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# ESE - 2025

## Preliminary Examination

# QUESTIONS WITH DETAILED SOLUTIONS

# MECHANICAL ENGINEERING

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# SUBJECTWISE WEIGHTAGE

| S.No. | Name of the Subject | No. of Questions |
|---|---|---|
| 01 | Fluid Mechanics & Turbo-machinery | 18 |
| 02 | Heat Transfer | 2 |
| 03 | Machine Design | 9 |
| 04 | Strength of Materials | 8 |
| 05 | Renewable Sources of Energy | 14 |
| 06 | Basic Thermodynamics | 18 |
| 07 | Refrigeration & Air Conditioning | 7 |
| 08 | IC Engines | 5 |
| 09 | Power plant | 14 |
| 10 | Engineering Mechanics | 3 |
| 11 | Production Engineering | 5 |
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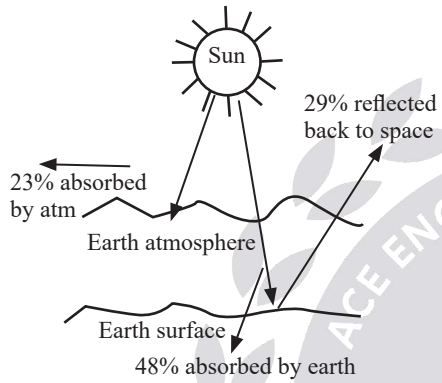
| 15 | Mechatronics and Robotics | 13 |
| 16 | Maintenance Engineering | 2 |
| **Total No. Of Questions** | | **150** |

01. The percentage of incoming radiation energy reflected back to space by the earth is about
(a) 10 % (b) 20 %
(c) 30 % (d) 40 %

**01. Ans: (c)**

**Sol:**




Approximately 30% of incoming solar radiation is energy reflected back to space by the earth.

02. 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

**02. Ans: (a)**

**Sol: Flat plate collector:** Glass cover plate should have high transmissivity of short waves and low transmissivity of long waves.
Absorber plate should have high absorptivity and low reflectivity, high thermal conductivity.
Eg: Copper is best material for absorber plate.
Statement (3) is not correct.

03. 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

**03. Ans: (a)**

**Sol:** Performance indices of solar collector.
1. Temperature range: Range of temperature to which the heat transporting fluid is heated up by the collector.
2. Collector efficiency:
$$= \frac{\text{Heat energy gain by fluid}}{\text{Incident solar energy}}$$
3. Concentration ratio
$$= \frac{\text{Area of aperture}}{\text{Area of receiver}}$$

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| | |
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| Verbal Ability | 10 Questions |

| | |
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04. 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

**04. Ans: (a)**

**Sol:** Solar thermal system applications:
- Space heating in cold climate regions
- Low grade thermal applications
- Used in drying industries. Eg: drying agricultural products.

05. 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

**05. Ans: (d)**

**Sol:** Chemical energy in hydrogen can be converted into thermal energy. Ex: combustion of hydrogen releases heat.
Hydrogen as a fuel to create steam can run turbines.
In fuel cell, hydrogen as a fuel, which convert chemical energy into electrical energy.

06. 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

**06. Ans: (c)**

**Sol:** Passive systems do not require any mechanical device and make use of natural processes.
Eg: Trombe wall.
Active heating system require mechanical devices like pumps/fans.
Statement (2) is not correct.

07. 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

**07. Ans: (c)**

**Sol:** In absorption cooling system, two working fluids are used.

1. Refrigerant
2. Absorbent

The absorbent must have high affinity for the refrigerant to absorb it effectively.

Statement (2) is not correct.

08. 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 3 only (d) 1, 2 and 3

**08. Ans: (d)**

**Sol:** All the given statements regarding solar green house are correct.

09. Consider the following statements regarding solar distillation :

1. Distillation is the process to convert saline water into freshwater.
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

**09. Ans: (*)**

**Sol:** Brackish water has a salinity higher than fresh water but lower than sea water. Brackish water accounts for a very small percentage of the total water on earth, around 1%.

The majority of water on Earth is/saline (sea water) approximately 96.5% with a very small portion of fresh water around.

Statement (2) & (3) are not correct.

10. Consider the following statements regarding wind energy :

1. A generator coupled to wind turbine is known as aero generator.
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

**10. Ans: (b)**

**Sol:** Horizontal axis windmills were first developed in the middle East and not by Australians. So statement (2) is incorrect.

The horizontal axis windmill was actually introduced in Europe (especially the Netherlands) around the 12th century, not by Australians. Windmills existed even earlier in Persia, but those were vertical-axis types.

11. 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

**11. Ans: (a)**

**Sol:** In single effect scheme, power is generated either during filling (flood) or during emptying (ebb), but not both. So statement (3) is incorrect.

12. 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

**12. Ans: (a)**

**Sol:** Concentrated vegetable oils obtained from Agro products can be used in diesel engines. Eg.: Biodiesel produced from vegetable oil.

13. Consider the following statements regarding fuel cell :
    1. A fuel cell continuously converts mechanical energy directly into electrical energy.
    2. Fuel cell is a static power conversion device.
    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

**13. Ans: (c)**

**Sol:** A fuel cell is an electro-chemical cell that convert chemical energy of hydrogen & oxygen into electrical energy with a by product of water.

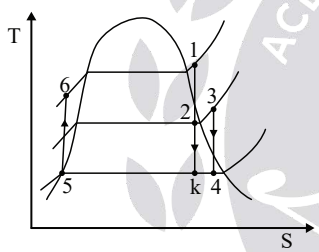
14. Consider the following statements regarding reheating in Rankine cycle:
    1. Erosion and corrosion problems in the steam turbine are eliminated.
    2. Final dryness fraction of steam is improved.
    3. There is decrease in the nozzle and blade efficiencies.

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

**14. Ans: (a)**

**Sol:** Because of reheating the moisture content in steam will be less even at the lateral stages of turbine. Therefore erosion and corrosion problem can be eliminated.

No way nozzle efficiency is affected by reheating mechanism.

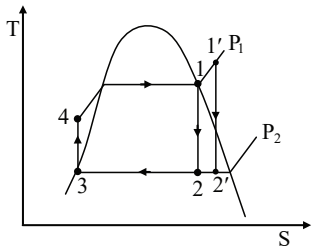



1-k-5-6-1 ⇒ Rankine cycle without reheating
1-2-3-4-5-6-1 ⇒ Rankine cycle with reheating

15. 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

**15. Ans: (b)**

**Sol:**




1-2-3-4-1 ⇒ Rankine cycle with saturated vapor
1′-2′-3-4-1′ ⇒ Rankine cycle with superheated vapor

Because of superheating the steam moisture content at the exit of the steam turbine is less.

16. 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

**16. Ans: (c)**

**Sol:** If reheating is done at optimum pressure ($P_{RH} = 0.25\ P_i$ to $0.35\ P_i$), there is a possibility to increase the efficiency of plant.

$P_i$ = steam pressure at inlet of turbine

Because of reheating, the condenser load increases (i.e., heat rejection in condenser increases)

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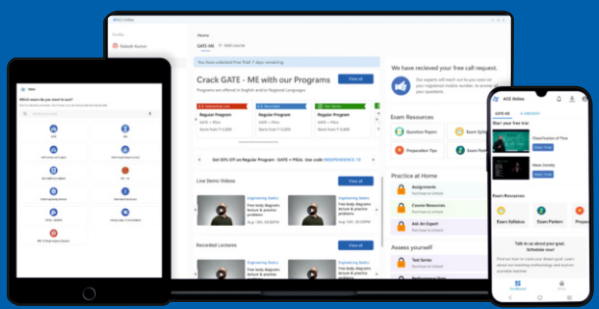


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17. In case of a steam turbine working on Rankine cycle, the work done per kg of steam flowing through the turbine and the amount of total heat supplied during the processes are 1080 kJ/kg and 3076.1 kJ/kg respectively. What is the thermal efficiency of the cycle?
(a) 23.7% (b) 29.3%
(c) 35.1 % (d) 41.4%

**17. Ans: (c)**

**Sol:** Work done per kg, WD = 1080 kJ/kg
Total heat supplied, $Q_s$ = 3076.1 kJ/kg

$$\eta_{th} = \frac{WD}{Q_s} \times 100$$

$$= \frac{1080}{3076.1} \times 100 = 35.1\ \%$$

18. 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

**18. Ans: (b)**

**Sol:** Since the feed water available for boiler is at high temperature with regeneration, the temperature difference between steam available from boiler and water available for boiler is low.
Smaller the temperature difference, the process tends to become reversible.
With regeneration, steam available for condensation is low, therefore condenser load decreases.

