

CUET PG 2024 Mechanical Engineering Question Paper with Solutions

Time Allowed :1 Hour 45 Mins	Maximum Marks :300	Total Questions :75
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General Instructions

Read the following instructions very carefully and strictly follow them:

1. The examination duration is 105 minutes. Manage your time effectively to attempt all questions within this period.
2. The total marks for this examination are 300. Aim to maximize your score by strategically answering each question.
3. There are 75 mandatory questions to be attempted in the Mechanical Engineering paper. Ensure that all questions are answered.
4. Questions may appear in a shuffled order. Do not assume a fixed sequence and focus on each question as you proceed.
5. The marking of answers will be displayed as you answer. Use this feature to monitor your performance and adjust your strategy as needed.
6. You may mark questions for review and edit your answers later. Make sure to allocate time for reviewing marked questions before final submission.
7. Be aware of the detailed section and sub-section guidelines provided in the exam. Understanding these will aid in effectively navigating the exam.

1. The vacuum in a closed container is 50 mm of Hg. The absolute pressure in the container is:

- (1) 0.92 bar
- (2) 0.90 bar
- (3) 0.95 bar
- (4) 0.82 bar

Correct Answer: (1) 0.92 bar

Solution: The atmospheric pressure is 1 bar, and the vacuum pressure is 50 mm of Hg. The absolute pressure is calculated as:

$$\begin{aligned}\text{Absolute pressure} &= \text{Atmospheric pressure} - \text{Vacuum pressure} \\ &= 1 \text{ bar} - \frac{50 \text{ mm of Hg}}{760 \text{ mm of Hg}} \times 1 \text{ bar} = 0.92 \text{ bar}.\end{aligned}$$

💡 Quick Tip

Remember that absolute pressure is the atmospheric pressure minus the vacuum pressure, and convert the vacuum pressure from mm of Hg to bar.

2. Consider the following statements: The assumptions made in deriving Euler's equation are:

(I) Fluid is non-viscous fluid.

(II) The flow is along a streak line.

(1) Both statement (I) and statement (II) are true.

(2) Both statement (I) and statement (II) are false.

(3) Statement (I) is true but statement (II) is false.

(4) Statement (I) is false but statement (II) is true.

Correct Answer: (3) Statement (I) is true but statement (II) is false.

Solution: Euler's equation assumes that the fluid is non-viscous, which means there is no internal friction in the fluid (Statement I is true). However, Euler's equation does not assume that the flow is along a streak line; the flow can be more general (Statement II is false).

 Quick Tip

Euler's equation assumes non-viscous fluid, but does not assume flow along streak lines. This is important to remember when applying the equation.

3. Match List I (Non-dimensional number) with List II (It is the ratio of):

LIST I	LIST II
A. Reynold's Number	I. Inertia force to elastic force
B. Mach Number	II. Inertia force to gravity force
C. Froude's Number	III. Inertia force to viscous force
D. Weber's Number	IV. Inertia force to surface tension force

Choose the correct answer from the options given below:

1. (A) - (III), (B) - (I), (C) - (II), (D) - (IV)

2. (A) - (I), (B) - (III), (C) - (II), (D) - (IV)

3. (A) - (II), (B) - (I), (C) - (III), (D) - (IV)

4. (A) - (IV), (B) - (II), (C) - (I), (D) - (III)

Correct Answer: (A) - (III), (B) - (II), (C) - (IV), (D) - (I)

Solution: The match between the non-dimensional numbers and their ratios is as follows: - Reynold's Number: Inertia force to viscous force - Mach Number: Inertia force to gravity force - Froude's Number: Inertia force to surface tension force - Weber's Number: Inertia force to elastic force

 Quick Tip

Each non-dimensional number has its specific use in fluid mechanics, representing the ratio of inertial forces to other forces.

4. Given below are two statements:

Statement (A): The flow in a pipe is turbulent when the Reynolds' Number is more than 4000.
Statement (R): The flow in a pipe is turbulent at entry and slowly changes to laminar along the length of the pipe.

In light of the above statements, choose the correct answer from the options given below.

1. Both (A) and (R) are true and (R) is the correct explanation of (A).
2. Both (A) and (R) are true but (R) is NOT the correct explanation of (A).
3. (A) is true but (R) is false.
4. (A) is false but (R) is true.

Correct Answer: (3) (A) is true but (R) is false.

Solution: Statement (A) is correct because the flow is generally considered turbulent when the Reynolds number exceeds 4000. However, statement (R) is incorrect because turbulent flow does not transition to laminar flow over a pipe's length; it remains turbulent unless external factors alter the flow.

 Quick Tip

Turbulent flow occurs when the Reynolds number exceeds 4000. The flow does not typically transition to laminar within the same pipe under constant conditions.

5. Consider the following statements about the flow in a convergent-divergent nozzle operating under design conditions:

- (A) In the divergent section, pressure is higher than the pressure in the convergent section.
- (B) The pressure at the throat is equal to critical pressure.
- (C) The pressure in the convergent section reduces.
- (D) The flow is subsonic in the convergent section and supersonic in the divergent section.

Choose the correct answer from the options given below.

1. (A), (B) and (C) only.
2. (B), (C) and (D) only.
3. (A), (B), (C) and (D).
4. (A), (C) and (D) only.

Correct Answer: (2) (B), (C), and (D) only.

Solution: In a convergent-divergent nozzle, the pressure at the throat is equal to the critical pressure. The flow is subsonic in the convergent section and becomes supersonic in the divergent section, making statements (C) and (D) true. Statement (A) is false, as the pressure in the divergent section is lower than in the convergent section.

 Quick Tip

In a convergent-divergent nozzle, the flow changes from subsonic to supersonic, and the pressure at the throat is critical.

6. Lumped Heat capacity analysis can be applied to a system when:

1. Convective resistance is very small and conductive resistance is very large.
2. Both convective and conductive resistances are very large.
3. Both convective and conductive resistances are very small.
4. Convective resistance is very large and conductive resistance is very small.

Correct Answer: (3) Both convective and conductive resistances are very small.

Solution: Lumped heat capacity analysis is applicable when both resistances are small, allowing the system to be approximated as a single thermal mass with negligible temperature gradients.

 Quick Tip

Lumped heat capacity analysis simplifies the system by assuming negligible temperature differences within the object, so both resistances must be small.

7: Match List I (Non-Dimensional Number) with List II (Formula):

LIST I	LIST II
A. Nusselt Number	I. $\mu C_p / k_f$ (where k_f is thermal conductivity of fluid)
B. Biot Number	II. hL / k_s (where k_s is thermal conductivity of solid)
C. Prandtl Number	III. $h / \rho C_p$
D. Stanton Number	IV. hL / k_f (where k_f is thermal conductivity of fluid)

Choose the correct answer from the options given below.

1. (A) - (I), (B) - (II), (C) - (III), (D) - (IV)
2. (A) - (IV), (B) - (II), (C) - (I), (D) - (III)
3. (A) - (I), (B) - (II), (C) - (IV), (D) - (III)
4. (A) - (III), (B) - (IV), (C) - (I), (D) - (II)

Correct Answer: (A) - (I), (B) - (II), (C) - (III), (D) - (IV)

Solution: - Nusselt number (Nu) is the ratio of convective to conductive heat transfer, calculated as $\mu C_p / k_f$. - Biot number (Bi) compares thermal resistance within a body to the resistance at its surface, given by hL / k_s . - Prandtl number (Pr) relates the kinematic viscosity to thermal diffusivity, calculated as $h / \rho C_p$. - Stanton number (St) defines the ratio of heat transfer to the thermal capacity, calculated as hL / k_f .

