water vapour to escape.

- **Cohesiveness** is the ability of the moulding material to get bonded between similar material like between two clay particles.
- **Adhesiveness** is the ability of the sand to get bond with different materials, like between sand and pattern and between sand and clay.



3. Flowability :→ It is the capacity of moulding sand to flow into all the corners of the mold Box due to ramming force.





4. Strength :→

Green Sand
Dry Sand
Hot Sand

"To Retain Shape and size of the cavity & to withstand force Liquid metal on mould surface, mould must be having Sufficient Strength"

5. Hardness :→

Mould Hardness Number : (0-100)

Avg :- 60-80

"Hardness is a Surface Property to minimize the erosion to withstand the force applied by the liquid metal mould must be having sufficient Hardness. It is expressed by Mould Hardness Number (0-100)".

"If Hardness is greater than 80, Permiability will be less. If Hardness is less than 60, Size of the Cavity will be increase."

6. Cohessive Property :→ Bond formation b/w two similar material.

7. Adhesive Property → Bond formation b/w two different material.

Moulding Sand — low Coefficient of Linear expansion

8. Collapsibility :→ Ability of the moulding sand due to which mould Surface will not Provide any resistance Solid contraction

End of Solution

135. Consider the following statements regarding hot and cold working:

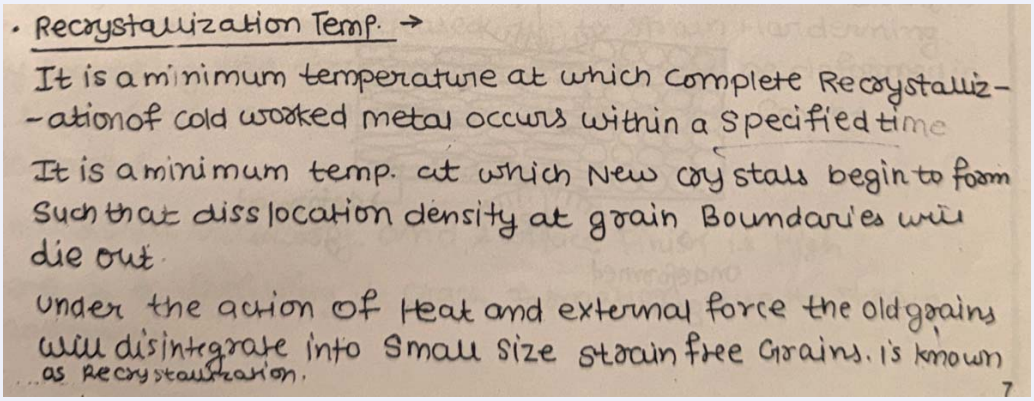
1. Cold working may be defined as plastic deformation of metals and alloys at a temperature above the recrystallization temperature for that metal or alloy.
2. Hot working may be explained as plastic deformation of metals and alloys at such a temperature at which recovery and recrystallization take place simultaneously with the strain hardening.
3. Recrystallization temperature is not a fixed temperature but is actually a temperature range.

Which of the above statements are correct?

(a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

Ans. (b)

1. Working of the material above the recrystallization temperature is known as hot working and below to recrystallization temperature is known as cold working.
2. In hot working plastic deformation of metals and alloys at a temperature at which recovery and recrystallization takes places to refine the grain structure under the action of heat and pressure.
3. Recrystallization temperature is the minimum temperature at which complete recrystallization of cold worked metal occur within a specified time.


• Recrystallization Temp. →
It is a minimum temperature at which complete Recrystalliz-
-ationof cold worked metal occurs within a specified time
It is a minimum temp. at which New crystals begin to form
such that disslocation density at grain Boundaries will
die out.
Under the action of Heat and external force the old grains
will disintgrate into small size strain free Grains. is known
as Recrystallization.

Recovery :→

At 0.3 times of melting temp. highly distorted grains will disintegrate into small size grains.

During Recrystallization complete grains will be disintegrate into small grains.

Grain Growth follows complete Crystallization if the material is left at elevated temperature.

HOT WORKING :→

- Working of the material Above the recrystallization temperature Due to Refinement of the grain structure Mechanical Properties such as toughness, Percentage of elongation and % of reduction area will be increased.
- Force required to get the deformation is less and the amount of deformation is high.

Since there is a recovery and recrystallization at every stage, there is No Strain Hardening and No-Crack formation.

Due to oxide formation rough surfaces can be Produced.

Due to shrinkage of the material during cooling dimensional accuracy will be less.

Tooling cost is more.

COLD WORKING :→

Working of the material below the recrystallization. Strength and Hardness will be increased due to Strain Hardening.

By Controlling the force applied grains will be deformed in a single direction and directional Properties can be Produced.

dimensional accuracy and surface finish is High.

There is a possibility of Crack formation due to Strain Hardening.

End of Solution

136. Higher calorific value of the fuel can be determined by using
(a) Dunkerley's formula (b) Euler's formula
(c) Rankine's formula (d) Dulong's formula

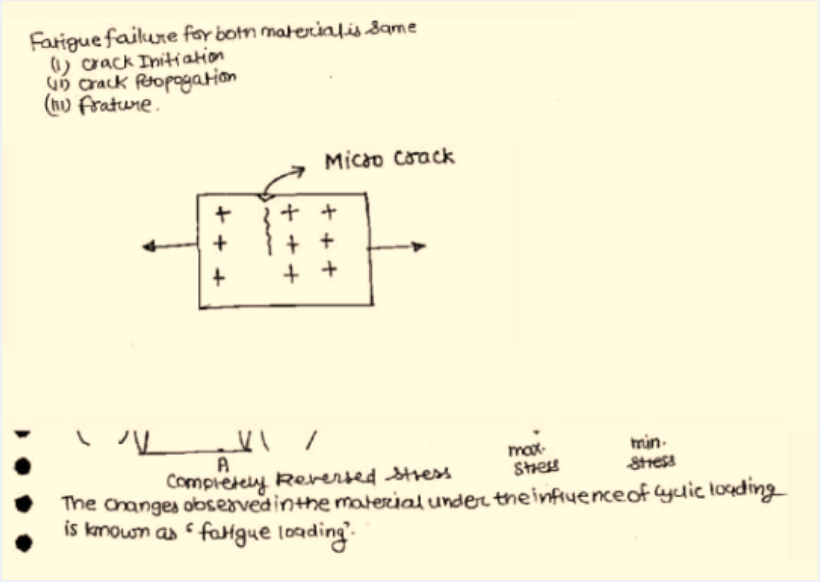
Ans. (d)
Dulong's formula is an empirical equation used to estimate the higher calorific value (HCV) of a fuel based on its elemental composition.