19. 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

**19. Ans: (d)**

**Sol:** A grade written as 5 - 10 cm,
500-AS-F-24-S1.6 indicates the coal has
- a size of 5 - 10 cm
- heating value of 5000 kcal/kg
- 8 to 10% ash
- ash softening temperature of 2400 - 2590°F, and sulphur content of 1.4 to 1.6%

A rank and grate of a coal gives a complete report of the material.

20. 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%

**20. Ans: (c)**

**Sol:** $m_s$ = 360 kg/hr
$Q_s$ = 2560.6 kJ/kg $\Rightarrow$ HS to steam
(i.e., heat utilised for producing steam)
CV = 29245.4 kJ/kg
$m_f$ = 60 kg/hr

$$\eta_b = \frac{m_s(Q_s)}{m_f \times CV} \times 100$$

$$= \frac{360 \times 2560.6}{29245.4 \times 60} \times 100 = 52.53\ \%$$

21. 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

**21. Ans: (a)**

**Sol:** Locomotive boiler is a fire tube boiler in which fire tubes are immersed in water.

22. 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

**22. Ans: (c)**

**Sol:** Babcock and Wilcox boiler is natural circulation water tube boiler.

23. 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
    (a) factor of evaporation
    (b) boiler efficiency
    (c) overall efficiency
    (d) evaporation efficiency

**23. Ans: (a)**

**Sol:** 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.

24. 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%

**24. Ans: (c)**

**Sol:** WD /kg = 7600 Nm

$(dh)_{stage}$ /kg = 10040 Nm

$$\eta_{stage} = \frac{WD/kg}{\frac{(dh)_{stage}}{kg}} \times 100$$

$$= \frac{7600}{10040} \times 100 = 75.69\ \%$$

25. 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

**25. Ans: (c)**

**Sol:** The leakage air in the condenser results in increase in back pressure on the prime mover.

26. 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

**26. Ans: (a)**

**Sol:** For centrifugal pump, following design parameters are used

$k_u = 0.95$ to 1.25

$k_f = 0.1$ to 0.25

$z = 6$ to 12

(low to medium head pumps)

27. 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

**27. Ans: (d)**

**Sol:** $\eta_{mano} = \dfrac{gH_m}{u_2 V_{w2}} = \dfrac{gH_m}{u_2^2}$

$\{\because u_2 = V_{w2}$ for radialvane pump$\}$

$\therefore \quad H_m = \eta_{mano} \times \dfrac{u_2^2}{g} = \dfrac{0.82}{9.81} \times \left(\dfrac{\pi \times 0.3 \times 1450}{60}\right)^2$

$H_m = \dfrac{0.82}{9.81} \times 22.78^2 = 43.38$ m

28. 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

**28. Ans: (c)**

**Sol:** $N_s = \dfrac{N\sqrt{a}}{H^{3/4}}$

$35 = \dfrac{1500 \times \sqrt{0.4}}{H^{3/4}}$

$H = 81.4$ m

Number of pumps $= \dfrac{\text{Total head}}{\text{head per pump}}$

$= \dfrac{240}{81.4} \approx 3$ pumps

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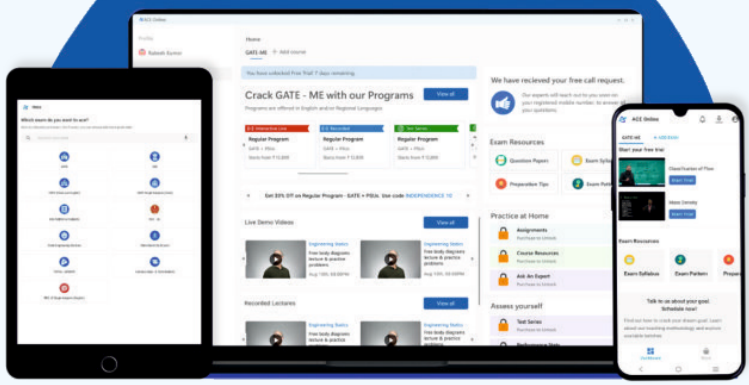


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29. Consider the following statements regarding reciprocating pumps:
    1. The ratio of theoretical discharge to actual discharge is known as coefficient of discharge.
    2. The difference between theoretical discharge and actual discharge is called 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

**29. Ans: (c)**

**Sol:**
1. $C_d = \frac{Q_{actual}}{Q_{th}}$
2. Slip $= Q_{th} - Q_{actual}$
3. In double acting pump, the pumping action takes place on both sides of piston.

30. 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

**30. Ans: (a)**

**Sol:**
1. Air vessels reduce pumping power by reducing frictional loss in pipe
2. Air vessels reduce frictional loss by maintaining lower velocity pipe.
3. Air vessels reduce chances of cavitation by maintaining higher pressure at pump inlet. Hence, cavitation susceptibility is reduced.

31. 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.

**31. Ans: (c)**

**Sol: Gas turbine power plant:**
- Peak temperature is high
- Peak pressure is low

**Steam turbine power plant:**
- Peak temperature is low
- Peak pressure is high

32. 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.

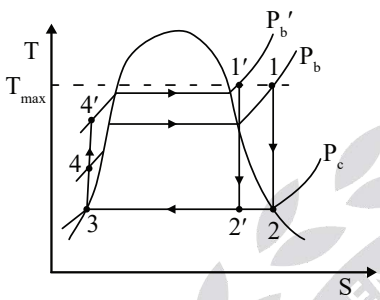
Which of the above statements are correct?

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

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

**32. Ans: (d)**

**Sol:**




For same maximum superheated temperature of steam, if boiler pressure ($P_b$) increases for same condensation pressure ($P_c$).

- Moisture content increases in lateral part of turbine.
- Condenser load decreases.
- Water enters to boiler at high temperature.
- Efficiency increases.
- $(T_{sat})_{Pb'} > (T_{sat})_{Pb}$
- Stage efficiency decreases due to more moisture in steam at the lateral stages.

33. 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

**33. Ans: (c)**

**Sol:** $N_s = \frac{N\sqrt{P}}{H^{5/4}} = \frac{150 \times \sqrt{6500}}{15^{5/4}} = 409.7 \approx 410$

34. 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

**34. Ans: (a)**

**Sol:** Ramjet engine needs some external help to lift upto certain height and to accelerate since it has no compressor and turbine (i.e., no self starting mechanism).

Ram jet engine is a supersonic system.

35. Consider the following statements about advantages of a pulse-jet engine :

1. A pulse-jet 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

**35. Ans: (a)**

**Sol:** Pulse jet engine has no self starting mechanism (i.e., it has no compressor and turbine).

It is also called flying bomb (it is preferably used by military force).

36. 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 2 only
(b) 1 and 3 only
(c) 2 and 3 only
(d) 1, 2 and 3

**36. Ans: (a)**

**Sol:** Turbojet is practically using for both local flights and internal flights.
After burner (reheat) enhance the thrust force of turbojet engine.
For effective combustion of fuel in CC, the flow should be decelerated for that purpose the inlet diffuser is significant.

37. 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

**37. Ans: (b)**

**Sol:** Centrifugal compressor is the best compressor for large volume flow rate at medium or low pressure.
Centrifugal compressor efficiency is less compared to axial flow compressor, because the pressure rise per stage of axial flow compressor is low (adverse pressure gradient is low) and flow enters, flowing and leaving axially (without any deflections in the flow).

38. 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

**38. Ans: (a)**

**Sol:** Degree of reaction for an axial flow compressor,

$$R_d = \frac{(dP)_{rotor}}{(dP)_{rotor} + (dP)_{stator}} = \frac{(dP)_{MB}}{(dP)_{stage}}$$

(or) $R_d = \frac{(dh)_{MB}}{(dh)_{stage}}$ (MB = movable blade)

39. 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

**39. Ans: (a)**

**Sol:** Molecular weights of elements,

C = 12 g/mol

O = 16 g/mol

Molecular weight of CO is $M_{CO} = 28$

40. 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

**40. Ans: (d)**

**Sol:** As the throttle is almost closed, a high vacuum is created in the intake manifold.

When quick deceleration is desired and the throttle is closed at high engine speed a very large vacuum is created in the intake system.

For starting the engine in cold climate, a very rich mixture is required.

41. 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 be atomization 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

**41. Ans: (a)**

**Sol:**

- The smaller the fuel drop size emitted by the injector, the more efficient will be atomization process.
- Fine droplets have more surface area, leading to better mixing with air quickly. This ensure more complete and efficient combustion, resulting in better power output, fuel economy and lower emissions.
- Fuel droplets break into very small droplets in a diesel engine during atomization because of the high pressure injection into a relatively lower pressure combustion chamber.

42. Consider regarding the following statements 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

**42. Ans: (c)**

**Sol:** If the injection is too early, ignition delay time will increase.

The cetane no. of a diesel fuel is a measure of its ignition quality.

A lower cetane number means longer ignition delay.

A higher cetane number means shorter ignition delay.