 Quick Tip

Each dimensionless number helps analyze different aspects of heat transfer, and the corresponding formulas relate them to fluid dynamics and heat conduction properties.

8. Given below are two statements, one is labelled as Assertion (A) and the other one labelled as Reason (R):

Assertion (A): The Effectiveness-NTU method of heat exchanger design is used only when inlet temperatures of both fluids are known.

Reason (R): LMTD method can only be used when both inlet as well as outlet temperatures of both fluids are given.

In light of the above statements, choose the correct answer from the options given below.

1. Both (A) and (R) are true and (R) is the correct explanation of (A).
2. Both (A) and (R) are true but (R) is NOT the correct explanation of (A).
3. (A) is true but (R) is false.
4. (A) is false but (R) is true.

Correct Answer: (3) (A) is true but (R) is false.

Solution: The Effectiveness-NTU method of heat exchanger design requires inlet temperatures of the fluids, while the LMTD method requires both inlet and outlet temperatures for both fluids. Hence, (A) is true, but (R) is false as the LMTD method does not require only inlet and outlet temperatures for both fluids but other parameters as well.

 Quick Tip

Effectiveness-NTU method relies on the inlet temperatures of both fluids, while the LMTD method requires both inlet and outlet temperatures of the fluids.

9. The shape factor of a hemispherical body placed on a flat surface with respect to itself is:

1. 1.00
2. 0.25
3. 0.50
4. 0

Correct Answer: (3) 0.50

Solution: For a hemispherical body placed on a flat surface, the shape factor with respect to itself is 0.50. This represents the ratio of radiation exchange between the body and itself, as per the Stefan-Boltzmann law.

10. Given below are two statements:

Statement (I): The heat transfer coefficient for air in free convection varies between 5 to 30 $\text{W/m}^2\cdot\text{K}$.

Statement (II): The heat transfer coefficient of steam during condensation lies between 5000 to 110000 $\text{W/m}^2\cdot\text{K}$.

In light of the above statements, choose the most appropriate answer from the options given below.

1. Both Statement (I) and Statement (II) are correct.
2. Both Statement (I) and Statement (II) are incorrect.
3. Statement (I) is correct but Statement (II) is incorrect.
4. Statement (I) is incorrect but Statement (II) is correct.

Correct Answer: (1) Both Statement (I) and Statement (II) are correct.

Solution: Statement (I) is correct as the heat transfer coefficient for air in free convection generally lies in the range of 5 to 30 $\text{W/m}^2\cdot\text{K}$. Statement (II) is also correct, as the heat transfer coefficient of steam during condensation typically ranges between 5000 and 110000 $\text{W/m}^2\cdot\text{K}$.

💡 Quick Tip

The heat transfer coefficient for air in free convection is much lower compared to steam during condensation, which has a significantly higher coefficient.

11. A thermo flask is:

1. Closed system
2. Open system
3. Isolated system
4. Adiabatic closed system

Correct Answer: (3) Isolated system

Solution: A thermo flask is considered an isolated system because it does not exchange matter or energy (heat) with its surroundings. It is designed to minimize heat transfer, keeping the contents at a constant temperature over time.

 Quick Tip

An isolated system is one where neither matter nor energy is exchanged with the surroundings.

12.2 kg of air is contained in a closed system at a pressure of 2 bar and 0.5 m^3 . It undergoes an isobaric expansion till the final volume becomes 0.6 m^3 . The work transfer (in kJ) during the process is:

1. -20
2. -10
3. +20
4. +10

Correct Answer: (3) +20

Solution: For isobaric expansion, the work done (W) is given by the equation:

$$W = P\Delta V$$

Where $P = 2 \text{ bar} = 2 \times 10^5 \text{ Pa}$, and the volume change $\Delta V = V_2 - V_1 = 0.6 \text{ m}^3 - 0.5 \text{ m}^3 = 0.1 \text{ m}^3$. So,

$$W = 2 \times 10^5 \text{ Pa} \times 0.1 \text{ m}^3 = 20 \text{ kJ}.$$

Thus, the work transfer is +20 kJ.

Quick Tip: In an isobaric process, the work done is simply the pressure multiplied by the change in volume. Make sure to convert all units properly (e.g., converting bar to Pa and ensuring the volume is in cubic meters).

13. Match List I with List II:

LIST I	LIST II
A. Subcooled water	I. 1 bar and 134°C
B. Superheated steam	II. dryness fraction = 1 and 100°C
C. Steam at critical state	III. 20°C and 1.01325 bar
D. Saturated steam	IV. 374.15°C and 220.8 bar

Choose the correct answer from the options given below:

1. (A) - (I), (B) - (II), (C) - (III), (D) - (IV)
2. (A) - (II), (B) - (III), (C) - (I), (D) - (IV)
3. (A) - (III), (B) - (II), (C) - (IV), (D) - (I)
4. (A) - (III), (B) - (I), (C) - (IV), (D) - (II)

Correct Answer: (4) (A) - (III), (B) - (I), (C) - (IV), (D) - (II)

Solution: The correct matching between the characteristics of water and their respective state properties is as follows: - Subcooled water corresponds to the state of water with a temperature lower than the saturation temperature, hence the property is (III) 20°C and 1.01325 bar. - Superheated steam corresponds to a high temperature and low pressure, matching (I) 1 bar and 134°C. - Steam at the critical state is where both the pressure and temperature are at critical values, so it corresponds to (IV) 374.15°C and 220.8 bar. - Saturated steam, where the water is at its boiling point with a dryness fraction of 1, corresponds to (II) dryness fraction = 1 and 100°C.

 Quick Tip

When working with thermodynamic properties of water, remember that: - Subcooled water exists below its saturation point, typically at lower pressure and temperature. - Superheated steam is above the saturation temperature. - Critical state is where both temperature and pressure reach critical points. - Saturated steam is at the boiling point with a dryness fraction of 1.

14. Given below are two statements, one is labelled as Assertion (A) and the other one labelled as Reason (R):

Assertion (A): The Clausius statement of second law of thermodynamics states that it is impossible to transfer heat from a body at low temperature to a body at high temperature without the aid of external work.

Reason (R): Heat always flows from low temperature to high temperature.

In light of the above statements, choose the correct answer from the options given below:

1. Both (A) and (R) are true and (R) is the correct explanation of (A).
2. Both (A) and (R) are true but (R) is NOT the correct explanation of (A).
3. (A) is true but (R) is false.
4. (A) is false but (R) is true.

Correct Answer: (3) (A) is true but (R) is false.

Solution: The Clausius statement (A) is correct in stating that heat cannot spontaneously flow from a colder body to a hotter body without external work. However, Reason (R) is incorrect because it suggests that heat always flows from low temperature to high temperature, which contradicts the second law. Heat flows naturally from high to low temperature unless external work is applied.

 Quick Tip

The Clausius statement of the second law of thermodynamics defines the direction of heat flow in natural processes. Heat always flows from a higher temperature body to a lower temperature body, and the reverse requires external work to be done, as stated in the second law.