End of Solution

137. Consider the following statements regarding fatigue failure:
1. Fatigue failure is defined as time-delayed fracture under cyclic loading.
2. Fatigue failure begins with a crack at some point in the material.
3. Fatigue cracks are not visible till they reach the surface of the component and by that time, the failure has already taken place.

Which of the above statements are correct?
(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (d)



End of Solution

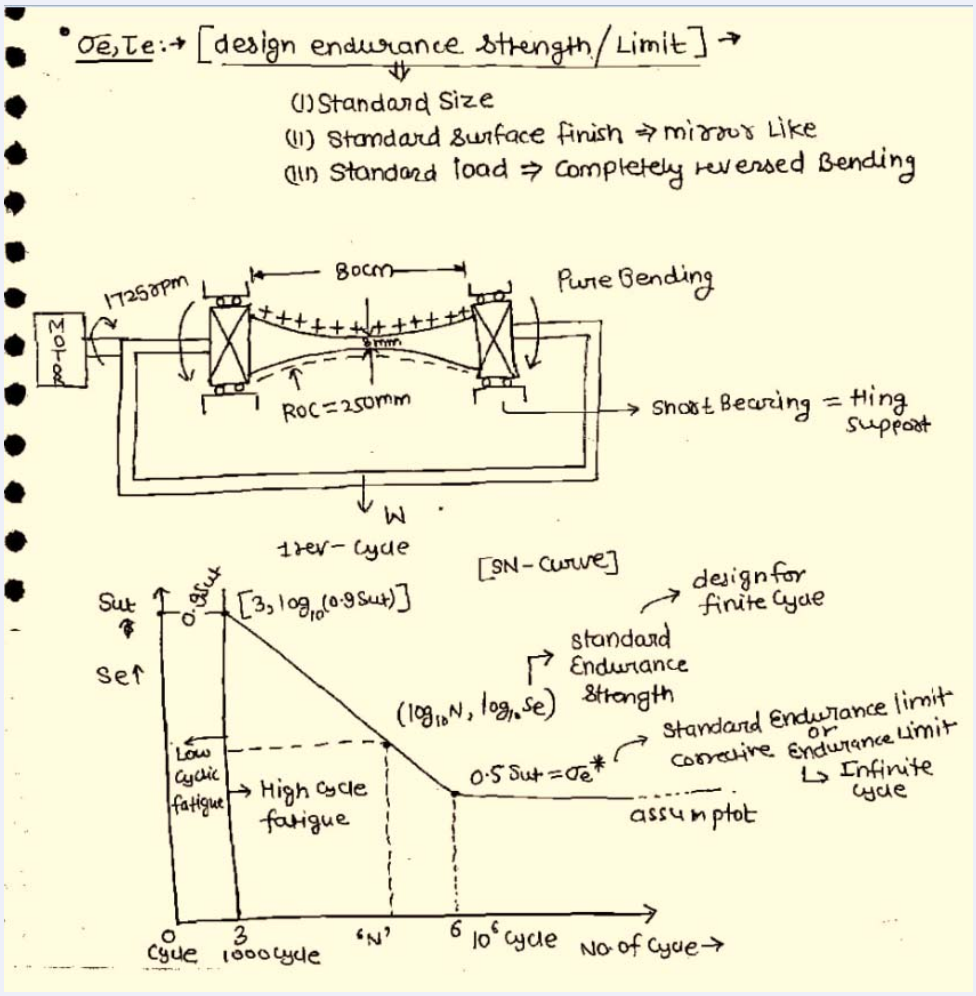
138. Consider the following statements regarding endurance limit and fatigue life:
1. Since the fatigue test cannot be conducted for unlimited or infinite number of cycles, 10^6 cycles are considered as sufficient number of cycles to define the endurance limit.
2. The fatigue life is defined as the number of stress cycles that the standard specimen can complete during the test before the appearance of the first fatigue crack.
3. The S-N curve is the graphical representation of stress amplitude versus number of stress cycles before the fatigue failure on a log-log graph paper.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only

(c) 1 and 3 only (d) 1, 2 and 3

Ans. (d)



End of Solution

139. Consider the following statements regarding surface finish factor:

1. The surface scratches serve as stress raisers and result in stress concentration.
2. The endurance limit is reduced due to introduction of stress concentration at surface scratches.
3. As the ultimate tensile strength increases, the surface finish factor also increases.