At higher engine speeds, the ignition delay generally decreases.

43. 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

**43. Ans: (a)**

**Sol:** Addition of hydrocarbon emissions to the exhaust during the scavenging process takes place primarily in two-stroke engines due to incomplete combustion and loss of unburned fuel.

In two stroke engines, the air fuel intake mixture is used to help push out the residual exhaust gases from the cylinder through the open exhaust port during scavenging process.

In two stroke engines, lubricating oil is not fully combustible as readily as fuel.

44. Consider the following statements regarding vapour compression refrigeration cycle:

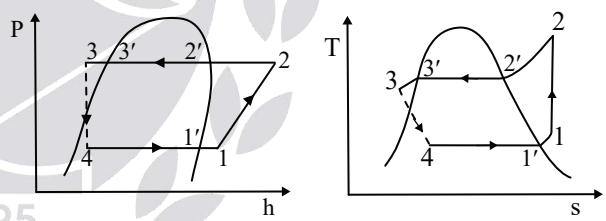
1. Normally in the practical cycles, the temperature of the liquid refrigerant leaving the condenser is lower than the saturation temperature.
2. Subcooling ensures that no vapour enters the expansion valve and furthermore, it increases the refrigerating effect.
3. The refrigerant is also subcooled before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

**44. Ans: (a)**

**Sol:**




Process 1-2: Isentropic compression in compressor
Process 2-3: Constant pressure heat rejection in condenser
Process 3-4: Throttling expansion in expansion device
Process 4-1: Constant pressure heat addition in evaporator

Before leaving the evaporator, the refrigerant is superheated and before leaving the condenser, the refrigerant is subcooled. ($T_3 < T_{3'}$)

where, $T_{3'}$ = saturation temperature

$T_3$ = sub-cooled temperature

Sub-cooling increases the refrigerating effect.

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45. 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

**45. Ans: (c)**

**Sol:**

| Refrigerant | Critical temperature |
|---|---|
| $CO_2$ | 30.98°C |
| $CH_2$ | –81.9°C |
| $NH_3$ | 132.22°C |

46. Consider the following statements regarding properties of refrigerants :
1. Ammonia is highly toxic and highly irritating refrigerant.
2. Carbon dioxide is corrosive refrigerant.
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

**46. Ans: (c)**

**Sol:**

| Property | Ammonia ($NH_3$) | Carbon dioxide ($CO_2$) | Sulphar dioxide ($SO_2$) |
|---|---|---|---|
| Toxicity | Toxic (Hazardous in high concentration) | Non-toxic | Toxic |
| Corrosiveness | Corrosive to copper & brass | Non-corrosive | corrosive |
| Flammability | Flammable | Non-flammable | Non-flammable |
| Odour | Strong, Pungent small | Odourless | Pungent, Suffocating smell |

47. 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

**47. Ans: (a)**

**Sol:** Lithium bromide (Li Br) is a hygroscopic salt, with high affinity for water. That is why it is used as an absorbent in water - LiBr absorption systems.

**Desirable properties of absorbent:**
- High affinity for refrigerant
- Low vapor pressure
- High solubility of refrigerant
- Low specific heat

- Chemical stability
- Non-corrosive
- Low viscosity
- Non-toxic and safe
- Easily available and low cost.

48. 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

**48. Ans: (c)**

**Sol:** Percentage saturation

$$= \frac{\text{Actual specific humidity}}{\text{Saturated specific humidity}} \times 100$$

Statement 1 correctly refers to ratio of specific humidities, just that it's usually expressed as actual/saturated, not the other way around. But since it says "saturated versus actual", it still implies a ratio of two specific humidities.

Specific humidity (or Humidity ratio) is the ratio of the mass of water vapor per unit mass of day air in the mixture of vapour and air, it is generally expressed as grams of water per kg of dry air.

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.

49. 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

**49. Ans: (b)**

**Sol:** Sensible heat ratio (SHR)

$$\text{SHR} = \frac{\text{Sensible heat}}{\text{Sensible heat + Latent Heat}}$$

$$= \frac{4.8}{4.8 + 1.4}$$

$$= 0.77$$

50. 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

**50. Ans: (a)**

**Sol:**
- Dry bulb temperature is the temperature of air as registered by an ordinary thermometer.
- Sensible heat is the heat that changes the temperature of a substance when added to or abstracted from it.

- Latent heat is the heat that does not affect the temperature but changes the state of substance when added to or abstracted from it.
- Dew point temperature is the temperature at which water vapour in the air is saturated.

51. 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

**51. Ans: (b)**

**Sol:** **Closed system:** Mass transfer = 0,
Energy transfer ≠ 0

52. Consider the following regarding pure substance : statements
    1. It is homogeneous in composition.
    2. It is homogeneous in chemical aggregation.
    3. It is variable in 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

**52. Ans: (a)**

**Sol:** The substance which has same physical structure and invariable chemical composition is called pure substance.

53. 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

**53. Ans: (c)**

**Sol:** The amount of heat required to convert liquid water completely into vapor is called the heat of evaporation.

degree of superheat = $T_{superheated} - T_{saturated}$
degree of subcooling = $T_{saturated} - T_{subcooling}$

54. 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

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**54. Ans: (b)**

**Sol:** Constant volume gas thermometer gives the reading in terms of pressure.

Thermocouple gives the reading in terms of electromotive force.

Pyrometer gives the reading in terms of intensity of radiation.

55. 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

**55. Ans: (d)**

**Sol:** First law can be applied for both reversible and irreversible process.

**Reversible closed system process:**
- V = C process
- P = C process
- T = C process
- Reversible adiabatic process ($PV^{\gamma} = C$)
- Polytropic process ($PV^{n} = C$)

**Irreversible closed system process:**
- Free expansion process

**Reversible open system process:**
- Boiling process
- Nozzle process
- Steam turbine process
- Condensation process
- Pumping process

**Irreversible open system process:**
- Throttling process

Perpetual Motion Machine-I (PMM-I) is violating the first law of Thermodynamics.

For a TD cycle,

$W_{net}$ = -ve for power consuming system like refrigerator

$W_{net}$ = +ve for power developing system like steam turbine power plant.

56. 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

**56. Ans: (a)**

**Sol:** Mixing process always comes under irreversible process.

57. 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.

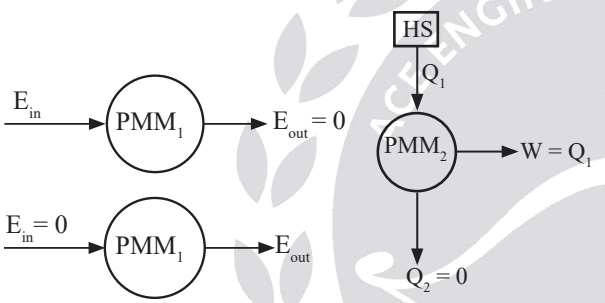
Which of the above statements are correct?

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

**57. Ans: (a)**

**Sol:** $PMM_1$ creates the energy or destroys the energy (it is violating first law of thermodynamics)

$PMM_2$ works with single high temperature reservoir (it violates the second law of thermodynamics)




58. 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

**58. Ans: (d)**

**Sol:** Carnot cycle is am impossible cycle for constructing a practical heat engine.

It can be used for only comparison purpose.

59. 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

**59. Ans: (c)**

**Sol:** $T_L = 40 + 273 = 313$ K

$T_H = 1000 + 273 = 1273$ K

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

$$\eta_c = 1 - \frac{313}{1273} = 1 - \frac{Q_R}{Q_S} \quad [\because Q_S = 1 + Q_R]$$

$$\eta_c = 0.754 = 1 - \frac{Q_R}{1 + Q_R}$$

$$\Rightarrow \frac{Q_R}{1 + Q_R} = 0.245$$

$$Q_R = 0.245 + 0.245\, Q_R$$

$$0.755\, Q_R = 0.245$$

$$Q_R = \frac{0.245}{0.755} = 0.325$$

60. 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

**60. Ans: (a)**

**Sol:** Given: $\gamma = 1.5$ , $\eta_0 = 0.6$

$$\eta_0 = 1 - \frac{1}{(r_c)^{\gamma - 1}}$$

$$0.6 = 1 - \frac{1}{(r_c)^{0.5-1}}$$

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

$$(r_c)^{0.5} = \frac{1}{0.4} = 2.5$$

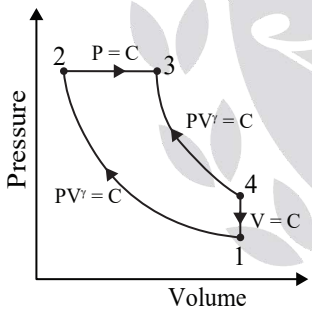
$$r_c = (2.5)^{\frac{1}{0.5}} = (2.5)^2 = 6.25$$

