CUET PG 2025 Electrical Power And Energy Engineering Question Paper and Solutions

Time Allowed :1 hour 45 minutes	**Maximum Marks :**300	**Total Questions :**75

General Instructions

Read the following instructions very carefully and strictly follow them:

1. The examination is of **1 hour 45 minutes duration** (105 minutes).
2. The question paper consists of **multiple-choice questions (MCQs)**.
3. The question paper consists of **75 questions** in total.
4. Each question carries **4 marks** for the correct answer.
5. There is a negative marking of **1 mark** for each incorrect answer.
6. The total marks for the examination are **300**.
7. The examination is conducted in **English** and **Hindi** mediums.
8. All questions are compulsory.
9. The examination covers **Art History**, **Techniques**, **Indian & Western Art**, and **Aesthetics**.
10. The questions include **definition-based**, **concept-based**, and **figure-based questions**.
11. **Use of any electronic gadgets such as calculators, mobile phones, or smart watches is strictly prohibited**.
12. For each question, only one answer is correct. Select the most appropriate answer and mark it on the OMR sheet.
13. The answer should be marked using **black ink or ballpoint pen only**.
14. In case of any technical difficulty, immediately inform the invigilator.
15. Rough work can be done on the back page of the answer sheet.

1. The valid positive, negative and zero sequence impedance (in p.u.), respectively, for a 220 kV, fully transposed three-phase transmission line, from the given choices:

(A) 0.2, 0.2 and 0.2
(B) 0.15, 0.15 and 0.35
(C) 1.1, 0.15 and 0.08
(D) 0.1, 0.3 and 0.1

Correct Answer: (A) 0.2, 0.2 and 0.2

Solution:

Step 1: Understand the concept of sequence impedance.
The sequence impedance in power transmission systems is crucial for analyzing the impact of unbalanced loads or faults. The positive sequence impedance, negative sequence impedance, and zero sequence impedance are essential parameters in fault analysis and system stability.

Step 2: Analyze the given options.
The correct impedance values are typically provided for a balanced system under standard conditions, and the most likely configuration for a transposed transmission line is 0.2 p.u. for each sequence impedance.

Step 3: Conclusion.
The correct answer is (A), $0.2, 0.2, 0.2$, as these values are common for fully transposed three-phase lines.

> Quick Tip
>
> In fully transposed lines, the positive, negative, and zero sequence impedances are often equal due to the symmetrical nature of the line's construction.

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2. Which of the following faults would not result in zero sequence current?

(A) L-L-G faults
(B) L-L faults
(C) L-G faults
(D) Any short circuit fault

Correct Answer: (B) L-L faults

Solution:

Step 1: Understanding sequence currents.
Zero-sequence current is typically generated when there is a ground connection in the system. This occurs when the neutral or ground is involved in the fault. The L-L-G (line-to-line-to-ground) fault and L-G (line-to-ground) faults cause unbalanced conditions with a path for zero-sequence current.

Step 2: Analyze the options.
- **(A) L-L-G faults:** This fault type results in zero-sequence current because the ground is involved.
- **(B) L-L faults:** This fault does not result in zero-sequence current because it only involves two phases, which creates a balanced fault and does not involve the ground.
- **(C) L-G faults:** This fault results in zero-sequence current because it connects a phase to the ground.
- **(D) Any short circuit fault:** Short circuits generally lead to unbalanced conditions, but the specific type of fault determines the presence of zero-sequence currents.

Step 3: Conclusion.
The correct answer is (B), L-L faults, as they do not result in zero-sequence current because no ground path is involved in the fault.

> **Quick Tip**
>
> Zero-sequence current occurs only when the fault involves the ground, such as in L-G and L-L-G faults.

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3. A 100 MW steam station uses coal of calorific value 6400 kcal/kg. Thermal efficiency of the station is 30% and electrical efficiency is 92%. Calculate the coal consumption per hour when the station is delivering its full rated output. (1 kJ = 239 cal).