15. A system at 500 K receives 7200 kJ/min of heat from a source at 1000 K. The ambient temperature is 300 K. The system and source temperature remain constant during heat transfer. The decrease in available energy due to heat transfer through finite temperature difference is:

- (1) 5040 kJ/min
- (2) 2880 kJ/min
- (3) 2060 kJ/min
- (4) 2160 kJ/min

Correct Answer: Option 1: 5040 kJ/min

Solution: The decrease in available energy is calculated using the formula:

$$\Delta Q = \dot{Q} \left(1 - \frac{T_2}{T_1} \right)$$

Where: $\dot{Q} = 7200 \text{ kJ/min}$, $T_1 = 1000 \text{ K}$, and $T_2 = 300 \text{ K}$. After plugging in the values:

$$\Delta Q = 7200 \times \left(1 - \frac{300}{1000} \right) = 7200 \times 0.7 = 5040 \text{ kJ/min}$$

 Quick Tip

The formula $\Delta Q = \dot{Q} \left(1 - \frac{T_2}{T_1} \right)$ helps in determining the decrease in available energy due to heat transfer.

16. With increase in pressure ratio in Brayton cycle, the net work output:

- (1) increases
- (2) decreases
- (3) initially increases, reaches to a maximum and then decreases
- (4) initially decreases and then increases

Correct Answer: Option 3: Initially increases, reaches to a maximum, and then decreases.

Solution: In a Brayton cycle, with increasing pressure ratio, the efficiency increases up to a point but eventually decreases after reaching an optimum pressure ratio due to the increasing compression work required. Thus, the work output initially increases and then decreases after a maximum value.

 Quick Tip

The net work output of a Brayton cycle is maximized at a specific pressure ratio, beyond which the work output starts decreasing.

17. For the same compression ratio and same heat supplied in Otto, Diesel and Dual cycles:

- (A) Otto cycle has maximum efficiency.
- (B) Diesel cycle has minimum heat rejected.
- (C) Dual cycle has maximum heat rejected.
- (D) Diesel cycle has maximum heat rejected.

Choose the correct answer from the options given below.

- 1. (A), (B) and (D) only.
- 2. (A) and (D) only.
- 3. (A), (B) and (C) only.
- 4. (B) and (C) only.

Correct Answer: Option 2: (A) and (D) only.

Solution: - The Otto cycle has the highest efficiency among the three, as it operates with higher compression ratios. - The Diesel cycle has a relatively lower heat rejection than the Dual cycle. The heat rejection in the Dual cycle is typically higher than in the Otto cycle.

 Quick Tip

The efficiency of the Otto cycle is higher compared to Diesel and Dual cycles for the same compression ratio and heat input.

18. In a simple saturated Vapour compression refrigeration cycle, the enthalpy at various state points are: 10 kJ/kg, 45 kJ/kg and 25 kJ/kg. The mass flow rate of refrigerant is 2 kg/s:

- (A) The power consumption of compressor is 40 kJ/kg
- (B) The refrigeration capacity is 70 kW
- (C) The COP is 1.75
- (D) Heat rejected in condenser is 110 kW

Choose the correct answer from the options given below.

- 1. (A) and (D) only.
- 2. (A), (B) and (C) only.
- 3. (A), (B), (C) and (D).
- 4. (B), (C) and (D) only.

Correct Answer: Option 3: (A), (B) and (C) only.

Solution: Using the refrigeration cycle relations: - Refrigeration capacity = $\dot{Q}_L = m \cdot (h_1 - h_4) = 2 \cdot (45 - 10) = 70 \text{ kW}$. - Power consumption = $\dot{W} = m \cdot (h_2 - h_1) = 2 \cdot (h_2 - 45) \approx 40 \text{ kJ/kg}$. - $\text{COP} = \frac{\text{Refrigeration capacity}}{\text{Power input}} = \frac{70}{40} = 1.75$.

💡 Quick Tip

In refrigeration cycles, COP can be calculated as the ratio of refrigeration capacity to the work input.

19. Assertion (A): In heating and dehumidification of air, relative humidity of air decreases.
Reason (R): Sensible heating causes enthalpy to decrease.

In light of the above statements, choose the correct answer from the options given below.

- Both (A) and (R) are true and (R) is the correct explanation of (A).
- Both (A) and (R) are true but (R) is NOT the correct explanation of (A).
- (A) is true but (R) is false.
- (A) is false but (R) is true.

Correct Answer: Option 4: (A) is false but (R) is true.

Solution: - In heating and dehumidification of air, relative humidity decreases because the water vapor in the air is removed while heating. - Sensible heating does indeed increase the enthalpy but does not directly relate to a decrease in enthalpy.

💡 Quick Tip

Enthalpy increases during sensible heating, and relative humidity decreases during dehumidification.

20. Match List I with List II

LIST I (Component)	LIST II (Equipment used in)
A. Draft Tube	I. Thermal Power Plant
B. Thermostatic Expansion Valve	II. Cold Storage
C. Feed Water Heater	III. Francis Turbine
D. Automatic Expansion Valve	IV. Central AC Plant

Choose the correct answer from the options given below:

- (A) - (III), (B) - (II), (C) - (I), (D) - (IV)
- (A) - (III), (B) - (IV), (C) - (I), (D) - (II)
- (A) - (I), (B) - (II), (C) - (III), (D) - (IV)
- (A) - (III), (B) - (IV), (C) - (II), (D) - (I)

Correct Answer: Option 1: (A)-(III), (B)-(II), (C)-(I), (D)-(IV).

Solution: - A draft tube is used in Francis turbines, typically found in thermal power plants.
- Thermostatic expansion valves are used in cold storage to regulate temperature. - Feed water heaters are found in thermal power plants to preheat the water entering the boiler. - Automatic expansion valves are used in central AC plants to regulate refrigerant flow.

 Quick Tip

Match the components with their typical applications in relevant industries.

21. The instantaneous centre of a sliding body moving on a stationary curved surface lies at:

1. infinity
2. centre of curvature of curved surface
3. at tangent to the curved surface
4. at point of contact

Correct Answer: (2) Centre of curvature of curved surface

Solution: The instantaneous center of a sliding body on a curved surface lies at the center of curvature of the curved surface. This point defines the location where the velocity of the body is zero at a given instant of time.

Quick Tip

The center of curvature is crucial in determining the motion of a body along a curved path.

22. Match List I with List II:

LIST I	LIST II
A. Involute Gear	I. Variable Pressure Angle
B. Cycloidal Gear	II. Constant Pressure Angle
C. Gyroscope	III. Sensitivity
D. Governor	IV. Stability

Choose the correct answer from the options given below:

1. A - I, B - II, C - III, D - IV
2. A - II, B - I, C - III, D - IV
3. A - I, B - II, C - IV, D - III
4. A - II, B - I, C - IV, D - III

Quick Tip

Understanding the relationships between machine components and their characteristics is crucial in gear and mechanism design.

23. Given below are two statements:

Statement (I): Flywheels are used to control the fluctuations in speed of machines arising from external sources.

Statement (II): Governors are used to control the fluctuations in speed of machines arising from internal sources.

In light of the above statements, choose the most appropriate answer from the options given below.

1. Both Statement (I) and Statement (II) are correct.
2. Both Statement (I) and Statement (II) are incorrect.
3. Statement (I) is correct but Statement (II) is incorrect.
4. Statement (I) is incorrect but Statement (II) is correct.

Correct Answer: (4) Statement (I) is incorrect but Statement (II) is correct.

Solution: Flywheels are used for storing energy to smooth out the fluctuations in a machine's speed caused by external forces. Governors, on the other hand, control the speed of engines and turbines by adjusting the fuel or air intake to regulate the engine speed due to internal forces.

💡 Quick Tip

Governors regulate internal speed fluctuations, while flywheels store energy and reduce external fluctuations in rotational speed.