61. 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

**61. Ans: (a)**

**Sol:**




**For Diesel cycle,**
Heat supplied at P = C
Heat rejection at V = C
Compression & expansion → Isentropic

62. Heat is conducted through a material with a temperature gradient of –9000 °C / m The thermal conductivity of the material is 25W / 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

**62. Ans: (c)**

**Sol:** $-k\frac{\partial T}{\partial x} = h(T_s - T_\infty)$

$\Rightarrow 25\times 9000 = h\,(T_s - T_\infty)$

$\Rightarrow 25\times 9000 = 345\,(T_s - 30)$

$T_s = \left(\frac{15000}{23}\right) + 30$

$= 652.17 + 30 = 682.17°C$

63. 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

**63. Ans: (c)**

**Sol:** In free convection, $\overline{Nu} = f(Gr, Pr)$
and forced convection, $\overline{Nu} = f(Re, Pr)$
As type of convection is not given
$h = f$(viscosity, surface geometry)

64. 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

**64. Ans: (b)**

**Sol:** **Specific Gravity (s):** For liquids, it is the ratio of density of a liquid at actual conditions to the density of pure water at 101 kN/m$^3$ and at 4°C. The specific

gravity of a gas is the ratio of its density to that of either hydrogen or air at some specified temperature or pressure. However, there is no general standard, so the conditions must be stated while referring to the specific gravity of a gas.

65. 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

**65. Ans: (a)**

**Sol:** Eutectic reaction, $L \underset{\text{heating}}{\overset{\text{cooling}}{\rightleftharpoons}} \alpha + \beta$
Upon cooling, a liquid phase is transformed into the two solid α and β phases at the temperature TE; the opposite reaction occurs upon heating. This is called a eutectic reaction (eutectic means "easily melted").

66. 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 / $m^2$

**66. Ans: (b)**

**Sol:** Given:
S = 0.9, $\rho = 900\ kg/m^3$
h = 15 cm = 0.15 m of Hg

$$H = 0.15\left(\frac{13.6}{0.9} - 1\right) = 2.17$$

$$P = \rho gH = 900 \times 9.81 \times 2.17 = 18{,}688.05\ Pa$$

67. Which principle is the basis for differential pressure measuring devices?
(a) Torricelli's (b) Bernoulli's
(c) Euler's (d) Continuity

**67. Ans: (b)**

**Sol:** The Bernoulli equation states that the sum of the flow, kinetic, and potential energies of a fluid particle along a streamline is constant. Therefore, the kinetic and potential energies of the fluid can be converted to flow energy (and vice versa) during flow, causing the pressure to change. This phenomenon can be made more visible by multiplying the Bernoulli equation by the density (ρ),

$$P + \rho\frac{V^2}{2} + \rho gz = \text{constant (along a streamline)}$$

Each term in this equation has pressure units, and thus each term represents some kind of pressure:
P is the static pressure (it does not incorporate any dynamic effects); it represents the actual thermodynamic pressure of the fluid. This is the same as the pressure used in thermodynamics and property tables.
$\rho V^2/2$ is the dynamic pressure; it represents the pressure rise when the fluid in motion is brought to a stop isentropically.
ρgz is the hydrostatic pressure term, which is not pressure in a real sense since its value depends on the reference level selected; it accounts for the elevation effects, i.e., fluid weight on pressure. (Be careful of the sign — unlike hydrostatic pressure ρgh which increases with fluid depth h, the hydrostatic pressure term ρgz decreases with fluid depth).
The sum of the static, dynamic, and hydrostatic pressures is called the total pressure. Therefore,

the Bernoulli equation states that the total pressure along a streamline is constant. Hence, Bernoulli equation is the basis for differential pressure measuring devices.

68. 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

**68. Ans: (b)**

**Sol:** During the movement if volume immersed on one side increases and on the other side decreases.
∴ Statement 1 is wrong.

69. 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.

**Code:**

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

**69. Ans: (b)**

**Sol:**

- Steady uniform flow → Flow at constant rate through a duct of uniform cross-section.
- Steady non-uniform flow → Flow at constant rate through a duct of non-uniform cross-section
- Unsteady uniform flow → Flow at varying rates through a long straight pipe of uniform
- Unsteady non-uniform flow → Flow at varying rates through a duct of non-uniform cross-section

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70. Consider the following statements regarding properties of stream function and potential function:
1. If velocity potential ($\phi$) exists, the flow should be rotational.
2. If velocity potential ($\phi$) satisfies the Laplace equation, it represents the possible steady incompressible irrotational flow.
3. If stream function ($\psi$) 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

**70. Ans: (b)**

**Sol:** If velocity potential function ($\phi$) exists, the flow must be irrotational.
$\therefore$ Statement 1 is wrong.

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

| List - I | List - II |
|---|---|
| P. Orifice meter | 1. $Q_{act} = C_d\left[\frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}}\right]\sqrt{2gh}$ |
| 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.

| Code: | P | Q | R | | P | Q | R |
|---|---|---|---|---|---|---|---|
| (a) | 2 | 3 | 1 | (b) | 1 | 2 | 3 |
| (c) | 3 | 1 | 2 | (d) | 3 | 2 | 1 |

**71. Ans: (c)**

**Sol:**

**Orifice meter,** $Q = \frac{C_d a_0 a_1\sqrt{2gh}}{\sqrt{a_1^2 - a_0^2}}$

**Venturi meter,** $Q_{act} = C_d\left[\frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}}\right]\sqrt{2gh}$

**Pitot tube,** $V = C_v\sqrt{2gh}$

72. 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

**72. Ans: (c)**

**Sol:** $U = \frac{1}{8\mu}\left\{-\frac{dp}{dx}\right\}.B^2$

$\Rightarrow \frac{dp}{dx} = \frac{-8\mu U}{B^2}$

$= \frac{-8 \times 2 \times 10^{-2} \times 2}{(10^{-2})^2}$

$\frac{dp}{dx} = -3200$ Pa/m

73. 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

**73. Ans: (a)**

**Sol:** Low-iron tempered glass is commonly used in flat plate solar collector because

- high transmissivity of short waves and low reflectivity of long waves.
- it is ideal for absorbing and retaining solar energy
- low iron content minimizes the greenish tint and enhances high transmission.
- high durability.

74. 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

**74. Ans: (a)**

**Sol:**

- Tollmien and Schlichting predicted that the waves would form and grow in the boundary layer.
- It has been seen that in the presence of an adverse pressure gradient, at a high Reynolds number, two-dimensional waves appear.

75. 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

**75. Ans: (b)**

**Sol:** Turbulence can be generated by frictional forces at the confining solid walls or by the flow of layers of fluids with different velocities over one another. The turbulence generated in these two ways are considered to be different. Turbulence generated and continuously affected by fixed walls is designated as wall turbulence, and turbulence generated by two adjacent layers of fluid in the absence of walls is termed as free turbulence.

76. 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

**76. Ans: (c)**

**Sol:** "Mechatronics is the synergistic combination of precision mechanical engineering, electronic control and systems thinking in the design of products and manufacturing processes".

Robotics can be considered as a part of Mechatronics; i.e., all robots are Mechatronic systems, but not all Mechatronic systems are robots.

All machines that do not have any kind of autonomy in their behavior, because they simply automatically act according to the inputs they receive (directly or indirectly) from humans, are strictly pure Mechatronic systems.

77. 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

**77. Ans: (c)**

**Sol:** A typical fuel cell produces a voltage from 0.6 V to 0.7 V at full rated load.

78. 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

**78. Ans: (d)**

**Sol:**

- Graphs are often exploited for modeling the communication between robots in multi-robot systems, and for this reason, they are also called communication graphs.
- 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.

79. 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

**79. Ans: (d)**

**Sol:** Microsoft Robotics Developer Studio (MRDS) is a Windows-based 3D simulator, and it can be used by both professional and non-professional developers as well as hobbyists. MRDS is freely

available but not open source, its programming environment is .NET-based and the user could build robotic applications across a variety of hardware equipment.

80. 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 software component model
(c) agnostic model
(d) hidden dotted model

**80. Ans: (a)**

**Sol:** The link between the component internal ports (dashed interface) and the component external ports (solid interface) is realized via communication patterns.

81. 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

**81. Ans: (d)**

**Sol:**

- 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 (DOF) actuators can also be designed in order to combine two motions, like the roto-translational direct drive motor.
- Their response time is in the order of tens to hundreds of milliseconds, but they can be profitably used in many Mechatronic applications.

82. 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

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**82. Ans: (c)**

**Sol:**

- Intrinsic tactile sensing in a two-dimensional (2-D) plane has been widely applied in practice. The Wii balance board from Nintendo Co., Ltd. is the most typical and well-known application. 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.
- Extrinsic sensing is based on sensors, which are often arranged in arrays that are mounted at or near the contact interface.