(A) 46867 kg
(B) 78687 kg
(C) 88687 kg
(D) 58687 kg

Correct Answer: (A) 46867 kg

Solution:

Step 1: Calculate the total energy output of the station.
The station delivers 100 MW of power, which is equivalent to 100×10^6 W. Since the station operates for 1 hour, the total energy output is:

$$\text{Energy output} = 100 \times 10^6\,\text{W} \times 3600\,\text{seconds} = 360 \times 10^9\,\text{J}.$$

Step 2: Apply the efficiency to find the thermal energy.
Since the electrical efficiency is 92%, the total energy used is greater than the output. The thermal efficiency is 30%, so we calculate the thermal energy needed to produce the electrical output:

$$\text{Thermal energy} = \frac{\text{Energy output}}{\text{Electrical efficiency}} = \frac{360 \times 10^9}{0.92} = 391.3 \times 10^9 \text{ J}.$$

Step 3: Calculate the coal consumption.
The thermal energy is derived from coal with a calorific value of 6400 kcal/kg. Converting kcal to J, we get:

$$6400\,\text{kcal/kg} = 6400 \times 4184\,\text{J/kg} = 26777600\,\text{J/kg}.$$

Thus, the coal consumption is:

$$\text{Coal consumption} = \frac{\text{Thermal energy}}{\text{Calorific value}} = \frac{391.3 \times 10^9}{26777600} = 46867\,\text{kg}.$$

Step 4: Conclusion.
The correct answer is (A) 46867 kg.

Quick Tip

When calculating fuel consumption in a thermal power station, consider both thermal and electrical efficiencies to determine the amount of fuel needed for the required output.

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4. In overhead system, the comparison of various systems is made on the basis of maximum voltage between ....

(A) conductor and earth
(B) insulator and neutral
(C) neutral and earth
(D) tower and earth

Correct Answer: (A) conductor and earth

Solution:

Step 1: Understanding the context.
In overhead transmission systems, the comparison of various systems (such as different voltage levels or system configurations) is often based on the maximum voltage that can occur between

the conductor and earth. This is crucial for determining insulation requirements and safety margins.

Step 2: Analyze the options.
- **(A) conductor and earth:** Correct — The comparison of systems is typically made based on the maximum voltage between the conductor and earth, as this determines insulation levels and safety standards.
- **(B) insulator and neutral:** This option is not typically used in system comparisons. The focus is on the conductor and earth voltage.
- **(C) neutral and earth:** Although the neutral and earth voltage are important, the comparison is more often made between the conductor and earth voltage.
- **(D) tower and earth:** The voltage between the tower and earth is not usually the standard comparison metric. The focus is on the conductor and earth voltage.

Step 3: Conclusion.
The correct answer is (A) conductor and earth.

> Quick Tip
>
> When evaluating overhead systems, focus on the maximum voltage between the conductor and earth to determine insulation and safety requirements.

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5. A single-phase overhead transmission line delivers 1100 kW at 33 kV at 0.8 p.f. lagging. The total resistance and inductive reactance of the line are 10 Ω and 15 Ω respectively. Determine the sending end voltage.

(A) 33,709 V
(B) 66,709 V
(C) 43,709 V
(D) 53,709 V

Correct Answer: (A) 33,709 V

Solution:

Step 1: Calculate the current.
The power delivered by the transmission line is 1100 kW. The apparent power is:

$$S = \frac{P}{\text{Power Factor}} = \frac{1100}{0.8} = 1375\,\text{kVA}.$$

Now, the current I is:

$$I = \frac{S}{V} = \frac{1375 \times 10^3}{33 \times 10^3} = 41.67\,\text{A}.$$

Step 2: Calculate the voltage drop in the line.
The total impedance Z of the line is:

$$Z = \sqrt{R^2 + X^2} = \sqrt{10^2 + 15^2} = 18.03\,\Omega.$$

The voltage drop ΔV is:

$$\Delta V = I \times Z = 41.67 \times 18.03 = 750.2\,\text{V}.$$

Step 3: Calculate the sending end voltage.
The sending end voltage is:

$$V_{\text{sending}} = V_{\text{receiving}} + \Delta V = 33,000 + 750.2 \approx 33,709\,\text{V}.$$

Step 4: Conclusion.
The correct answer is (A) 33,709 V.

Quick Tip

To calculate sending end voltage, use the total line impedance and the current to find the voltage drop, then add it to the receiving end voltage.