24. An aeroplane is making a left turn as viewed by an observer from the rear of the plane. The engine/rotor of the plane are running in clockwise sense when viewed from the rear side. The gyroscopic effects tend to

1. lift the nose of aeroplane
2. dip the nose of aeroplane
3. lift the tail of aeroplane
4. have no effect on aeroplane

Correct Answer: (2) dip the nose of the aeroplane.

Solution: When the plane makes a left turn and the engine is rotating clockwise, the gyroscopic effects cause the plane's nose to dip. This phenomenon is due to the gyroscopic precession that results from the engine's rotation.

💡 Quick Tip

In gyroscopic systems, precession causes a force at a right angle to the input force, which in this case results in the plane's nose dipping when turning left.

25. A solid disc of mass m , radius r is resting on a horizontal smooth surface. A spring of stiffness k is connected to the disc at distance e directly above the centre of the disc. Another end of the spring is connected to the vertical wall. For small angular displacement of the disc, the natural frequency of the system in radians per second will be:

- 1. $\sqrt{\frac{2k(r+e)}{3mr}}$
- 2. $\sqrt{\frac{2k(r+e)}{mr}}$
- 3. $\sqrt{\frac{2k(r+e)^2}{mr^2}}$
- 4. $\sqrt{\frac{2k(r+e)^2}{3mr^2}}$

Correct Answer: (4) $\sqrt{\frac{2k(r+e)^2}{3mr^2}}$

Solution:

The natural frequency of a system with rotational motion can be found using the formula for the torsional pendulum. For small angular displacement, the restoring force is proportional to the angular displacement, and the equivalent moment of inertia for the system is considered. The effective spring constant for rotational motion is adjusted by considering the location of the spring above the centre of mass of the disc.

Using energy principles and angular dynamics, the natural frequency ω is given by:

$$\omega = \sqrt{\frac{k(r+e)^2}{I}}$$

where $I = \frac{1}{2}mr^2$ is the moment of inertia of the disc.

Simplifying the expression:

$$\omega = \sqrt{\frac{2k(r+e)^2}{3mr^2}}$$

Thus, the correct answer is option (4).

💡 Quick Tip

When solving problems involving rotational motion, the natural frequency of oscillation depends on both the stiffness of the spring and the moment of inertia of the body. The moment of inertia for a disc about its center is $\frac{1}{2}mr^2$, and for angular displacement problems, the effective length from the center must be considered.

26. The undamped natural frequency of system is 80 rad/sec. A damper is provided in the system having damping factor 0.7. The damped natural frequency of the system in rad/sec will be:

1. 67.13 rad/sec
2. 77.13 rad/sec
3. 57.13 rad/sec
4. 47.13 rad/sec

Correct Answer: Option 1: 67.13 rad/sec

Solution: The damped natural frequency ω_d is related to the undamped natural frequency ω_n and the damping factor ζ by the following formula:

$$\omega_d = \omega_n \sqrt{1 - \zeta^2}$$

Given that $\omega_n = 80$ rad/sec and $\zeta = 0.7$, we can calculate the damped natural frequency as:

$$\omega_d = 80 \sqrt{1 - (0.7)^2} = 80 \times 0.714 \approx 67.13 \text{ rad/sec}$$

 Quick Tip

The damping factor reduces the frequency of oscillation by a factor related to its magnitude. As ζ increases, the damped frequency decreases.

27. The type of brake in which frictional force assists in applying the brakes is termed as:

1. Partially self-energising
2. Self-locking
3. Self-backing
4. Self-acting

Correct Answer: Option 1: Partially self-energising

Solution: A partially self-energising brake utilizes the frictional force to assist in applying the brake, which reduces the force needed by the operator. This mechanism is commonly used in drum brakes, where the friction increases the braking force as the brake shoes move.

 Quick Tip

Self-energising brakes use the frictional forces to aid the application, while self-locking brakes prevent reverse motion. Self-acting brakes do not require external force but rely solely on the frictional effect.

28. A shaft is subjected to Bending Moment (M) and Torsional Moment (T), the equivalent torsional moment in the shaft is:

- 1. $\sqrt{M^2 + T^2}$
- 2. $\frac{1}{2}\sqrt{M^2 + T^2}$
- 3. $M + \frac{1}{2}\sqrt{M^2 + T^2}$
- 4. $T + \frac{1}{2}\sqrt{M^2 + T^2}$

Correct Answer: Option 1: $\sqrt{M^2 + T^2}$

Solution: When a shaft is subjected to both bending moment M and torsional moment T , the equivalent torsional moment is given by the formula:

$$\text{Equivalent Moment} = \sqrt{M^2 + T^2}$$

This formula combines the effects of bending and torsional moments to represent the overall stress on the shaft.

 Quick Tip

For shafts subjected to both bending and torsion, the combined effect is calculated using the Pythagorean theorem to find the equivalent torsional moment.

29. A specimen is subjected to a stress which follows sinusoidal variation with respect to the time from minimum zero value to a maximum value σ .

1. (A), (B) and (D) only.
2. (A), (B) and (C) only.
3. (B) and (C) only.
4. (B) and (D) only.

Correct Answer: Option 1: (A), (B) and (D) only.

Solution: Given that the stress follows a sinusoidal variation from zero to a maximum value of σ , we can conclude the following: - The mean value of the stress is 0, as the average of a sinusoidal wave is zero. - The amplitude of the stress is $\frac{\sigma}{2}$, which is half the maximum value of the sinusoidal variation. - The nature of the stress is fluctuating stress, as it varies periodically with time between the minimum and maximum values.

 Quick Tip

For sinusoidal variation, the mean stress is zero, amplitude is half of the maximum stress, and the stress is considered fluctuating.

30. Three identical gears A, B, and C are used in power transmission. Gear A and C are input and output gears. Gear B is an idler gear, connecting A and C. The gear which is subjected to reversed nature of stress is:

1. A
2. B
3. C
4. A and C

Correct Answer: Option 4: A and C.

Solution: In a power transmission system with an idler gear (B), gears A and C transmit the power and will experience opposite directions of rotational motion. The stress on the gears A and C will be reversed in nature because they are engaged in the power transmission process. Gear B, as the idler gear, does not transmit power and does not experience reversed stress.

 Quick Tip

In a gear system with an idler gear, the input and output gears experience reversed stresses while the idler gear remains unaffected.

31. The coefficient of restitution of a perfectly plastic impact is equal to:

1. Infinity
2. 2
3. 1
4. 0

Correct Answer: 4. 0

Solution: In a perfectly plastic impact, the objects involved in the collision do not rebound, and the velocity of separation is zero. The coefficient of restitution is defined as the ratio of relative velocity after collision to relative velocity before collision. Since there is no rebound, the coefficient of restitution equals zero.

 Quick Tip

For a perfectly plastic collision, the coefficient of restitution is always zero.

32. A ball is thrown vertically upward with velocity 5 m/sec. It takes 10 sec for its upward journey. The time taken by the ball for its downward journey is:

1. 10 sec
2. 50 sec

3. 2 sec
4. 20 sec

Correct Answer: 4. 20 sec

Solution: The time for the upward and downward journey is the same in the absence of air resistance, as gravity acts equally on both the upward and downward journeys. Since the time taken for the upward journey is 10 seconds, the downward journey will also take 10 seconds. Therefore, the total time for the entire journey is $10 + 10 = 20$ seconds.

 Quick Tip

For vertical motion under gravity, the time taken for upward and downward journeys are equal in the absence of air resistance.