83. Consider the following statements regarding simple electroencephalography (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

**83. Ans: (a)**

**Sol:** A subjective index is obtained by a questionnaire, whereas an objective index is determined by a bio-signal.

- EEG is one of the bio-signals used as indexes for determining preference.
- Visualization of the Mind Status Using EEG

84. 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 behavious, 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

**84. Ans: (d)**

**Sol:** 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 multi-variable, 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.

85. 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

**85. Ans: (a)**

**Sol: Impedance 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.

86. 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

**86. Ans: (a)**

**Sol: Component-based software engineering (CBSE):** CBSE 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.

A compact and widely accepted definition of a software component is the following one:

- "A software component is a unit of composition with contractually specified interfaces and explicit context dependencies only. A software component can be developed independently and is subject to composition by third parties.
- Software components explicitly consider reusable pieces of software including notions of independence and late composition.
- CBSE is based on the explication of all relevant information of a component to make it usable by other software elements whose authors are not known.

87. 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

**87. Ans: (a)**

**Sol:** 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 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.

88. 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

**88. Ans: (d)**

**Sol:** 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,
- the back-end, which takes the information generated by the front-end and provides an updated map estimate using an estimation algorithm.

89. 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 of 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.

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

**89. Ans: (a)**

**Sol: Refractoriness:** Ability to withstand higher temperature without losing its strength and hardness is called as refractoriness property.

**Permeability:** The ability to escape air or gases through the moulding sand is called Porosity property. Porosity is indicated in terms of permeability number.

**Cohesiveness:** It is the ability of formation of bond between the same material particles or Ability of sand particle to stick together.

**Adhesiveness:** It is the ability of formation of bond between the sand particles with other materials.

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CLASSROOM COACHING
Selected in: Transport, R&B Dept., Govt. of TG.

RANK 1 CE
Venkat Reddy
MEGA MOCK TEST
Selected in Public Health, MA & UD Dept. Govt. of TG.

RANK 3 EE
Devarakonda Sathwik
CLASSROOM COACHING
Selected in Transport, R&B Dept., Govt. of TG.

RANK 4 EE
Sangem Ravi Kumar
CLASSROOM COACHING
Selected in Transport, R&B Dept., Govt. of TG.

RANK 4 CE
Makam Jeevan Kumar
CLASSROOM COACHING
Selected in Public Health, MA & UD Dept., Govt. of TG.

RANK 6 CE
Balraj Madgan
MEGA MOCK TEST
Selected in Transport, R&B Dept., Govt. of TG.

RANK 7 EE
Challabotla Saikiran
CLASSROOM COACHING
Selected in Transport, R&B Dept., Govt. of TG.

RANK 7 ME
Vineetha Boddula
CLASSROOM COACHING
Selected in Irrigation & CAD Dept., Govt. of TG.

RANK 7 CE
Rama Krishna
CLASSROOM COACHING
Selected in Transport, R&B Dept., Govt. of TG.

RANK 8 CE
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AND MANY MORE..

## 500+ SELECTIONS

**CE : 434 | EE : 61 | ME : 20**

90. 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

**90. Ans: (b)**

**Sol:** **Cold working:** Plastic deformation of a material below its recrystallization temperature is called as Cold Working.

**Hot Working:** Plastic deformation of a material above its recrystallization temperature is called as Hot Working.

Recrystallization Temperature [RCT]

$= \frac{1}{3}$ to $\frac{1}{2}$ Melting point temperature of metal

91. 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

**91. Ans: (c)**

**Sol:** **Hot Hardness Temperature or Red Hardness :** Temperature is the minimum temperature above which increase in temperature will cause a considerable reduction in hardness of tool material. The tungsten or molybdenum will be added to increase the hot hardness temperature of tool material.

92. 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 | 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.

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

**92. Ans: (b)**

**Sol:** **Clearance fit:** In this, lower limit of hole is larger than upper limit of shaft. That is smallest hole diameter is greater than largest shaft diameter.

**Interference fit:** In this, the lower limit of shaft is larger than upper limit of hole and to make the assembly force is required between mating parts and there will be no motion is observed.

**Transition fit:** In this type of fit tolerance zones of hole and shaft overlapped and it gives sometimes clearance and sometime interference.

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

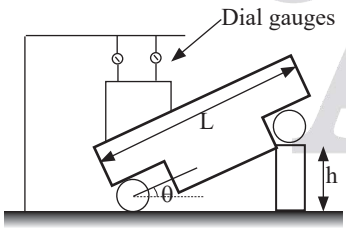
(a) L/h (b) h/L

(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.*

**93. Ans: (b)**

**Sol:**




After arranging sine bar geometrical observation gives equation:

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

94. 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.

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

**94. Ans: (d)**

**Sol:** **In-line layout:** An in-line layout (or) product layout is used when tasks are performed in a specific order. It is MEANT for in-floor towline carts/conveyors.

**Loop layout:** Loop layout is used for rail guided vehicles operating in a closed circuit path/track. It is commonly used in automated warehouses (material handling system).

**Robot-centred layout:** It is used for industrial robots.

95. 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 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

**95. Ans: (d)**

**Sol:**

- MRP uses MPS and computes gross and net requirements of sub-assemblies, components and raw materials. Statement (1) is correct.
- MRP is known as dependent demand items inventory control technique. Statement (2) is correct.
- MRP distinguishes independent demand items such as final assemblies and dependent demand items such as sub-assemblies, components, etc. Statement (3) is correct.

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

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

**96. Ans: (a)**

**Sol:** Dummy activity is an artificial activity and it consumes (i) zero time and (ii) zero resources.

97. Match the following lists:

| List - I (Selective control technique) | List - II (Basis of classification) |
|---|---|
| P. ABC | 1. Critically 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.

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

**97. Ans: (c)**

**Sol:**

| Classifications | Basis |
|---|---|
| ABC | Annual consumption value |
| VED | Critically of usage (or) functionality |
| XYZ | Storage value (or) storage cost |

98. 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

**98. Ans: (d)**

**Sol:**

- Reliability analysis can be divided into two broad categories
  (i) Qualitative (Expert analysis, judgement)
  (ii) Quantitative (Failure rate analysis)
- Reliability engineering deals with the design and construction of systems and products, taking into account the reliability of their parts and components.
- Reliability management deals with the various management issues in the context of managing the design, manufacture, and/or operation of reliable products and systems.

99. 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

**99. Ans: (c)**

**Sol:**

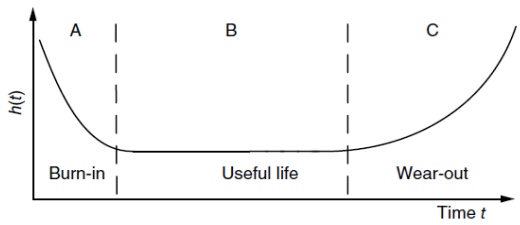
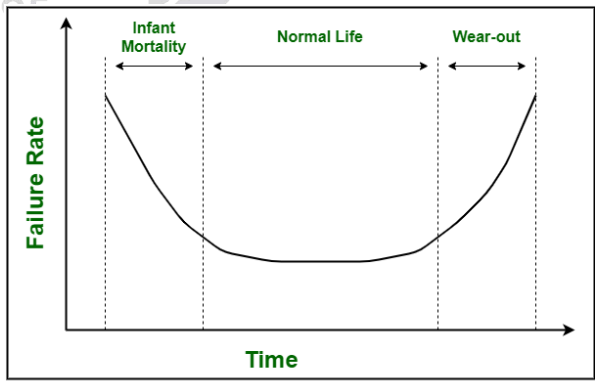



*Fig: Bathtub curve*

The failure rate function can have many different shapes. One is the bathtub shape shown in Figure, 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.