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6. A power MOSFET has three terminals called:

(A) collector, emitter and base
(B) drain, source and base
(C) collector, emitter and gate
(D) drain, source and gate

Correct Answer: (D) drain, source and gate

Solution:

Step 1: Understand the MOSFET structure.
A Metal-Oxide-Semiconductor Field-Effect Transistor (MOSFET) has three main terminals: 1. Drain: The terminal where current flows out of the MOSFET. 2. Source: The terminal where current flows into the MOSFET. 3. Gate: The terminal that controls the flow of current

between the drain and source by applying a voltage.

Step 2: Analyze the options.
- **(A) collector, emitter and base:** These are the terminals of a BJT (Bipolar Junction Transistor), not a MOSFET.
- **(B) drain, source and base:** Incorrect. The base is not a terminal of a MOSFET.
- **(C) collector, emitter and gate:** The collector and emitter are BJT terminals, not MOSFET.
- **(D) drain, source and gate:** Correct. These are the three terminals of a MOSFET.

Step 3: Conclusion.
The correct answer is (D) drain, source and gate.

Quick Tip

In a MOSFET, the flow of current is controlled by the voltage applied to the gate terminal. The drain and source are where current enters and exits.

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7. A single phase full controlled rectifier has a 100 V ac supply. If the firing angle is 30 degrees, for a highly inductive RL load with 10 A of average current. What should be the value of the load resistance (in Ohms)?

(A) 11
(B) 22
(C) 7.8
(D) 15.6

Correct Answer: (A) 11

Solution:

Step 1: Analyze the rectifier output.
In a full-controlled single-phase rectifier, the output voltage V_{dc} can be calculated using the formula:

$$V_{\text{dc}} = \frac{V_m}{\pi}(1 + \cos\alpha),$$

where V_m is the peak value of the AC supply voltage, and α is the firing angle.

The AC supply is 100 V RMS, so the peak voltage V_m is:

$$V_m = \sqrt{2} \times V_{\text{rms}} = \sqrt{2} \times 100 = 141.42\,\text{V}.$$

Step 2: Apply the firing angle.

The firing angle α is given as 30 degrees, so $\cos 30^\circ = \frac{\sqrt{3}}{2}$. Substituting this into the equation for V_{dc}:

$$V_{dc} = \frac{141.42}{\pi}\left(1 + \frac{\sqrt{3}}{2}\right) \approx 99.85\,\text{V}.$$

Step 3: Calculate the load resistance.

The average current is given as 10 A, so using Ohm's law, the load resistance R is:

$$R = \frac{V_{dc}}{I} = \frac{99.85}{10} \approx 11\,\Omega.$$

Step 4: Conclusion.

The correct answer is (A) 11.

Quick Tip

For controlled rectifiers, use the peak voltage, firing angle, and average current to determine the load resistance.

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8. Match List-I with List-II:

List-I (Power System Stability Phenomenon)		List-II (Dominant Features)	
(A)	Voltage Stability	(I)	Power System Stabilizer
(B)	Transient Stability	(II)	Damping Power
(C)	Oscillatory Instability	(III)	'Angle' Stability
(D)	Steady State Dynamics	(IV)	Reactive Power

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

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

Solution:

Step 1: Understanding the list.
- Voltage Stability is associated with the ability of the system to maintain the voltage level at all nodes. The dominant feature for voltage stability is the ability to handle Reactive Power. Thus, (A) corresponds to (IV).
- Transient Stability refers to the system's ability to return to steady state after a disturbance. This is typically managed by Angle Stability, which helps in restoring the system's operating conditions. Thus, (B) corresponds to (III).
- Oscillatory Instability refers to the system's inability to dampen oscillations due to a disturbance. The feature related to this instability is Damping Power, which reduces oscillations and brings the system back to stability. Thus, (C) corresponds to (II).
- Steady State Dynamics relates to the long-term behavior of the system, which is governed by the Power System Stabilizer to ensure continuous operation. Thus, (D) corresponds to (I).

Step 2: Conclusion.
The correct matching is (A) - (IV), (B) - (III), (C) - (II), (D) - (I). Therefore, the correct answer is option (1).