33. Consider the following statements about shear stresses in beams

- (A) The shear stress at neutral axis of a rectangular section is the maximum stress.
- (B) The shear stress variation across a rectangular section is parabolic.
- (C) The shear deformations are small as compared to bending deformation.
- (D) The shear centre is also known as centre of moment.

Correct Answer: 3. (A), (B), (C) and (D)

Solution: - Statement (A) is true because the maximum shear stress in a rectangular section occurs at the neutral axis. - Statement (B) is true because shear stress varies parabolically across the section of a beam. - Statement (C) is correct as shear deformations are typically much smaller than bending deformations in beams. - Statement (D) is also true because the shear centre is the point where the applied shear force does not cause any twisting, and it is also called the centre of moment.

 Quick Tip

In beam theory, shear stress distribution is parabolic, and the maximum occurs at the neutral axis.

34. Forces whose line of action passes through a common point are known as

1. Resultant forces
2. Resolution of forces
3. Parallel forces
4. Concurrent forces

Correct Answer: 4. Concurrent forces

Solution: Forces whose lines of action pass through a common point are called concurrent forces. These forces can act at the same point but in different directions.

 Quick Tip

Concurrent forces always pass through a single point, and their resultant can be determined by vector addition.

35. Consider the following statements:

- (A) Frictional force is dependent of area of contact.
- (B) Frictional force acts in tangential direction to the surface in contact.
- (C) Maximum value of static friction is known as limiting friction.
- (D) Dynamic friction is also known as kinetic friction.

Correct Answer: 3. (A), (B), (C) and (D).

Solution: - Statement (A) is false as frictional force is not directly dependent on the area of contact, but rather on the nature of the surfaces in contact and the normal force. - Statement (B) is true since frictional force always acts in the tangential direction to the surface in contact. - Statement (C) is true because the maximum value of static friction is known as limiting friction. - Statement (D) is true as dynamic friction is also referred to as kinetic friction, which occurs when the surfaces are in relative motion.

 Quick Tip

Limiting friction is the maximum static friction that occurs just before motion begins, and kinetic friction acts once the surfaces start sliding.

36. Consider the following statements

- (A) For the two shafts connected in parallel, the angle of twist of each shaft is same.
- (B) For the two shafts connected in series, the shear stress in each shaft is same.
- (C) The shear stress in a circular shaft under torsion varies linearly.
- (D) The shear stress at the centre of a circular shaft under torsion is zero.

Choose the correct answer from the options given below:

- (1) (A), (B) and (D) only.
- (2) (A), (C) and (D) only.
- (3) (A), (B), (C) and (D).
- (4) (B), (C) and (D) only.

Correct Answer: (2) (A), (C) and (D) only.

Solution: - Statement (A) is true because when shafts are connected in parallel, the angle of twist is the same for both shafts. - Statement (B) is false because in shafts connected in series, the shear stress varies due to the varying lengths and resistances of the shafts. - Statement (C)

is true as the shear stress in a circular shaft under torsion increases linearly with the radius from the center to the surface. - Statement (D) is true because the shear stress is zero at the center of a shaft under torsion, increasing with radius from the center to the outer surface.

 Quick Tip

In torsion, shear stress is directly proportional to the distance from the center of the shaft. The center experiences no shear stress.

37. Match List I with List II

LIST I (Hardness Test)	LIST II (Type of indenter used)
A. Rockwell hardness test	I. square based diamond-pyramid
B. Vickers hardness test	II. hard steel ball
C. Brinell hardness test	III. rhombic based diamond-pyramid
D. Knoop hardness test	IV. diamond cone

Choose the correct answer from the options given below:

- (1) (A - I), (B - II), (C - III), (D - IV)
- (2) (A - II), (B - III), (C - I), (D - IV)
- (3) (A - I), (B - II), (C - IV), (D - III)
- (4) (A - III), (B - I), (C - II), (D - IV)

Correct Answer: (1) (A - I), (B - II), (C - III), (D - IV)

Solution: - The Rockwell hardness test uses a diamond cone indenter (Option I). - The Vickers hardness test uses a square-based diamond-pyramid indenter (Option II). - The Brinell hardness test uses a hard steel ball indenter (Option III). - The Knoop hardness test uses a rhombic based diamond-pyramid indenter (Option IV).

 Quick Tip

Different hardness tests use various indenters like diamonds, steel balls, or cones, each suitable for specific materials and testing conditions.

38. In a plane stress system, two principal stresses are 785 N/mm^2 and 115 N/mm^2 . If the system just causes yielding, what is the uni-axial yield stress of the material according to the Von Mises criterion:

- (1) 887 N/mm^2
- (2) 734 N/mm^2
- (3) 635 N/mm^2
- (4) 903 N/mm^2

Correct Answer: (2) 734 N/mm^2

Solution: According to the Von Mises yield criterion, the equivalent stress σ_v is given by:

$$\sigma_v = \sqrt{\sigma_1^2 - \sigma_1\sigma_2 + \sigma_2^2}$$

Substitute $\sigma_1 = 785 \text{ N/mm}^2$ and $\sigma_2 = 115 \text{ N/mm}^2$:

$$\sigma_v = \sqrt{785^2 - 785 \times 115 + 115^2} = \sqrt{616225 - 90275 + 13225} = \sqrt{536175} \approx 734 \text{ N/mm}^2$$

Thus, the uni-axial yield stress is 734 N/mm^2 .

💡 Quick Tip

For Von Mises yield criterion, the equivalent stress accounts for the interaction of principal stresses and provides an effective yield stress.

39. Under ideal conditions in drawing operation, maximum possible reduction of area in one pass is:

- (1) 28 %
- (2) 47 %
- (3) 63 %
- (4) 71 %

Correct Answer: (3) 63 %

Solution: In drawing, the maximum possible reduction of area in one pass is theoretically limited by the material properties. The maximum reduction of area is generally accepted as 63

💡 Quick Tip

In drawing, the maximum reduction of area is an important factor influencing the successful shaping of the material, typically achieving up to 63

40. Match List I with List II

LIST I (Material)	LIST II (Form of microstructure)
A. Gray Cast Iron	I. Presence of large amount of iron carbide
B. White Cast Iron	II. Graphite in the form of spheroid
C. Ductile Cast Iron	III. Graphite exists as rosettes in ferrite or pearlite matrix
D. Malleable Cast Iron	IV. Graphite in the form of flakes

Correct Answer: (1) (A - I), (B - IV), (C - II), (D - III)

Solution: - Gray Cast Iron: This type of iron has graphite in the form of flakes, which is associated with the formation of a brittle structure. - White Cast Iron: This type has a large amount of iron carbide, making it hard and brittle. - Ductile Cast Iron: In this form, graphite exists in the shape of spheroids, which enhances its ductility. - Malleable Cast Iron: The

graphite in malleable cast iron forms as rosettes in a matrix of ferrite or pearlite, improving the material's strength and malleability.

 Quick Tip

Graphite form influences the mechanical properties of cast iron. Flakes reduce strength, while spheroidal or rosette formations increase ductility and toughness.

41. Tempering is a heat treatment process by which:

- (1) Hardness is Reduced and Toughness is Improved.
- (2) Hardness is Improved and Toughness is Reduced.
- (3) Toughness is Reduced and Hardness is Improved.
- (4) Toughness is Improved and Hardness is Improved.

Correct Answer: (1) Hardness is Reduced and Toughness is Improved.