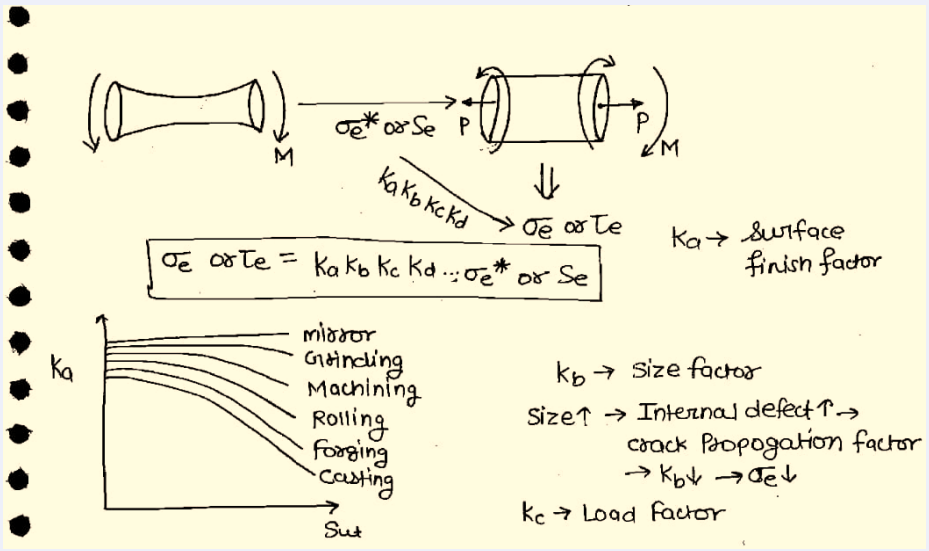
Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only

(c) 1 and 3 only (d) 1, 2 and 3

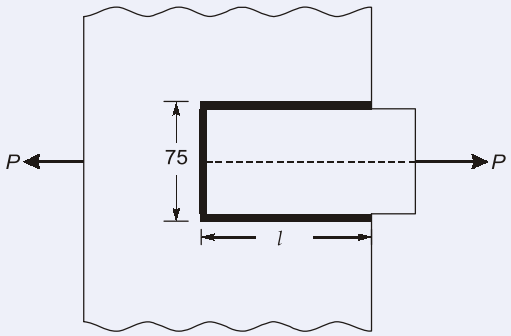
Ans. (a)

Endurance limit increases as the surface finish factor increases. Tensile strength is not a function of surface finish factor.



End of Solution

140. A plate, 75 mm wide and 10 mm thick, is joined with another steel plate by means of single transverse and double parallel fillet welds as shown in the figure. The joint is subjected to a maximum tensile force of 55 kN. The permissible tensile and shear stresses in the weld material are 70 N/mm^2 and 50 N/mm^2 respectively. What is the required length of each parallel fillet weld after adding 15 mm for starting and stopping of the weld run?



(a) 40.29 mm (b) 55.83 mm
(c) 50.74 mm (d) 60.16 mm

Ans. (a)

Given : P = 55 kN = 55 × 10^3 N; σ_{per} = 70 N/mm^2; τ_{per} = 50 N/mm^2

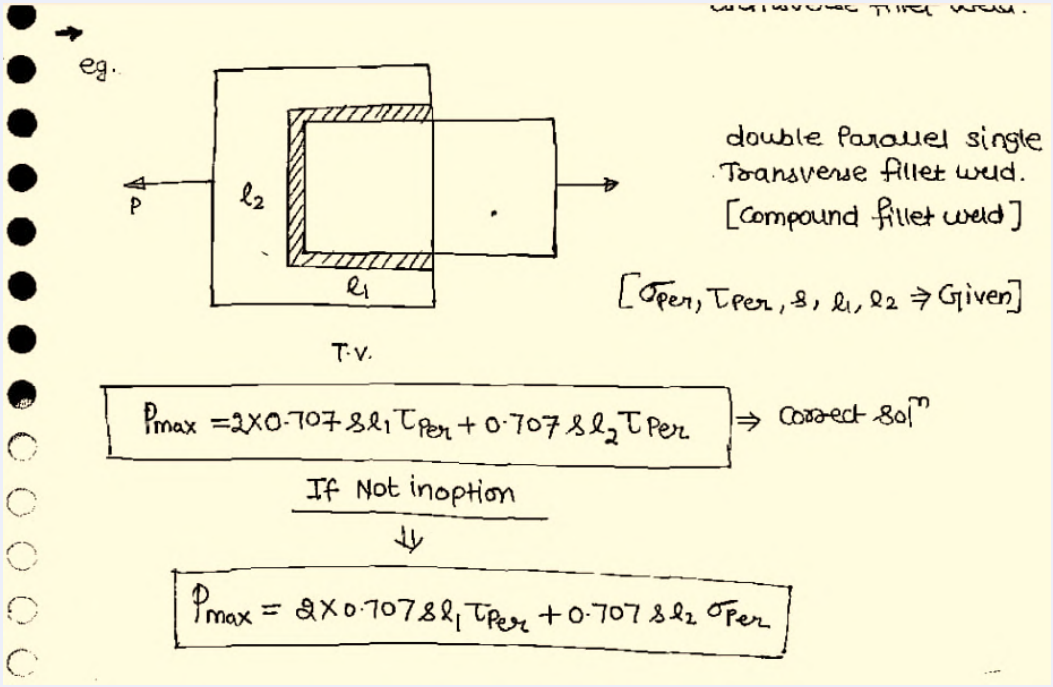
As we know, $P = 0.707 \times 75 \times 10 \times 70 + 2 \times 0.707 \times l \times 10 \times 50$

$55 \times 10^3 = 33117.5 + 707l$

l = 25.293 mm

Required length of each parallel fillet weld = l + 15 mm

= 25.29 + 15 = 40.29 mm



End of Solution

141. A cylindrical pressure vessel with 1 m inner diameter is subjected to internal steam pressure of 1.5 MPa. The thickness of the plate is 14 mm and the diameter of rivets is 23 mm. The permissible stress for the cylinder plate and the rivets in shear is 60 N/mm^2. Find the total number of rivets.