**(OR)**

**Bath tub analogy:** It shows three distinct phases.
(i) Infant mortality
(ii) Useful life
(iii) Wear-out




**Bathtub Curve**

# Hearty Congratulations

## To our students CIVIL ENGINEERING

## Selected in SSC JE - 2024

**HARSHIT KHARE**
Roll No. 3008100089
*Selected in:* **CPWD**

**RAMSWRUP**
Roll No. 2404100567
*Selected in:* **CPWD**

**LAKSHIT BHARDWAJ**
Roll No. 3206106390
*Selected in:* **CPWD**

**M V SIVA RAM REDDY**
Roll No. 8008101372
*Selected in:* **CPWD**

**RAVINDRA DHAKAD**
Roll No. 6005100485
*Selected in:* **CPWD**

**RAHUL KUMAWAT**
Roll No. 2401100340
*Selected in:* **CPWD**

**VISHAL SINGH**
Roll No. 3013105309
*Selected in:* **MES**

**S R JAFFER SHARIEF**
Roll No. 8006102160
*Selected in:* **MES**

**BEHARA SRIKANTH**
Roll No. 8007102883
*Selected in:* **MES**

**ANIRUDH KOTIYAL**
Roll No. 2003101448
*Selected in:* **MES**

**FAIZAN AHMAD**
Roll No. 3010108428
*Selected in:* **MES**

**AMBATI NAGA SRI SAI**
Roll No. 8601105973
*Selected in:* **MES**

**BHASKAR SHARMA**
Roll No. 2201112287
*Selected in:* **MES**

**SRINI VASA RAO**
Roll No. 8601101840
*Selected in:* **MES**

**PIJUSH AKHULI**
Roll No. 4426100222
*Selected in:* **MES**

**ABHIMANU KUMAR**
Roll No. 3205100298
*Selected in:* **MES**

**NIMESH SINGH**
Roll No. 2201114868
*Selected in:* **MES**

**LALAM RAMU NAIDU**
Roll No. 8601102319
*Selected in:* **MES**

**GYANENDRA KUMAR**
Roll No. 2201110803
*Selected in:* **CWC**

**ADARSH AGRAHARI**
Roll No. 3003100031
*Selected in:* **BRO**

**REDDI SANNIBABU**
Roll No. 8007102353
*Selected in:* **MES**

**KONAPALA MANOJ**
Roll No. 2201109855
*Selected in:* **MES**

**SUNIL SHARMA**
Roll No. 4415100648
*Selected in:* **MES**

**RINKESH KUMAR**
Roll No. 6204103361
*Selected in:* **MES**

& many more..

**Total 150+ Selections** | **CE-98** | **EE-29** | **ME-24**

100. 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

**100. Ans: (b)**

**Sol:** The signals generated by vibration may be analyzed in the time or frequency domains:

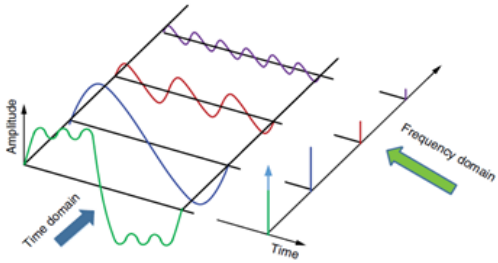



*Fig: Frequency versus time domain analysis.*

**Time domain:** The signal is a function of time.

**Frequency domain:** The time domain signal is decomposed into a linear combination of a basic periodic (sine wave) signal and its harmonics. The amplitudes of different frequencies provide information that is used in assessing the condition or degradation.

101. 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

**101. Ans: (a)**

**Sol:**

- Bearing is the intermediate machine element present between the rotating shaft and casing or hub to permit relative rotation to shaft and to support the loads acting on the shaft.
- Key is the intermediate machine element present between the hub and shaft to transmit power either from the shaft to hub or from hub to shaft.
- Power screw is the machine element that transforms rotational motion to translation.

102. 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

**102. Ans: (a)**

**Sol:** Ergonomics is defined as the relationship between man and machine and application of anatomical, physiological and psychological principles to solve the problems arising from the man-machine relationship. The word 'ergonomics' is coined from two Greek words -'ergon' which means 'work' and 'nomos' which means 'natural laws'. Ergonomic means the natural laws of work.

From design considerations the topics of ergonomic studies are as follows:

- 'Anatomical factors in the design of a driver's seat.
- Layout of instrument dials and display panels for accurate perception.
- Design of hand levers and hand wheels.
- Energy expenditure in hand and foot operations.
- Lighting, noise and climatic conditions in machine environment.

Ergonomists have carried out experiments to determine the best dimensions of a drives seat, the most convenient hand or foot pressure or dimensions of levers and hand wheels.

103. 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

**103. Ans: (b)**

**Sol:** Given data:

Load (P) = 50 kN = 50,000 N

Number of rivets = 3

Permissible shear stress = 50 N/mm$^2$

$P = n \times (\pi/4) \times d^2 \times \tau$

$\Rightarrow 50{,}000 = 3 \times (\pi/4) \times d^2 \times 50$

$\Rightarrow d \approx 20.6$ mm

104. 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

**104. Ans: (d)**

**Sol:** Strength of a material has been defined as its ability to resist the action of an external force without breaking.

Elasticity is the property of a material which enables it to regain its original shape and size after the removal of external load.

Plasticity is the property of the material which enables the formation of permanent deformation.

105. 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

**105. Ans: (a)**

**Sol:** Maximum principal stress theory (Rankine) implies failure when the maximum principal stress equals the ultimate strength of the material.

106. 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

**106. Ans: (d)**

**Sol:** Dulong's formula is used to calculate the HCV of solid and liquid fuel like coal and diesel.

107. 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

**107. Ans: (d)**

**Sol:** The following statements for fatigue failure are correct:
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.

108. 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

**108. Ans: (d)**

**Sol: Endurance limit and fatigue life:**
1. 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.

109. 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?

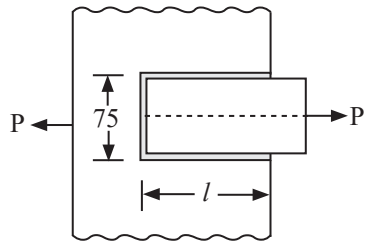
(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

**109. Ans: (d)**

**Sol:**

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

110. 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

**110. Ans: (a)**

**Sol:** Given:

Applied Load = 55 kN = 55,000 N

Permissible tension = 70 N/mm$^2$

Permissible shear = 50 N/mm$^2$

Fillet leg = 10 mm

Effective throat thickness: $t = 0.707 \times h = 7.07$ mm

$$P = \sigma \times t \times 75 + 2 \times \tau \times t \times l$$

$\Rightarrow l = 25.29$mm

Adding 15 mm for weld run

Length of each parallel weld,

$l = 25.29 + 15 = 40.29$ mm

111. 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

**111. Ans: (c)**

**Sol:** Given data:

Inner diameter of pressure vessel, D = 1 m

Internal steam pressure, P = 1.5 MPa

Thickness of the plate, t = 14 mm

Diameter of rivets, d = 23 mm.

Permissible shear stress in rivets, $\tau = 60\ N/mm^2$.

Total No. of rivets, n = ?

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

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

$$\Rightarrow n \cong 48$$

112. 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

**112. Ans: (c)**

**Sol:** The following statements are bolt of uniform strength:
- Resilience is defined as the ability of the material to absorb energy when deformed elastically and to release this energy when unloaded.
- The resilience of the bolt can also be increased by increasing its length.

113. 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

**113. Ans: (b)**

**Sol:** The addendum of a gear is the radial distance between the pitch circle and the addendum circle, which is also the height of the gear tooth that projects beyond the pitch line.

114. 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) $3(n-2)-j_1-2j_2$

**114. Ans: (a)**

**Sol:** Kutzback's equation for the DOF of a mechanism is as follows for a planar mechanism

$$DOF = 3(n-1)-2J_1-J_2$$

where,

$J_1$ = No.of joints having 1 DOF pairs,

$J_2$ = No.of joints having 2 DOF pairs

115. 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

**115. Ans: (c)**

**Sol:** An ejector condenser uses steam ejectors or air ejectors to create a vacuum and draw out the exhaust steam. It operates without any moving parts like pumps. No extraction pump is required because the ejector itself handles the removal of air-steam mixtures. It is considered a low-level condenser because it can be installed at or below the turbine level.

116. 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

**116. Ans: (c)**

**Sol:** Inversion of a mechanism refers to the process of obtaining different mechanisms by fixing different links of a kinematic chain.

117. Consider the following statements regarding instantaneous centres:

1. For a pivoted or pin joint, the instantaneous centre for the two links lie 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

**117. Ans: (d)**

**Sol:**

- If two links have a hinged joint, the location of the hinge is the relative instantaneous centre because one link is in pure rotation with respect to the other about that hinge.
- If the relative motion between two links is pure sliding, the relative instantaneous centre lies at infinity on a line perpendicular to the direction of sliding.
- If one link is rolling (without slipping) over another link, the point of contact is the relative instantaneous centre.

118. 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** | (b) | **P** | **Q** | **R** |
| | 2 | 3 | 1 | | 1 | 2 | 3 |
| (c) | **P** | **Q** | **R** | (b) | **P** | **Q** | **R** |
| | 3 | 1 | 2 | | 3 | 2 | 1 |

**118. Ans: (c)**

**Sol:**

- The base circle of a cam is the smallest circle that can be drawn tangent to the cam profile, with its centre located at the cam's centre of rotation.
- Prime circle is the smallest circle that can be drawn from the centre of the cam and tangent to the pitch curve.
- Pitch circle is the circle drawn from the cam's centre, passing through the pitch point.

119. What is the damping ratio ($\zeta$) of critically damped system?

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

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

**119. Ans: (a)**

**Sol:** For critical damped system damping ratio is 1.

$\zeta < 1$ system is undamped.