Solution: Tempering is a heat treatment process that involves heating a material (usually steel) to a temperature below its critical point, followed by cooling. This process reduces the brittleness of the material, increases its toughness, and decreases hardness. As a result, tempering is commonly used to balance toughness and hardness, improving the material's ability to absorb energy without fracturing.

 Quick Tip

Tempering is essential for reducing the brittleness of hardened steel while improving its toughness, typically done after hardening.

42. Centre-line feeding resistance (CFR) indicates the difficulty of feeding a given alloy in a mould. Normally, feeding is considered to be difficult if:

- (1) $CFR > 70\%$
- (2) $CFR = 68\%$
- (3) $CFR = 48\%$
- (4) $48\% < CFR < 68\%$

Correct Answer: (1) $CFR > 70\%$

Solution: Centre-line feeding resistance (CFR) is an important parameter in casting processes that measures the resistance to filling the mold. A CFR greater than 70% typically indicates that the feeding of the material into the mold is difficult. This could lead to issues such as improper filling or void formation in the final casting. A lower CFR value indicates better feeding capability.

 Quick Tip

In casting, CFR is used to evaluate mold filling efficiency. A high CFR indicates difficulties in achieving a full mold without defects.

43. Production scheduling is simple and high volume of output and high labour efficiency are achieved in the following case of

1. fixed position layout
2. product layout
3. process layout
4. combination of line and process layout

Correct Answer: 2. product layout.

Solution: In a product layout, the operations are arranged in a sequence according to the production process, which allows high volume output and high labour efficiency. This layout is ideal for repetitive and high-volume production.

 Quick Tip

Product layouts are efficient for mass production as they reduce work-in-progress and handling time, making them ideal for high volume production.

44. For clearance fit, the upper limit of the shaft should be:

1. greater than the upper limit of the hole
2. lesser than the upper limit of the hole
3. greater than the lower limit of the hole
4. lesser than the lower limit of the hole

Correct Answer: 3. greater than the lower limit of the hole.

Solution: In clearance fit, the shaft is always smaller than the hole. Therefore, the upper limit of the shaft must be greater than the lower limit of the hole to ensure a clearance gap between the parts.

 Quick Tip

Clearance fits are designed to provide sufficient space between mating parts, ensuring that the parts can move freely without interference.

45. A ratchet screw in a micrometer is provided to

1. allow zero adjustment
2. prevent wearing of screw thread
3. lock the required measurement
4. maintain constant pressure on the job specimen

Correct Answer: 4. maintain constant pressure on the job specimen.

Solution: A ratchet screw in a micrometer is used to apply a constant pressure on the job specimen, ensuring that the measurement is consistent and accurate regardless of the user's hand pressure.

 Quick Tip

The ratchet mechanism in a micrometer prevents measurement errors caused by variations in applied pressure, ensuring repeatable results.

46. In a multispindle CNC machine tool, 3 operations are performed with times 50, 70, and 80 seconds at each of its work centers. The cycle time (time required to manufacture one workpiece) in seconds will be:

1. 200
2. 66.66
3. 70
4. 80

Correct Answer: 3. 70.

Solution: In a multispindle CNC machine, the cycle time is determined by the operation that takes the longest time, since all operations are performed simultaneously. In this case, the operation with the longest time is 80 seconds.

 Quick Tip

For multispindle machines, the cycle time is determined by the slowest operation, as all spindles work simultaneously.

47. G-code is a

1. low level language
2. middle level language
3. high level language
4. APT - Automatically Programmed Tool

Correct Answer: 1. low level language.

Solution: G-code is a low-level language used in CNC machines to control the movements of the machine tool. It consists of a series of commands that tell the machine how to move, cut, and operate during manufacturing.

 Quick Tip

G-code is a fundamental part of CNC programming, giving instructions to the machine about its movements and operations.

48. A variable which does not appear in the basic variable column of a simplex table for a solution is assigned

1. zero value
2. a positive value
3. infinite value
4. a negative value

Correct Answer: 1. zero value.

Solution: In the simplex method, variables that are not part of the current solution (non-basic variables) are assigned a value of zero. This is because they are not contributing to the objective function at that point in the solution.

 Quick Tip

In the simplex method, non-basic variables are assigned zero value, and only basic variables contribute to the objective function value at each iteration.

49. The unoccupied cells in the transportation table are analogous to

1. current solution variables
2. non-basic variables
3. next after opportunity cost cells
4. optimal values of the objective function

Correct Answer: 2. non-basic variables.

Solution: In the transportation problem, unoccupied cells represent non-basic variables. These are cells that are not currently being used to transport goods but may be used in future iterations based on the opportunity cost method to find the optimal solution.

 Quick Tip

Unoccupied cells in a transportation table are analogous to non-basic variables in linear programming, and they may become part of the solution in the next steps.

50. PERT technique deals with the project of

1. probabilistic nature
2. deterministic nature
3. non-repetitive nature
4. repetitive nature

Correct Answer: 1. probabilistic nature.

Solution: The PERT (Program Evaluation and Review Technique) method is designed for projects with uncertain or probabilistic durations. It considers the variability in task completion times and uses statistical methods to estimate project duration and probabilities.

💡 Quick Tip

PERT is used for projects with uncertain timelines, where task durations are variable and follow a probabilistic distribution.

51. The eigenvalues of the matrix

$$\begin{bmatrix} 1 & -2 & 3 \\ -2 & 2 & -4 \\ 3 & -4 & 7 \end{bmatrix}$$

are:

1. 0, 1, $5 + \sqrt{31}$
2. 0, 1, $5 - \sqrt{31}$
3. $5 + \sqrt{31}$, $5 - \sqrt{31}$, 1
4. $5 + \sqrt{31}$, $5 - \sqrt{31}$, 0

Correct Answer: 4. $5 + \sqrt{31}$, $5 - \sqrt{31}$, 0.

Solution: To solve for the eigenvalues of the matrix, we need to calculate the characteristic equation $\det(A - \lambda I) = 0$, where A is the given matrix and λ represents the eigenvalues. Solving the resulting cubic equation gives us the eigenvalues as $5 + \sqrt{31}$, $5 - \sqrt{31}$, and 0.

💡 Quick Tip

When solving for eigenvalues, always start by setting up and solving the characteristic equation $\det(A - \lambda I) = 0$.

52. The solution of the following system of linear equations

$$4x_1 - 8x_2 - 2x_3 = 0 \quad 3x_1 - 5x_2 - 2x_3 = 0 \quad 2x_1 - 8x_2 + x_3 = 0$$

is:

1. $x_1 = 1, x_2 = 1, x_3 = 1$
2. $x_1 = \frac{3}{2}, x_2 = \frac{1}{2}, x_3 = 0$
3. The system has no solution
4. The system has infinitely many solutions

Correct Answer: 4. The system has infinitely many solutions.

Solution: We use Gaussian elimination to solve the system of linear equations. The augmented matrix for this system leads to an under-determined system, indicating infinitely many solutions. This system has dependent equations, meaning we have more variables than independent equations.

 Quick Tip

When solving a system with more variables than equations, check if the system is consistent or under-determined. If it is, expect infinitely many solutions.

53. The value of the integral

$$\oint_C (y^3 \mathbf{i} - x^3 \mathbf{j}) \cdot (\mathbf{i} dx + \mathbf{j} dy)$$

where C is the closed curve, is:

1. $-\frac{3}{2}\pi a^3$
2. $-\frac{3}{2}\pi a^4$
3. $-\frac{3}{2}\pi a^4$
4. $-\frac{3}{2}\pi a^3$

Correct Answer: 1. $-\frac{3}{2}\pi a^3$.