(a) 23 (b) 37

(c) 48 (d) 51

Ans. (c)

Given : D = 1 m; P = 1.5 MPa; t = 14 mm; d = 23 mm; τ_{per} = 60 N/mm^2

[Assuming longitudinal joint]

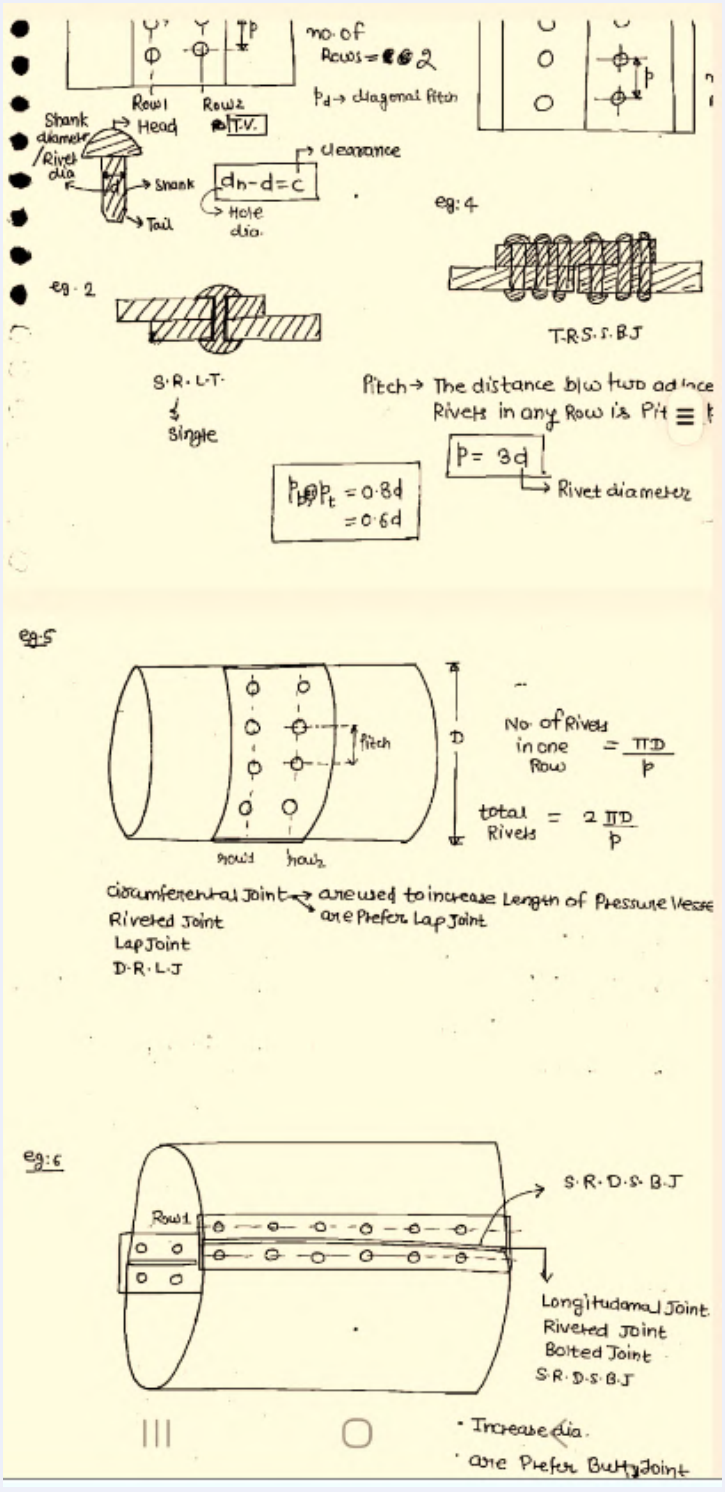
According to question,

$$P \times A = n \times \frac{\pi}{4} \times d^2 \times \tau_{per}$$

$$1.5 \times \frac{\pi}{4} \times (1000)^2 = n \times \frac{\pi}{4} \times (23)^2 \times 60$$

$$n = 47.26$$

$$n \simeq 48$$



End of Solution

142. Consider the following statements regarding bolt of uniform strength:
1. Resilience is defined as the ability of the material to absorb energy when deformed elastically and to release this energy when unloaded.
2. The shock-absorbing capacity of bolt can be decreased if the shank of bolt is turned down to a diameter equal to the root diameter of threads.
3. The resilience of the bolt can also be increased by increasing its length.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (c)

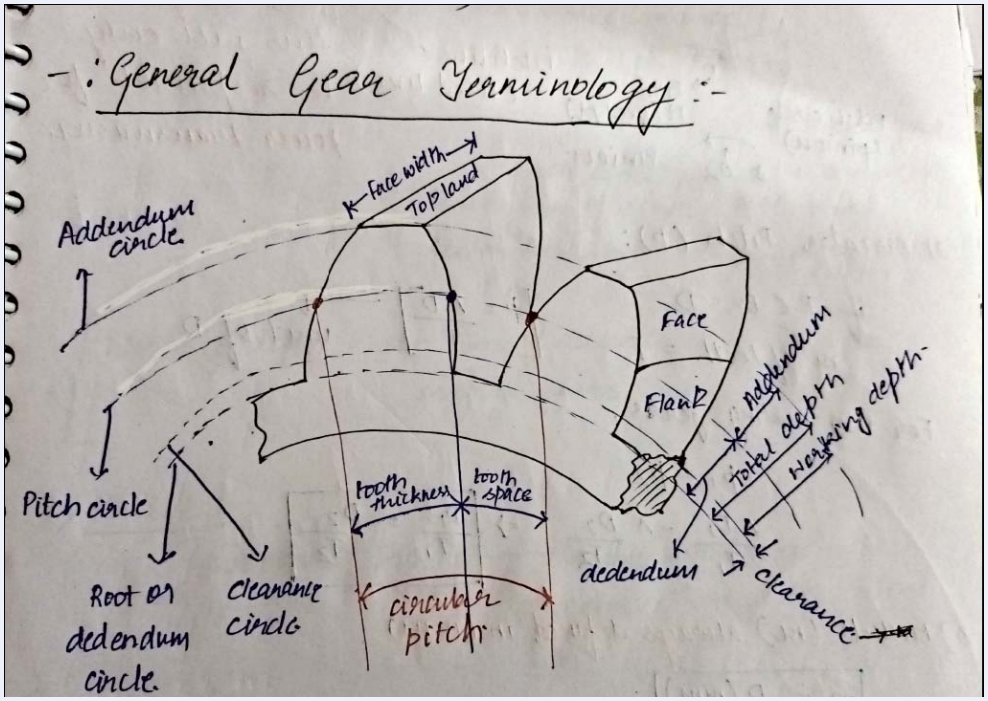
The shock absorbing capacity of bolt can be increases if the shank of bolt is turned down to a diameter equal to the root diameter of threads.