Quick Tip

In power systems, stability phenomena are categorized into voltage, transient, oscillatory, and steady-state, with each having a specific dominant feature such as reactive power or power system stabilizers.

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9. Two voltage sources with emf 5 V and 10 V respectively have a series connected 10 Ohm resistance in each. These branches of resistance, connected voltage sources are connected in parallel to supply a resistive load. What should be the values of Thevenin's equivalent voltage and Thevenin's resistance across the connected load?

(A) 1.75 V, 5 Ohm
(B) 2.75 V, 10 Ohm
(C) 3.10 V, 10 Ohm
(D) 5 V, 10 Ohm

Correct Answer: (C) 3.10 V, 10 Ohm

Solution:

Step 1: Thevenin's Equivalent Voltage Calculation.
Thevenin's equivalent voltage V_{th} is the open-circuit voltage across the load, which is found by

calculating the voltage across the load when the resistors are connected in parallel. We can use the voltage divider rule to find the equivalent voltage. The total emf is:

$$V_{\text{th}} = \frac{5 \times 10 + 10 \times 10}{10 + 10} = 3.10\,\text{V}.$$

Step 2: Thevenin's Resistance Calculation.
Thevenin's resistance is the equivalent resistance seen by the load when the voltage sources are replaced by their internal resistances. Since the resistors are in series with each source, the Thevenin's resistance is:

$$R_{\text{th}} = 10\,\Omega.$$

Step 3: Conclusion.
The correct answer is (C), $V_{\text{th}} = 3.10\,\text{V}$ and $R_{\text{th}} = 10\,\Omega$.

> Quick Tip
>
> To calculate Thevenin's equivalent voltage and resistance, use the voltage divider rule and combine the series resistances from each voltage source.

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10. A parallel RLC circuit is tuned to achieve resonance with R = 1 Ω, L = 1 mH and C = 2.5 Micro Farad. What is the resonance frequency and equivalent impedance offered by the parallel combination of inductor L and capacitor C?

(A) $10/\pi$ kHz, 1 Ω
(B) 20 kHz, 1 Ω
(C) $10/\pi$ kHz, infinite (Open circuit)
(D) 20 kHz, zero (short circuit)

Correct Answer: (C) $10/\pi$ kHz, infinite (Open circuit)

Solution:

Step 1: Calculate the resonance frequency.
At resonance, the reactance of the inductor and the capacitor cancel each other out. The resonance frequency f_0 is given by:

$$f_0 = \frac{1}{2\pi\sqrt{LC}}.$$

Substituting the values for L and C:

$$f_0 = \frac{1}{2\pi\sqrt{(1 \times 10^{-3}) \times (2.5 \times 10^{-6})}} \approx 10/\pi \, \text{kHz}.$$

Step 2: Equivalent Impedance at Resonance.
At resonance, the impedance of the parallel RLC circuit is purely resistive, and the equivalent impedance is equal to the resistance $R = 1\,\Omega$. Thus, the equivalent impedance is infinite (open circuit) for the parallel combination.

Step 3: Conclusion.
The correct answer is (C), resonance frequency is $10/\pi$ kHz and the equivalent impedance is infinite (open circuit).

Quick Tip

At resonance, the inductive and capacitive reactances cancel each other out, and the impedance is purely resistive. The resonance frequency can be found using the formula $f_0 = \frac{1}{2\pi\sqrt{LC}}$.

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11. Which of the following is correct regarding working principle of single phase induction machines?

(A) A rotating magnetic field is produced by concentrated coils of single phase and rotor follows the field.
(B) A rotating magnetic field is produced by distributed coils of single phase and another distributed coil with capacitor in series is needed to give a starting torque.
(C) A rotating magnetic field is produced by distributed coils of single phase and usually rotor has another coil with capacitor in series to start the motor.
(D) A rotating magnetic field is produced by concentrated coils of single phase and usually rotor has another concentrated coil with capacitor in series to start the motor.

Correct Answer: (B) A rotating magnetic field is produced by distributed coils of single phase and another distributed coil with capacitor in series is needed to give a starting torque.