Solution: Using Green's Theorem, we convert the line integral into a double integral over the region enclosed by the curve C . The integral simplifies to the value $-\frac{3}{2}\pi a^3$, considering the given components of the vector field.

 Quick Tip

For closed line integrals, use Green's Theorem to convert the line integral into a double integral over the region enclosed by the curve.

54. The value of the integral

$$\int_{0.2}^{1.4} (\sin x - \log_e x + e^x) dx$$

using Simpson's three-eighth rule, by taking interval size $h = 0.2$, is:

1. 4.05
2. 4.052985
3. 4.502985
4. 4.052985

Correct Answer: 2. 4.052985.

Solution: To apply Simpson's three-eighth rule, we use the given function values at the specified intervals and calculate the weighted sum. The result of the integral is approximately 4.052985.

 Quick Tip

Simpson's three-eighth rule is a numerical integration technique that is particularly effective when dealing with irregular intervals and provides better accuracy for certain functions.

55. Which of the following is not a non-linear partial differential equation, where $p = \frac{\partial z}{\partial x}$ and $q = \frac{\partial z}{\partial y}$?

1. $p + q = pq$
2. $x^2 p^2 + y^2 q^2 = z^2$
3. $(x + y) \left(\frac{\partial z}{\partial x} + \frac{\partial z}{\partial y} \right)^2 + (x - y) \left(\frac{\partial z}{\partial x} - \frac{\partial z}{\partial y} \right)^2 = 1$
4. $\frac{\partial^2 z}{\partial x^2} + \frac{\partial^2 z}{\partial x \partial y} - 6 \frac{\partial^2 z}{\partial y^2} = x^2 \sin(x + y)$

Correct Answer: 4. $\frac{\partial^2 z}{\partial x^2} + \frac{\partial^2 z}{\partial x \partial y} - 6 \frac{\partial^2 z}{\partial y^2} = x^2 \sin(x + y)$.

Solution: The equation in option 4 is a linear partial differential equation, as it only involves second-order derivatives with respect to x and y and does not contain terms where p and q are multiplied. The other equations are non-linear due to the presence of terms like pq or powers of p and q .

 Quick Tip

In non-linear partial differential equations, the derivatives of the function are raised to powers or multiplied together.

56. Given below are two statements, one is labelled as Assertion (A) and the other one labelled as Reason (R).

Assertion (A): Smart materials can be used as microsensors and microactuators, both.

Reason (R): Smart materials belong to intelligent mechanisms.

Choose the correct answer from the options given below:

1. Both (A) and (R) are true and (R) is the correct explanation of (A). 2. Both (A) and (R) are true but (R) is NOT the correct explanation of (A). 3. (A) is true but (R) is false. 4. (A) is false but (R) is true.

Correct Answer: 2. Both (A) and (R) are true but (R) is NOT the correct explanation of (A).

Solution: Smart materials indeed serve as both microsensors and microactuators due to their ability to change properties in response to stimuli. However, Reason (R) stating that smart materials belong to "intelligent mechanisms" is not a correct explanation for their use in microsensors and microactuators. Smart materials are not necessarily part of intelligent mechanisms, but they can be used to make such mechanisms.

 Quick Tip

Smart materials can act as sensors and actuators because of their unique properties, such as shape memory or piezoelectric effects.

57. Which of the following does not belong to the static characteristics of transducers?

1. Accuracy
2. Dead band
3. Response time
4. Resolution

Correct Answer: 3. Response time.

Solution: Static characteristics of transducers refer to the performance of the transducer under steady-state conditions, without any time-dependent changes. These include accuracy, dead band, and resolution. Response time, on the other hand, is a dynamic characteristic that describes how quickly a transducer responds to changes in the measured quantity.

 Quick Tip

Static characteristics of transducers deal with their behavior when conditions are steady, while dynamic characteristics like response time involve time-dependent behaviors.

58. Which of the following sensors can be used to monitor linear and angular velocities and detect motion?

- Options:**
1. (A) Incremental encoder
 2. (B) Tachogenerator
 3. (C) Piezoelectric sensors
 4. (D) Pyroelectric sensors

Choose the correct answer from the options given below:

1. (A), (B) and (D) only.
2. (A), (B) and (C) only.
3. (A), (B), (C) and (D).
4. (B), (C) and (D) only.

Correct Answer: 2. (A), (B) and (C) only.

Solution: Incremental encoders and tachogenerators are both commonly used to measure linear and angular velocities, as they produce output signals proportional to the motion. Piezoelectric sensors can also be used to detect motion by converting mechanical energy into electrical energy. Pyroelectric sensors, however, are typically used for detecting heat and infrared radiation, not motion.

 Quick Tip

To measure motion and velocities, use sensors like incremental encoders and tachogenerators that directly convert mechanical motion to electrical signals.

59. Match List I with List II

Mechanical Drive

Function

Choose the correct answer from the options given below:

LIST I Mechanical Drive	LIST II Function
A. Cams	I. Lock a mechanism when it is holding a load.
B. Gears	II. Movement of one part relative to another with minimum friction and maximum accuracy.
C. Ratchets	III. Imparts a reciprocating or oscillatory motion to another body in contact.
D. Bearings	IV. Transmission of rotary motion between parallel and inclined shafts.

1. (A) - (II), (B) - (III), (C) - (IV), (D) - (I)
2. (A) - (II), (B) - (III), (C) - (I), (D) - (IV)
3. (A) - (I), (B) - (II), (C) - (IV), (D) - (III)
4. (A) - (III), (B) - (IV), (C) - (I), (D) - (II)

Correct Answer: 2. (A) - (II), (B) - (III), (C) - (I), (D) - (IV)

Solution: - Cams (A) are used for imparts reciprocating or oscillatory motion to another body, hence (III). - Gears (B) help in the movement of one part relative to another with accuracy, hence (II). - Ratchets (C) are used to lock a mechanism, hence (I). - Bearings (D) are used for transmitting rotary motion between parallel and inclined shafts, hence (IV).

 Quick Tip

Cams, gears, ratchets, and bearings are basic mechanical components, each serving specific functions in machines to provide motion control, accuracy, and locking.

60. Which of the following pressure control valves is used to sense the hydraulic pressure of an external line and give a signal when it reaches some preset value?

1. Pressure regulating valve
2. Pressure setting valve
3. Pressure sequence valve
4. Pressure limiting valve

Correct Answer: 3. Pressure sequence valve

Solution: Pressure sequence valves are used to sense the hydraulic pressure in an external line and send a signal when it reaches a preset value, typically used to control multiple actuators.

 Quick Tip

Pressure sequence valves are key in controlling the sequence of operations in hydraulic systems based on pressure thresholds.

61. In an electrical actuation system, solid-state switches include:

1. (A) Bipolar transistors
2. (B) Thyristors and triacs
3. (C) Relays

4. (D) Diodes

Choose the correct answer from the options given below:

1. (A), (B) and (D) only
2. (A), (B) and (C) only.
3. (A), (B), (C) and (D).
4. (B), (C) and (D) only.

Correct Answer: 3. (A), (B), (C) and (D)

Solution: Solid-state switches include bipolar transistors (A), thyristors and triacs (B), relays (C), and diodes (D), all of which are used in electrical actuation systems to control current flow.

 Quick Tip

Solid-state switches are essential components in electrical systems, providing efficient and reliable switching without mechanical parts.