End of Solution

143. What is 'addendum' of a gear tooth?
(a) The radial distance between pitch and dedendum circle
(b) The height of the tooth above the pitch circle
(c) The width of the tooth space at the pitch circle
(d) The size of the gear tooth's fillet radius

Ans. (b)

Addendum is the radial distance between the pitch circle and the top of the tooth (addendum circle) of a gear.



End of Solution

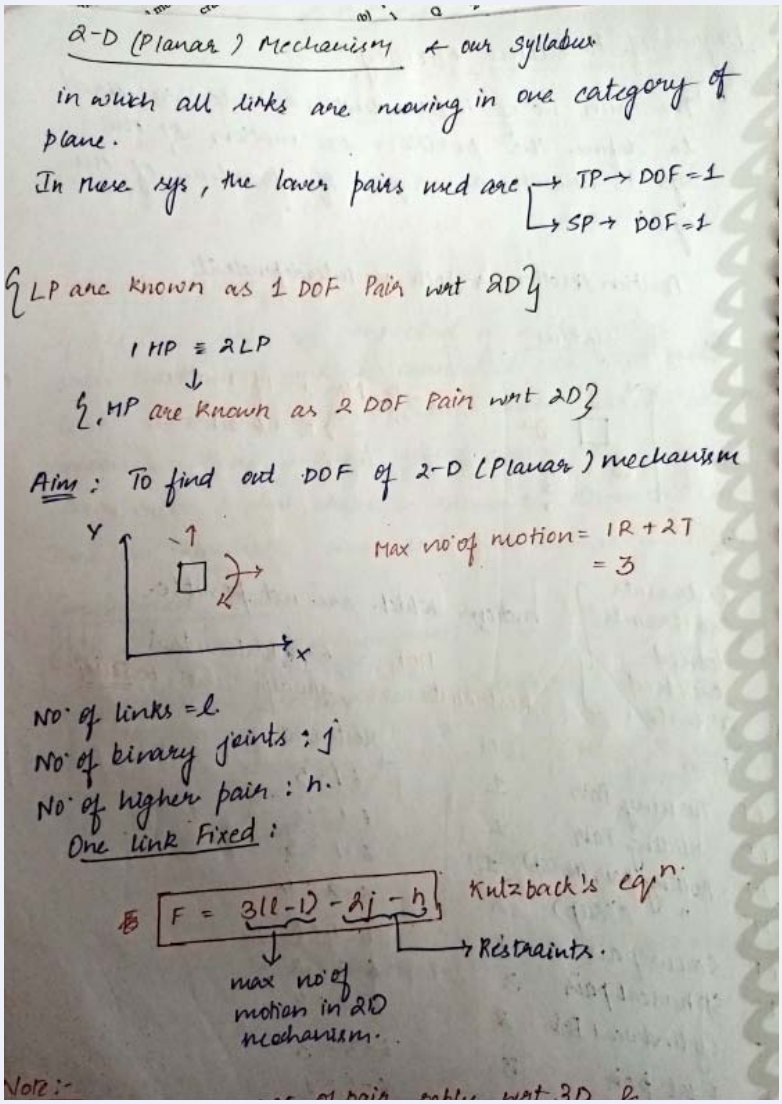
144. What is the resulting mobility m of a planar n-link mechanism, when we use j_1 to denote the number of single-degree-of-freedom pairs and j_2 for the number of two-degree-of-freedom pairs?

(a) $3(n-1)-2j_1-j_2$ (b) $3(n-1)-j_1-2j_2$

(c) $3(n-2)-2j_1-j_2$ (d) $3(n-2)-j_1-2j_2$

Ans. (a)

$$DOF = 3(n-1)-2j_1-j_2$$



End of Solution

145. Which one of the following is a low-level type condenser that operates without extraction pump?

(a) Barometric condenser (b) Low-level jet condenser

(c) Ejector condenser (d) Mixing type condenser

Ans. (c)

An ejector condensor uses steam ejectors (or steam jets) to create a vacuum and remove condensate and air without the need for an extraction pump.