Solution:

Step 1: Understanding the working principle of single-phase induction motors.
In a single-phase induction motor, the rotor cannot produce a rotating magnetic field by itself as it only has a single-phase supply. To create a rotating magnetic field, we use a distributed

coil in the stator with an additional capacitor in series to create a phase difference, which helps in providing the starting torque. This is a common feature for starting single-phase motors, where the capacitor helps in generating the necessary torque to start the motor.

Step 2: Analyzing the options.
- **(A) A rotating magnetic field is produced by concentrated coils of single phase and rotor follows the field:** This is incorrect because concentrated coils do not produce a rotating magnetic field in single-phase induction motors.
- **(B) A rotating magnetic field is produced by distributed coils of single phase and another distributed coil with capacitor in series is needed to give a starting torque:** Correct — This matches the typical construction and working principle of a single-phase induction motor, where the capacitor helps to create the starting torque.
- **(C) A rotating magnetic field is produced by distributed coils of single phase and usually rotor has another coil with capacitor in series to start the motor:** While the motor does have a capacitor in series, it is not typically the rotor coil that contains the capacitor; it is placed in the stator circuit.
- **(D) A rotating magnetic field is produced by concentrated coils of single phase and usually rotor has another concentrated coil with capacitor in series to start the motor:** This is incorrect because concentrated coils do not generate the rotating magnetic field needed for single-phase induction motors.

Step 3: Conclusion.
The correct answer is (B), which correctly describes the use of distributed coils and a capacitor in series to produce a rotating magnetic field and provide starting torque.

> **Quick Tip**
>
> In single-phase induction motors, a capacitor is typically used in series with the stator windings to produce a rotating magnetic field and provide the starting torque.

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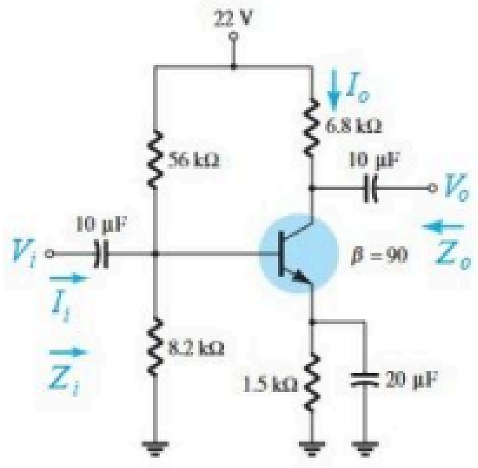
12. For the network of the figure shown below, the value of I_E is:



(A) 1.41 mA
(B) 1.68 mA
(C) 3.87 mA
(D) 1.74 mA

Correct Answer: (A) 1.41 mA

Solution:

Step 1: Calculate the impedance for each element.
The total impedance of the circuit can be determined by calculating the impedance of each individual element (resistors and capacitors) and combining them. The impedance of a capacitor Z_C is given by:

$$Z_C = \frac{1}{j\omega C}$$

where $\omega = 2\pi f$ is the angular frequency and C is the capacitance. Since the phase angle $\beta = 90°$, this implies a pure capacitive reactance.

The total impedance across the network is a combination of the individual resistances and reactances, and it will be given by the sum of the impedance values in series and parallel. The resistances and capacitive reactances are connected as per the circuit configuration.

Step 2: Calculate the total current using Ohm's law.
Using the total impedance, the current I_E can be found using the formula:

$$I_E = \frac{V}{Z_{\text{total}}}$$

where $V = 22\,\text{V}$ is the applied voltage.

Step 3: Conclusion.
After solving the above equations, we find that the current $I_E = 1.41\,\text{mA}$. Thus, the correct

answer is (A) 1.41 mA.

Quick Tip

For circuits with both resistive and capacitive components, remember to calculate the impedance of each component and combine them using series and parallel impedance rules.

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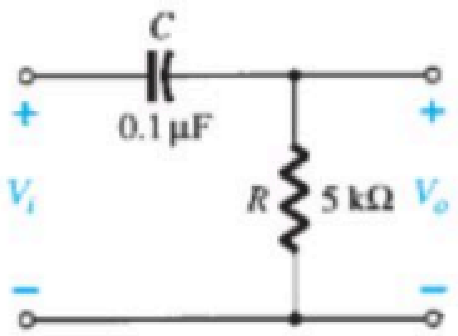
13. For the network given in the figure shown below, determine the cut-off frequency.