62. The sequence for flow of signal in working principle of microsensors includes:

1. (A), (B), (C), (D) only
2. (A), (C), (B), (D) only
3. (B), (A), (D), (C) only
4. (C), (B), (D), (A) only

Correct Answer: 1. (A), (B), (C), (D) only

Solution: The correct sequence of signal flow in microsensors is: 1. Input signal (A) is received. 2. Transducer element (B) processes the signal. 3. Sensor element (C) detects the signal. 4. Output signal (D) is generated.

 Quick Tip

Understanding the signal flow helps in optimizing the functionality of microsensors in detecting and converting input signals to output.

63. Some of the examples of non-contact sensors includes ———.

- (A) Proximity sensors
- (B) Temperature sensors
- (C) Torque sensors
- (D) Acoustic sensors

Choose the correct answer from the options given below:

1. (A), (B) and (D) only.
2. (A), (B) and (C) only.
3. (A), (B), (C) and (D).
4. (B), (C) and (D) only.

Correct Answer: 1. (A), (B) and (D) only.

Solution: Non-contact sensors are those that do not require physical contact with the object to measure its properties. Proximity sensors, temperature sensors, and acoustic sensors are examples of non-contact sensors. Torque sensors, however, require direct contact with the object being measured.

 Quick Tip

Non-contact sensors are commonly used in applications where direct contact might damage the object or when measuring delicate or inaccessible objects.

64. What is the minimum number of degree of freedom for assembling round peg in round hole?

1. 2
2. 3
3. 4
4. 5

Correct Answer: 2. 3

Solution: The minimum number of degrees of freedom required for assembling a round peg into a round hole is 3. This includes two translational degrees of freedom (moving along X and Y axes) and one rotational degree of freedom (rotation around the center).

 Quick Tip

Assembling a round peg in a round hole requires freedom for both linear movement and rotation to align and fit the components properly.

65. Given below are the two statements, one is labelled as Assertion (A) and other one labelled as Reason (R).

Assertion (A): The end-effector does not contribute to manipulability.

Reason (R): The end-effector is external to the manipulator.

Choose the correct answer from the options given below:

1. Both (A) and (R) are true and (R) is the correct explanation of (A).
2. Both (A) and (R) are true but (R) is NOT the correct explanation of (A).

3. (A) is true but (R) is false.
4. (A) is false but (R) is true.

Correct Answer: 4. (A) is false but (R) is true.

Solution: The assertion is false because the end-effector does contribute to manipulability by affecting the performance and accuracy of the manipulator. The reason is true, as the end-effector is typically external to the manipulator and is attached at the robot's arm's end.

 Quick Tip

The end-effector in robotic systems plays a crucial role in defining the functionality of the manipulator, such as picking, placing, or sensing tasks.

66. Match List I with List II

LIST I (Robot Configuration)	LIST II (Joints)
A. Cylindrical	I. RRR
B. Cartesian	II. RPP
C. Spherical	III. PPP
D. Articulated	IV. RRP

Choose the correct answer from the options given below:

1. (A) - (I), (B) - (II), (C) - (III), (D) - (IV)
2. (A) - (I), (B) - (III), (C) - (II), (D) - (IV)
3. (A) - (II), (B) - (III), (C) - (IV), (D) - (I)
4. (A) - (II), (B) - (IV), (C) - (III), (D) - (I)

Correct Answer: 1. (A) - (I), (B) - (II), (C) - (III), (D) - (IV)

Solution: The robot configurations and their corresponding joint types are as follows: - Cylindrical robots have 2 Revolute joints (R) and 1 Prismatic joint (P), making it (II). - Cartesian robots have 3 Prismatic joints (P), making it (III). - Spherical robots have 3 Revolute joints (R), making it (I). - Articulated robots have 2 Revolute joints (R) and 1 Prismatic joint (P), making it (IV).

 Quick Tip

The configuration of a robot depends on its joints and their types, influencing the robot's motion and application in different tasks.

67. Given below are the two statements:

Statement (I): The scale factor in homogeneous transformation matrix can be any real value.

Statement (II): For robotics study, the scale factor in homogeneous transformation matrix is one.

Choose the most appropriate answer from the options given below:

1. Both Statement (I) and Statement (II) are correct.
2. Both Statement (I) and Statement (II) are incorrect.
3. Statement (I) is correct but Statement (II) is incorrect.
4. Statement (I) is incorrect but Statement (II) is correct.

Correct Answer: 4. Statement (I) is incorrect but Statement (II) is correct.

Solution: In homogeneous transformation matrices used in robotics, the scale factor is typically one. This is because the transformation matrices are used to describe the position and orientation of objects without scaling them. Statement (I) is incorrect, while Statement (II) is correct.

 Quick Tip

In robotics, homogeneous transformation matrices are used to calculate the position and orientation of objects, and scaling is usually not part of the transformation.

71. The human eye perception is limited to approximately

1. 16 gray levels
2. 32 gray levels
3. 64 gray levels
4. 128 gray levels

Correct Answer: 3. 64 gray levels

Solution: The human eye can typically distinguish around 64 different shades of gray in varying lighting conditions, which is why the perception of gray levels is limited to around 64. This is a physiological limitation of the human visual system.

 Quick Tip

The ability to distinguish different gray levels is crucial in image processing and vision-based applications, especially in low-contrast environments.

72. One single robot for continuous arc welding is unable to resolve the following issue:

1. The edges of parts to be welded are irregular.
2. The quality of weld depends on the speed of electrode movement.
3. Loading and unloading of the parts.
4. The arc welding process is usually in low quantity and changes often.

Correct Answer: 3. Loading and unloading of the parts.

Solution: A single robot used for continuous arc welding is unable to handle the loading and unloading of parts effectively, as this requires additional coordination and automation beyond the robot's movement. This issue is typically addressed by introducing additional handling robots or conveyor systems.

 Quick Tip

The limitations of single robots in manufacturing processes can be overcome by using complementary automation systems for material handling, improving overall efficiency.

73. The link parameters are:

1. constant for a given link
2. variables for a given link
3. constant for a manipulator
4. variable for a manipulator

Correct Answer: 1. constant for a given link

Solution: Link parameters refer to the physical characteristics of the robot's links, such as length, mass, and moments of inertia. These are constants for a given link and are typically used in robot kinematics and dynamics calculations.

 Quick Tip

Link parameters are fundamental in robot analysis, affecting both the kinematic and dynamic models used in controlling and simulating robot movement.

74. What is the function of Joints in a Robot Manipulator?

1. ensures mobility and reachability
2. confers orientation
3. performs required task
4. means of articulations

Correct Answer: 4. means of articulations

Solution: Joints in a robot manipulator are the elements that connect the links, allowing for relative movement between the links. They provide the means of articulation, enabling the robot to perform tasks by controlling the movement of its parts.

 Quick Tip

Understanding the function of joints is crucial for designing robot manipulators with the desired motion capabilities and workspace reach.

75. What is the order of basic transformation of frame $i - 1$ to frame i

1. (A), (B), (C), (D)
2. (A), (C), (D), (B)
3. (D), (B), (C), (A)
4. (D), (A), (C), (B)

Correct Answer: 2. (A), (C), (D), (B)

Solution: The order of transformation for frame $i - 1$ to frame i starts with translation along the z_{i-1} axis by distance d_i , followed by translation along the x_{i-1} axis by distance a_i , then rotation by an angle θ_i about the z_{i-1} axis, and finally rotation by an angle α_i about the x_{i-1} axis.

 Quick Tip

The transformation sequence is crucial for accurate kinematic modeling in robotic systems, especially when dealing with multiple frames of reference.