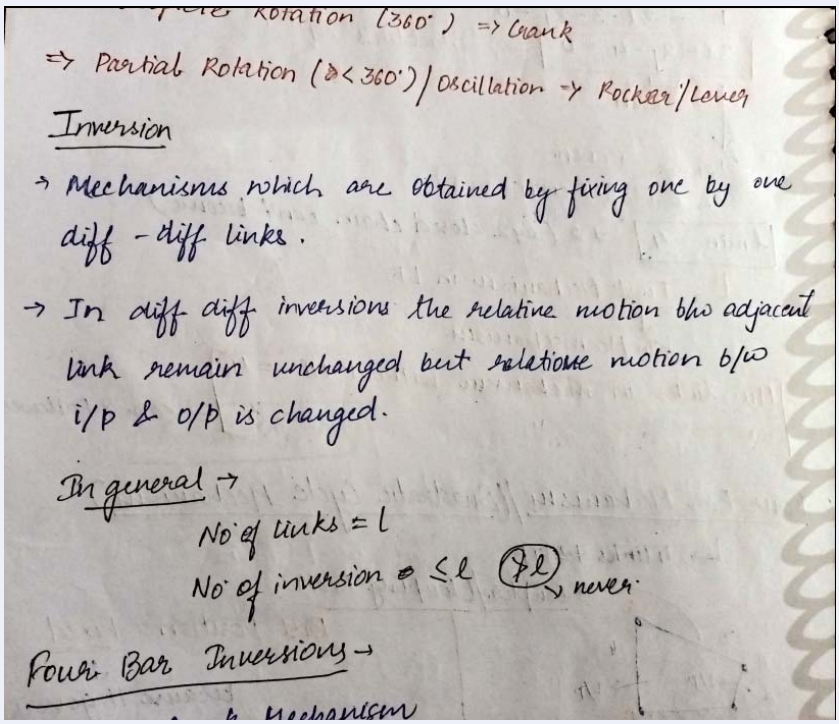
End of Solution

146. What is the method of obtaining different mechanisms by fixing different links of a kinematic chain?

(a) Crank-rocker (or lever) mechanism (b) Crank-crank (or double crank) mechanism
(c) Inversion of the mechanism (d) Grashof's law

Ans. (c)

Inversion is a process of obtaining different mechanisms by fixing different links of a kinematic chain, one at a time.



End of Solution

147. Consider the following statements regarding instantaneous centres:

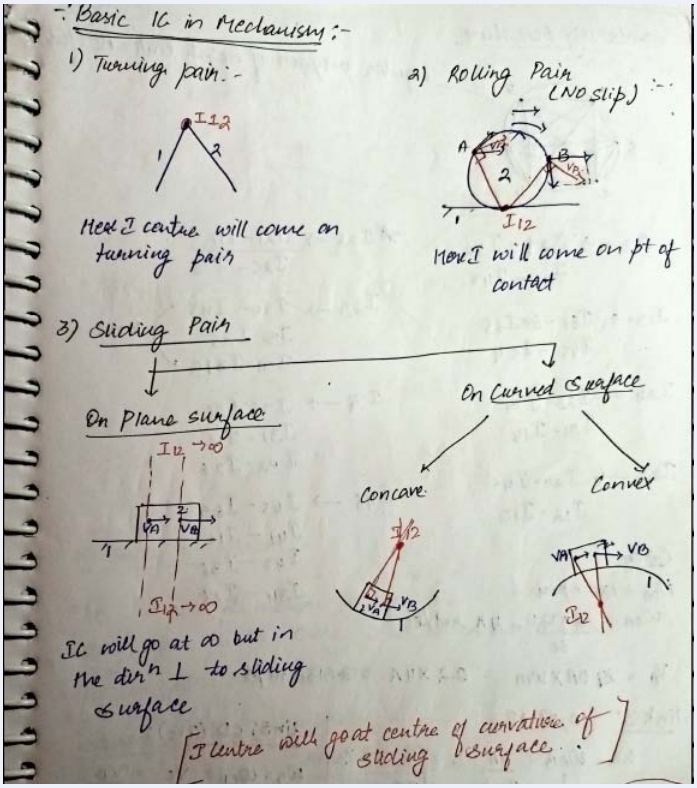
1. For a pivoted or pin joint, the instantaneous centre for the two links lies on the centre of the pin.
2. In a pure rolling contact of the two links, the instantaneous centre lies at their point of contact.
3. In a sliding motion, the instantaneous centre lies at infinity in a direction perpendicular to the path of motion of the slider.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (d)

Motion type	Instantaneous centre location
1. Pin joint	At the centre of the pin
2. Pure rolling	At point of contact
3. Sliding motion [Rectilinear motion]	At infinitely (perpendicular to motion direction)
4. Curvilinear motion [Convex/concave surface]	Centre of curvature



End of Solution

148. Match the following lists:

List-I	List-II
P. Base circle	1. It is the smallest circle drawn to the pitch curve from the centre of rotation of the cam
Q. Prime circle	2. It is the circle drawn through the centre and pitch point
R. Pitch circle.	3. It is the smallest circle that can be drawn to the cam profile from the centre of rotation

Select the correct answer using the code given below.

(a) P Q R
2 3 1

(b) P Q R
1 2 3

(c) P Q R
3 1 2

(d) P Q R
3 2 1

Ans. (c)

A radial cam with reciprocating roller follower is shown in Fig. (above). The following nomenclature is used in reference to planar cam mechanisms :

Base circle	:	It is the smallest circle tangent to the cam profile drawn from the centre of rotation of a radial cam.
Prime circle	:	It is the smallest circle drawn tangent to the pitch curve from the centre of rotation of the cam.
Pitch point	:	It is a point on the pitch curve having the maximum pressure angle.
Pitch circle	:	It is the circle drawn through the centre and passing through pitch point.
Trace point	:	It is a reference point on the follower and is used to generate the pitch curve. In the case of a knife edge follower, it is the knife edge, and in the case of a roller follower, it is the centre of the roller.
Pitch curve	:	It is the curve generated by the trace point as the follower moves relative to the cam. Pitch curve can be assumed to be drawn by the trace point assuming that the cam is fixed, and the trace point of the follower rotates around the cam.