$\zeta > 1$ system is over-damped.

120. 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

(d) the non-linear direction

**120. Ans: (b)**

**Sol:** Critical speed of a shaft is defined as the speed at which a rotating shaft will tend to vibrate violently in the transverse direction.

121. 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

**121. Ans: (a)**

**Sol:**

- The angle of approach in gears refers to the angular distance a pair of meshing teeth travels from their first point of contact to the pitch point, which is the point where the line of centers intersects the line of action.
- The angle of recess in a gear system refers to the angle of rotation of a gear, from the point of contact where the teeth begin to disengage (the pitch point) to the point where they completely disengage.
- The angle of approach is generally greater than the angle of recess in gear mechanics because of the design of the teeth and the fact that the approach portion of the engagement is usually a more gradual transition than the recess portion.

# Hearty Congratulations to our students GATE - 2025

**84 TIMES AIR 1st IN GATE**

AIR 1 PI Devendra Umbrajkar

AIR 1 EE Pradip Chauhan

AIR 1 IN Kailash Goyal

AIR 2 EE Kailash Goyal

AIR 2 ME Gollangi Sateesh

AIR 2 ES Jitesh Choudhary

AIR 3 ME Nimesh Chandra

AIR 3 ME Sanket Tupkar

AIR 3 PI Sadhan Anumala

AIR 3 XE Rohan Biswal

AIR 3 PI Aditya Kumar Prasad

AIR 4 CE Harshil Maheshwari

AIR 5 EC Mohammed Nafeez

AIR 5 IN Sachin Yadav

AIR 5 ME Uday G.

AIR 5 PI Kuldeep Singh naruka

AIR 6 CE Nimish Upadhyay

AIR 6 CE Shivanand Chaurasia

AIR 6 EE Shivam Kumar Gupta

AIR 6 EE Puneet Soni

AIR 6 EC P Jaswanth Bhavani

AIR 6 PI Kaushal Kumar Kaushik

AIR 7 EC Subhadip Dey

AIR 7 ME Abhinn Srivastava

AIR 7 IN Dev Jignesh Patel

AIR 7 DA Sairam Gudla

AIR 7 CS Hemanth Reddu P

AIR 7 PI Waleed Shaikh

AIR 7 XE Sanket Tupkar

AIR 8 ME Goutam Kumar

AIR 8 IN Pushpendra Payal

AIR 8 CS Rishi Sharma

AIR 9 EC Sai Charan Chilukuri

AIR 9 ME Rahul Paliwal

AIR 9 PI Anish Vanapalli

AIR 10 EE Neelava Mukherjee

AIR 10 ME Ashutosh kumar

AIR 10 ME Jetti Ganateja

AIR 10 ME Pitchika Kumar Vasu

AIR 10 CE Adnan Quasain

& mamy more....

122. 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

**122. Ans: (c)**

**Sol:** A gear where half of its width has a tooth helix in one direction and the other half in the opposite direction is called a herringbone gear or double helical gear. Herringbone gears have two sets of helical teeth, each set with teeth angled in the opposite direction, creating a "V" shape when viewed from the side.

123. 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

**123. Ans: (b)**

**Sol:** In a simple gear train, an intermediate gear (also known as an idler gear) does not affect the overall velocity ratio. The velocity ratio, which is the ratio of the speeds of the driven and driver gears, is determined solely by the number of teeth on the first and last gears in the simple gear trains.

124. 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

**124. Ans: (d)**

**Sol:** The area under a turning moment diagram represents the work done per cycle of an engine. Dividing the area of the turning moment diagram by the length of its base yields the mean turning moment. The maximum ordinate of the turning moment diagram represents the highest point on the curve, which corresponds to the maximum torque that the crankshaft experiences.

125. 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°

**125. Ans: (c)**

**Sol:** In a two-cylinder engine, the cranks are typically set at a 90-degree angle to each other. This arrangement ensures that one cylinder is always in a power stroke position, allowing the engine to start easily regardless of where the crankshaft stops.

126. For the FCC crystal structures, 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

**126. Ans: (b)**

**Sol:** For the FCC crystal structure, there are eight atoms ($N_c = 8$), six face atoms ($N_f = 6$), and no interior atoms ($N_i = 0$).

Thus, $N = 0 + \frac{6}{2} + \frac{8}{8} = 4$

127. 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.

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

**127. Ans: (a)**

**Sol:** Hexagonal $\rightarrow$ $\alpha = \beta = 90°, \gamma = 120°$
Cubic $\rightarrow$ $\alpha = \beta = \gamma = 90°$
Monoclinic $\rightarrow$ $\alpha = \gamma = 90° \neq \beta$

| Crystal structure | Lattice Parameters | No.of space lattices |
|---|---|---|
| 1. Cubic | $a = b = c$<br>$\alpha = \beta = \gamma = 90°$ | 3 |
| 2. Rhombohedral | $a = b = c$<br>$\alpha = \beta = 90, \gamma \neq 90°$ | 1 |
| 3. Tetragonal | $a = b \neq c$<br>$\alpha = \beta = \gamma = 90°$ | 2 |
| 4. Orthorhombic | $a \neq b \neq c$<br>$\alpha = \beta = \gamma = 90°$ | 4 |
| 5. Hexagonal | $a = b \neq c$<br>$\alpha = \beta = 90°, \gamma = 120°$ | 1 |
| 6. Monoclinic | $a \neq b \neq c$<br>$\alpha = \beta = 90°, \gamma \neq 90°$ | 2 |
| 7. Triclinic | $a \neq b \neq c$<br>$\alpha \neq \beta \neq \gamma \neq 90°$ | 1 |

128. 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

**128. Ans: (d)**

**Sol:** Electrostatic precipitator is a device that removes fine particles, like dust and smoke, from a flowing gas using the force of an induced electrostatic charge.

In this device, negatively charged ionized gas molecules (or particles) are created by discharge electrodes and are then attracted to grounded collection electrodes, where they accumulate and can be removed.

129. The eutectic copper-silver and lead-tin phase diagrams have only two solid phases $\alpha$ and $\beta$; these are sometimes termed as

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

**129. Ans: (b)**

**Sol:** The isomorphous and eutectic phase diagrams discussed thus far are relatively simple, but those for many binary alloy systems are much more complex. The eutectic copper–silver and lead–tin phase diagrams have only two solid phases, α and β; these are sometimes termed terminal solid solutions because they exist over composition ranges near the concentration extremes of the phase diagram.

130. 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

**130. Ans: (a)**

**Sol:** In the as-quenched state, martensite, in addition to being very hard, is so brittle that it cannot be used for most applications; also, any internal stresses that may have been introduced during quenching have a weakening effect. The ductility and toughness of martensite may be enhanced and these internal stresses relieved by a heat treatment known as tempering.

131. 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

**131. Ans: (c)**

**Sol:** **Ferrous alloys** (steels and cast irons) are those in which iron is the prime constituent. Most steels contain less than 1.0 wt% C and, in addition, other alloying elements, which render them susceptible to heat treatment (and an enhancement of mechanical properties) and/or more corrosion resistant.

**Stainless steel** is typically considered a high-alloy steel because it contains a minimum of 10.5% chromium by weight, which gives it corrosion resistance.

Ferrous alloys are used extensively as engineering materials because
- Iron-bearing compounds are abundant.
- Economical extraction, refining, and fabrication techniques are available.
- They may be tailored to have a wide variety of mechanical and physical properties.

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AIR 9

KRISHNA KUMAR D


AIR 10

RAJESH BADUGU


AIR 10

RAJVARDHAN SHARMA


AIR 10

AKSHAY VIDHATE

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**TOTAL 36 SELECTIONS IN TOP 10** | **CE: 09 | ME: 10 | EE: 08 | E&T: 09**

132. 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 value and pump bodies. |

Select the correct answer using the code given below.

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

**132. Ans: (a)**

**Sol: Gray Iron:**

- Miscellaneous soft iron castings in which strength is not a primary consideration
- Small cylinder blocks, cylinder heads, pistons, clutch plates, transmission Cases
- Diesel engine castings, liners, cylinders, and pistons

**Ductile (Nodular) Iron**

- Pressure-containing parts such as valve and pump bodies
- High-strength gears and machine components
- Pinions, gears, rollers, slides

**Malleable Iron**

- General engineering service at normal and elevated temperatures

**Compacted Graphite Iron**

- Diesel engine blocks, exhaust manifolds, brake discs for high-speed trains

133. 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 a corrosion-resistant material.
3. Superalloys 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

**133. Ans: (d)**

**Sol:** **Molybdenum alloys** are used for extrusion dies and structural parts in space vehicles; incandescent light filaments, x-ray tubes, and welding electrodes employ tungsten alloys.

**Tantalum** is immune to chemical attack by virtually all environments at temperatures below 150°C and is frequently used in applications requiring such a corrosion-resistant material.