End of Solution

149. What is the damping ratio (ζ) of critically damped system?

(a) $\zeta = 1$ (b) $\zeta < 1$

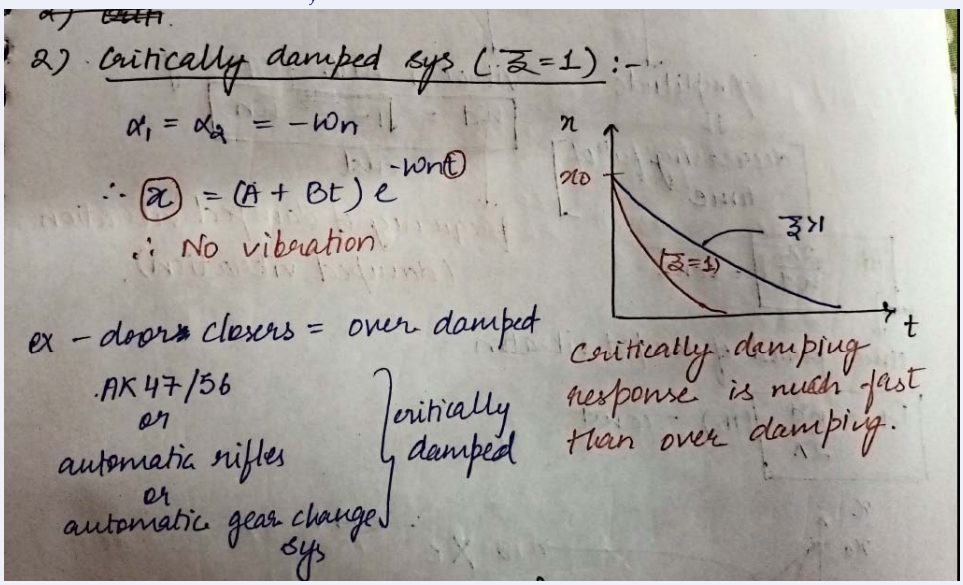
(c) $\zeta > 2$ (d) $1 < \zeta < 2$

Ans. (a)

Damping ratio is the ratio of actual damping in a system to critical damping.

$$\zeta = \frac{C}{C_C}$$

$\zeta_y = 1$ for critical damping



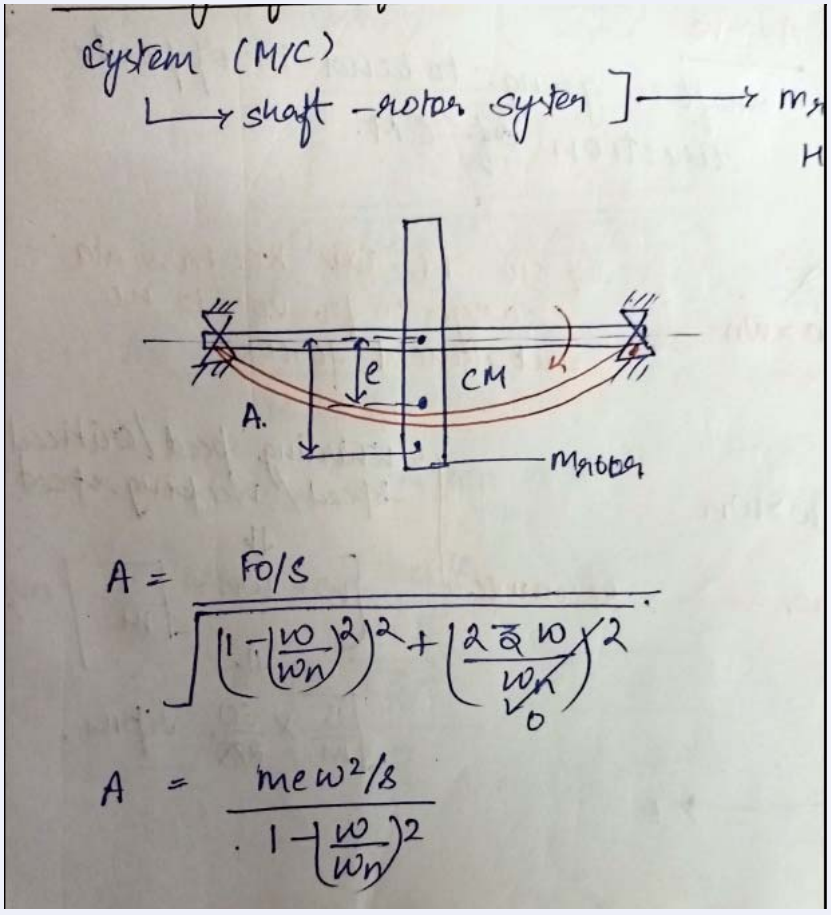
End of Solution

150. The critical speed of a rotating shaft is the speed at which the shaft starts to vibrate violently in

(a) the linear direction
(b) the transverse direction
(c) the rotational direction or ti
(d) the non-linear direction

Ans. (b)

The critical speed of a rotating shaft is the speed at which the natural frequency of transverse vibration matches the rotational speed of the shaft. At this speed, resonance occurs, leading to large amplitude transverse vibrations. This can cause violent vibrations. Potential damage or failure of the shaft.



End of Solution

■■■■

MADE EASY students top in ESE 2024

• 4 Streams 4 Toppers all 4 MADE EASY Students • 40 out of 40, in Top 10 • 197 out of total 206 Vacancies (95% Selections)

CE 10 in Top 10

1 AIR	2 AIR	3 AIR	4 AIR	5 AIR	6 AIR	7 AIR	8 AIR	9 AIR	10 AIR
ROHIT DHONDGE	HARSHIT PANDEY	LAXMIKANT	D MADHANKUMAR	AMAN PRATAP SINGH	SANCHIT GOEL	SUNIL SEERVI	ROHIT KUMAR	ANKIT MEENA	BADUGU RAJESH
CLASSROOM COURSE	CLASSROOM COURSE	CLASSROOM COURSE	CLASSROOM COURSE	CLASSROOM COURSE	CLASSROOM COURSE	CLASSROOM COURSE	CLASSROOM COURSE	TEST SERIES & IGP	ONLINE COURSE

ME 10 in Top 10

1 AIR	2 AIR	3 AIR	4 AIR	5 AIR	6 AIR	7 AIR	8 AIR	9 AIR	10 AIR
MUNISH KUMAR	RAJESH KASANIYA	GOLLANGI SATEESH	D. AJINKYA RADHAKISAN	BANKURU NAVEEN	CHANDAN JOSHI	DINESH KR. SHARMA	SHAILENDRA SINGH	KRISHNA K. DWIVEDI	V. AKSHAY SANTOSH
TEST SERIES & IGP	ONLINE COURSE	TEST SERIES & IGP	CLASSROOM COURSE	CLASSROOM COURSE	ONLINE COURSE	CLASSROOM COURSE	CLASSROOM COURSE	CLASSROOM COURSE	IGP