The superalloys have superlative combinations of properties. Most are used in aircraft turbine

components, which must withstand exposure to severely oxidizing environments and high temperatures for reasonable time periods.

134. Consider the following statements regarding nanostructured materials:
1. Nanostructured materials may be defined as those materials whose structural elements-clusters, crystallites or molecules have 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

**134. Ans: (a)**

**Sol:** Fullerenes and carbon nanotubes can indeed be viewed as curved pieces of graphite (graphene). For example, a carbon nanotube is essentially a rolled-up sheet of graphene.

135. 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

**135. Ans: (d)**

**Sol:** Creep Test requires the measurement of four variables: stress, strain, temperature and time. The objective of this testing is to determine the continuing change in the deformation of materials at elevated temperatures when stresses below the yield point.

136. Match the following list:

| 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 in a body along which the property is measured. |

Select the correct answer using the code given below.

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

**136. Ans: (b)**

**Sol:**

**(i) Isotropy:** A body is said to be isotropic if its physical properties are not dependent upon the direction in the body along which they are measured, e.g. a polycrystalline material in which the grains or crystals are randomly oriented behaves isotropically, i.e. its properties are independent of direction. Aluminium, steels and cast irons have

random distribution of crystals.

**(ii)** **Ductility** is an important property of a material which governs its ability to be deformed in processes, e.g. drawing, rolling and forging. Adequate ductility ensures that the material during these processes will not fracture. There is an associated property by virtue of which sheets can be rolled from material is called 'malleability'.

**(iii)** **Anisotropy:** The quality of variation of a physical property with the direction in a body along which the property is measured, e.g., the resistivity of certain single crystals measured with the electric field along a particular crystallographic direction may be higher than along directions perpendicular to it. Thus such crystals are anisotropic with respect to resistivity. Obviously, anisotropy is a state having different properties in different directions. Various composite materials, aggregates of polycrystals with a preferred orientation, wood, laminated plastics, etc. are few examples showing high anisotropy.

137. What is the relation between K and E?

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

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

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

**137. Ans: (a)**

**Sol:** Relation between K and E,

$E = 3K(1-2\nu)$

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

138. 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 certain values.

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

**138. Ans: (a)**

**Sol:** The angle of notch reduce impact strength.

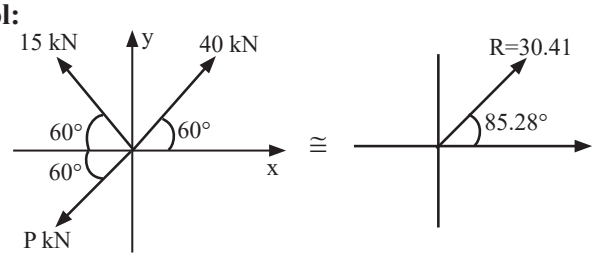
139. What is the magnitude of the third force P, if three forces of magnitudes 40 kN, 15 kN and P kN are acting at a point O. The angles made by 40 kN, 15 kN and P kN forces with X-axis are 60°, 120° and 240° respectively, and the magnitude and direction of the resultant force are 30.41 kN and 85.28°? (Take cos 85.28° = 0.08229)

(a) 18 kN (b) 19 kN

(c) 20 kN (d) 21 kN

**139. Ans: (c)**

**Sol:**



$\Sigma F_x = 40\cos 60 - 15\cos 60 - P\cos 60$

$= 30.41 \cos 85.28$

$\frac{40}{2} - \frac{15}{2} - \frac{P}{2} = 2.5$

$P = 20$ kN

140. 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

**140. Ans: (c)**

**Sol:**

1. Limiting friction $fs = \mu_s N$

$\Rightarrow \frac{f_s}{N} = \mu_s$ = constant

2. Limiting friction in motion $f_k = \mu_k N$

$\mu_k = \frac{f_k}{N}$

$\Rightarrow \mu_k$ is always less than $\mu_s$

$\mu_k < \mu_s$

So statement 2 is wrong.

3. Limiting friction just depends on nature of surfaces in contact and independent of shape and area of the surfaces in contact.

141. 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. $4r/(3\pi)$ |
| S. Parabolic area | 4. h/2 |

Select the correct answer using the code given below.

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

**141. Ans: (d)**

**Sol:** Semicircular area $\rightarrow$ $4r/(3\pi)$

Triangular area $\rightarrow$ h/3

Rectangular area $\rightarrow$ h/2

Parabolic area $\rightarrow$ 3b/8

142. 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

**142. Ans: (a)**

**Sol:** Given:

$s = 2t^3 - 24t + 6$

Find time 't', when V = 72 m/s

$\Rightarrow V = \frac{ds}{dt} = 6t^2 - 24$

$72 = 6t^2 - 24$

$12 = t^2 - 4 \Rightarrow t^2 = 16$

$\Rightarrow \quad t = 4$ sec

143. Match the following lists:

| List-I (Name) | List - II (Symbol) |
|---|---|
| P. Tensile strain | 1. $\tau$ |
| Q. Tensile stress | 2. $\phi$ |
| R. Shear strain | 3. $\varepsilon$ |
| S. Shear stress | 4. $\sigma$ |

Select the correct answer using the code given below.

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

**143. Ans: (c)**

**Sol:** Tensile strain $\rightarrow \varepsilon$
Tensile stress $\rightarrow \sigma$
Shear strain $\rightarrow \phi$
Shear stress $\rightarrow \tau$

144. 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 $2 \times 10^5$ 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

**144. Ans: (a)**

**Sol:** L = 150 cm = 1500 mm
d = 2 cm = 20 mm
$P = 20 \text{ kN} = 20 \times 10^3$ N
$E = 2 \times 10^5$ N/mm$^2$

$\delta\ell = \frac{PL}{AE} = ?$

$$= \frac{20 \times 10^3 \times 1500}{\frac{\pi}{4} \times 20^2 \times 2 \times 10^5} = \frac{1.5}{\pi} \text{mm}$$

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

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

**145. Ans: (d)**

**Sol:** Principal planes are planes within a material where only normal stresses act, meaning there is no shear stress present on these planes. The normal stresses on these planes are called principal stresses.

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

(a) $p_1 \cos^2\theta + p_2 \sin^2\theta + q \sin 2\theta$
(b) $\{(p_1 + p_2)/2\}\sin 2\theta + q \cos 2\theta$
(c) $p_1 \sin^2\theta + p_2 \cos^2\theta + q \sin 2\theta$
(d) $\{(p_1 + p_2)/2\}\cos 2\theta + q \sin 2\theta$

where symbols have their usual meanings.

**146. Ans: (a)**

**Sol:** Assume $\sigma_x = p_1$, $\sigma_y = p_2$, $\tau_{xy} = q$
Normal stress on inclined plane is

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

$$= \frac{\sigma_x}{2}[1+\cos 2\theta] + \frac{\sigma_y}{2}[1-\cos 2\theta] + \tau_{xy}\sin 2\theta$$

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

$$= p_1\cos^2\theta + p_1\sin^2\theta + q\sin 2\theta$$

147. 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

**147. Ans: (a)**

**Sol:** $h_f = \frac{fLV^2}{2gD} = \frac{1}{12.1} f\frac{LQ^2}{D^5}$

148. 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 (or 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

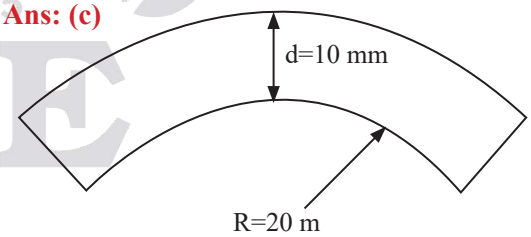
**148. Ans: (d)**

**Sol:** The following statements regarding shear force and bending moment diagrams are correct:
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 (or fixing moment).
3. The positive values of shear force and bending moment are plotted above the baseline, and negative values below the baseline.

149. 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$^2$

**149. Ans: (c)**

**Sol:**




**Flexure formula:**

$$\frac{E}{R} = \frac{\sigma_b}{y} \Rightarrow \sigma_b = \frac{E_y}{R}$$

$$\sigma_b = \frac{2\times 10^5 \times 5}{20000} = 50 \text{ N/mm}^2$$

150. The sum of pressure head and potential head is termed as
(a) datum head
(b) velocity head
(c) piezometric head
(d) static head

**150. Ans: (c)**

**Sol:** The piezometric head (or hydraulic head) is a key concept in fluid mechanics and hydraulics, representing the total mechanical energy per unit weight of a fluid at a point. It combines pressure head and elevation or datum head, and is defined as:

$$\text{Piezometric Head} = \frac{p}{\rho g} + z$$

where, $\frac{p}{\rho g}$ = Pressure head, $z$ = elevation head

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