EE 10 in Top 10

1 AIR	2 AIR	3 AIR	4 AIR	5 AIR	6 AIR	7 AIR	8 AIR	9 AIR	10 AIR
RAJAN KUMAR	SATYAM CH. KHAIRNAR	PRIYANSHU MUDGAL	NAMAN AGARWAL	MAYANK KUMAR SINGH	RITVIK KOK	MANTHAN SHARMA	MAYANK JAIMAN	ANMOL SINGH	AKSHIT PARASHARI
CLASSROOM COURSE	CLASSROOM COURSE	ONLINE COURSE	ONLINE COURSE	CLASSROOM COURSE	ONLINE COURSE	CLASSROOM COURSE	ONLINE COURSE	ONLINE COURSE	ONLINE COURSE

E&T 10 in Top 10

1 AIR	2 AIR	3 AIR	4 AIR	5 AIR	6 AIR	7 AIR	8 AIR	9 AIR	10 AIR
HIMANSHU THAPLIYAL	YASHASVI VIJAYVARGIYA	UNNATI CHANSORIA	RAJIV RANJAN MISHRA	PARAG SAROHA	CHANDRIKA GADGIL	DEBARGHYA CHATTERJEE	VIDHU SHREE	T. PIYUSH DAYANAND	RAJVARDHAN SHARMA
CLASSROOM COURSE	CLASSROOM COURSE	ONLINE COURSE	CLASSROOM COURSE	ONLINE COURSE	CLASSROOM COURSE	CLASSROOM COURSE	ONLINE COURSE	CLASSROOM COURSE	CLASSROOM COURSE

MADE EASY students top in GATE 2025

• 10 All India Rank 1 (CE, ME, IN, ES & EE) • 46 Selections in Top 10 • 401 Selections in Top 100

CE 10 in Top 10

AIR CE 1	AIR CE 2	AIR CE 3	AIR CE 4	AIR CE 5
ABHAY SINGH	HARSHVARDHAN SINGH	PANKAJ MEENA	HARSHIL MAHESHWARI	KARTIK POKHRIYAL
CLASSROOM COURSE	CLASSROOM COURSE	CLASSROOM COURSE	ONLINE COURSE	CLASSROOM COURSE

AIR CE 6	AIR CE 6	AIR CE 9	AIR CE 10	AIR CE 10
SHIVANAND CHAURASIA	NIMISH UPADHYAY	TARUN YADAV	ADNAN QUASAIN	RAHUL SINGH
ONLINE COURSE	ONLINE COURSE	CLASSROOM COURSE	CLASSROOM COURSE	ONLINE COURSE

ME+PI 14 in Top 10

AIR ME 1	AIR ME 2	AIR ME 3	AIR PI 3	AIR PI 5	AIR PI 6	AIR PI 7
RAJNEESH BIJARNIYA	GOLLANGI SATEESH	NIMESH CHANDRA	ADITYA KUMAR PRASAD	KULDEEP SINGH NARUKA	KAUSHAL KUMAR KAUSHIK	WALEED SHAIKH
CLASSROOM COURSE	ONLINE COURSE	CLASSROOM COURSE	CLASSROOM COURSE	CLASSROOM COURSE	ONLINE COURSE	TEST SERIES

AIR ME 7	AIR ME 8	AIR ME 10	AIR ME 10	AIR ME 10	AIR ME 10	AIR PI 10
ABHINN	GOUTAM KUMAR	ASHUTOSH KUMAR	JETTI GANATEJA	MUHAMMED SINAN K	PITCHIKA KUMAR VASU	M GOPU GANESH
CLASSROOM COURSE	TEST SERIES	CLASSROOM COURSE	TEST SERIES	TEST SERIES	ONLINE COURSE	TEST SERIES

EE+CS 6 in Top 10

AIR EE 1	AIR EE 2	AIR EE 6	AIR EE 6	AIR CS 9	AIR EE 10
PRADIP CHAUHAN	KAILASH GOYAL	PUNEET SONI	SHIVAM KUMAR GUPTA	OMHARI	NEELAVA MUKHERJEE
TEST SERIES	CLASSROOM COURSE	TEST SERIES	TEST SERIES	TEST SERIES	POSTAL PACKAGE & TEST SERIES

IN+EC 9 in Top 10

AIR IN 1	AIR EC 2	AIR IN 2	AIR IN 5	AIR EC 5	AIR EC 6	AIR IN 6	AIR IN 7	AIR EC 9
KAILASH GOYAL	ANKUSH PHILIP JOHN	S. BHATTACHARYA	SACHIN YADAV	M. M. NAFEEZ	PENTELA BHAVANI	UTKARSH PATIL	DEV J. PATEL	CHILUKURI S. CHARAN
CLASSROOM COURSE	POSTAL PACKAGE & TEST SERIES	TEST SERIES	TEST SERIES	TEST SERIES	TEST SERIES	CLASSROOM COURSE	TEST SERIES	TEST SERIES

ES+XE 7 in Top 10

AIR ES 1	AIR ES 2	AIR ES 2	AIR XE 3	AIR ES 5	AIR ES 7	AIR XE 9
YASH JAIN	JITESH CHOUDHARY	TARUN YADAV	ROHAN KUMAR BISWAL	SACHIN KUMAR	ANKIT KUMAR	APAR HARSH CHANDRA
CLASSROOM COURSE	CLASSROOM COURSE	CLASSROOM COURSE	TEST SERIES	CLASSROOM COURSE	CLASSROOM COURSE	CLASSROOM COURSE

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