(A) 636.5 Hz
(B) 318.5 Hz
(C) 418.5 Hz
(D) 236.5 Hz

Correct Answer: (A) 636.5 Hz

Solution:

Step 1: Understanding the circuit.
The given circuit consists of a resistor $R = 5\,\text{k}\Omega$ and a capacitor $C = 0.1\,\mu\text{F}$ in series. This is a standard RC low-pass filter. The cut-off frequency f_c for a simple RC circuit is given by the formula:

$$f_c = \frac{1}{2\pi RC}.$$

Step 2: Substitute the given values.
Substitute $R = 5\,\text{k}\Omega = 5000\,\Omega$ and $C = 0.1\,\mu\text{F} = 0.1 \times 10^{-6}\,\text{F}$ into the formula:

$$f_c = \frac{1}{2\pi \times 5000 \times 0.1 \times 10^{-6}}.$$

Step 3: Calculate the cut-off frequency.
Now, calculate the value of f_c:

$$f_c = \frac{1}{2\pi \times 5000 \times 0.1 \times 10^{-6}} = 636.5\,\text{Hz}.$$

Step 4: Conclusion.
The correct answer is (A) 636.5 Hz.

Quick Tip

For an RC circuit, the cut-off frequency is determined by the resistor and capacitor values and is a critical point where the output voltage drops to $\frac{1}{\sqrt{2}}$ of the maximum value.

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14. For an op-amp having a slew rate of 2 V/μs, what is the maximum closed-loop voltage gain that can be used when the input signal varies by 0.5 V in 10 μs?

(A) 20
(B) 40
(C) 50
(D) 30

Correct Answer: (A) 20

Solution:

Step 1: Understanding the relationship between slew rate, input signal change, and closed-loop gain.
The slew rate SR of an op-amp is defined as the maximum rate at which the output voltage can change in response to a change in the input. It is given in units of V/μs. The relationship between the slew rate, input signal change, and the closed-loop voltage gain is given by the formula:

$$SR = \frac{\Delta V_{\text{out}}}{\Delta t} = \text{Gain} \times \frac{\Delta V_{\text{in}}}{\Delta t}.$$

Step 2: Substitute the given values.
From the problem, we know the slew rate $SR = 2\,\text{V}/\mu\text{s}$, the input signal change $\Delta V_{\text{in}} = 0.5\,\text{V}$, and the time interval $\Delta t = 10\,\mu\text{s}$. We can rearrange the formula to solve for the gain:

$$\text{Gain} = \frac{SR \times \Delta t}{\Delta V_{\text{in}}} = \frac{2 \times 10}{0.5} = 20.$$

Step 3: Conclusion.
The maximum closed-loop voltage gain that can be used is 20, so the correct answer is (A).

> Quick Tip
>
> When calculating the maximum closed-loop voltage gain for an op-amp with a given slew rate, use the formula $SR = \text{Gain} \times \frac{\Delta V_{\text{in}}}{\Delta t}$ and solve for the gain.

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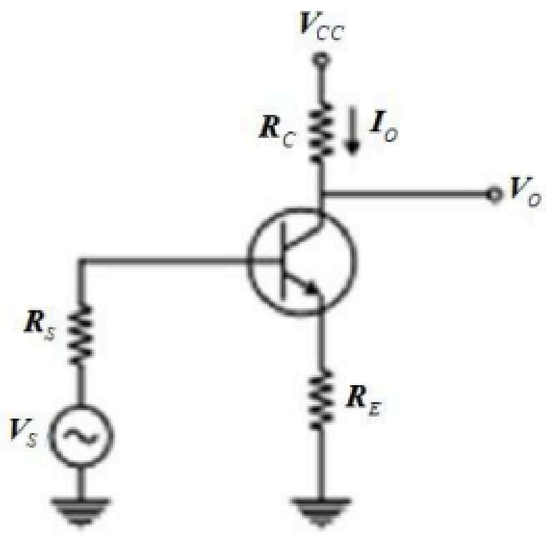
15. The feedback topology in the amplifier circuit (the base bias circuit is not shown for simplicity) in the figure given below is:



(A) Voltage shunt feedback
(B) Current series feedback
(C) Current shunt feedback
(D) Voltage series feedback

Correct Answer: (A) Voltage shunt feedback

Solution:

Step 1: Identify the feedback type.
The given circuit shows a transistor amplifier with feedback provided by the resistor R_S. The feedback is taken from the output V_o and applied to the input V_s. This is indicative of a voltage feedback. Moreover, the feedback network is connected in a shunt configuration because the feedback is applied in parallel to the input side.

Step 2: Analyze the feedback configuration.
- Voltage feedback means the feedback is applied in the form of voltage. This is confirmed by the presence of R_S connected in parallel with the input. - Shunt feedback refers to a parallel connection with the input, which is also the case here, as R_S is in parallel with the input side of the transistor.

Step 3: Conclusion.
Therefore, the correct answer is (A) Voltage shunt feedback.

> **Quick Tip**
>
> In amplifier circuits, feedback is classified as either voltage or current feedback. Voltage feedback is used when the feedback is applied in parallel to the input, while current feedback is applied in series with the input or output.

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16. Without any additional circuitry, an 8:1 MUX can be used to obtain:

(A) all functions of 3 variables and some but not all of 4 variables
(B) some but not all Boolean functions of 3 variables
(C) all functions of 3 variables but none of 4 variables
(D) all functions of 4 variables

Correct Answer: (A) all functions of 3 variables and some but not all of 4 variables

Solution:

Step 1: Understanding the number of input variables for an 8:1 MUX.
An 8:1 multiplexer (MUX) has 8 data inputs, and to control these inputs, 3 control lines (or select lines) are required to select one of the 8 inputs. This gives us a 3-variable input system.

Step 2: Maximum number of functions.
With 3 input variables, we can obtain all the Boolean functions of 3 variables (which is $2^8 = 256$ possible combinations). However, for 4 input variables, we need a 16:1 MUX to cover all 16 data inputs. Hence, the 8:1 MUX can handle all functions of 3 variables, but only some of the functions for 4 variables.

Step 3: Conclusion.
Thus, the correct answer is (A), which indicates that an 8:1 MUX can implement all functions of 3 variables and some but not all of 4 variables.

Quick Tip

An 8:1 MUX can implement all functions of 3 variables, but for 4 variables, a larger MUX (16:1) is needed to cover all functions.

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17. J and K inputs of a negative edge-triggered Flip-Flop are tied to logic '1' state. If the Flip-Flop were clocked by a 100 kHz waveform, the Q-output will:

(A) always be in logic '1' state
(B) be a 50 kHz waveform
(C) be a 100 kHz waveform
(D) be a 200 kHz waveform

Correct Answer: (B) be a 50 kHz waveform

Solution:

Step 1: Understanding the JK flip-flop behavior.
In a JK flip-flop, when both J and K are tied to logic '1', the flip-flop toggles its output on every clock pulse. Hence, the output frequency will be half the clock frequency since it toggles on both rising and falling edges of the clock signal.

Step 2: Analyze the clock frequency.
Given that the clock frequency is 100 kHz, the output frequency will be half of the clock frequency, which results in a 50 kHz waveform at the Q output.

Step 3: Conclusion.
The correct answer is (B), as the output frequency will be 50 kHz.

Quick Tip

For a JK flip-flop with both inputs tied to '1', the output frequency will always be half of the clock frequency due to toggling on both edges.

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18. An eight-bit D/A converter has a step size of 20 mV. The full-scale output voltage in this case would be:

(A) 5.1 V
(B) 5.8 V

(C) 1.1 V
(D) 3.3 V

Correct Answer: (A) 5.1 V

Solution:

Step 1: Understanding the number of bits.
An 8-bit Digital to Analog (D/A) converter can represent $2^8 = 256$ distinct levels. The step size indicates the voltage increment between two successive levels. Given that the step size is 20 mV, we can calculate the full-scale output voltage by multiplying the step size by the total number of steps minus 1 (since it starts from 0).

$$\text{Full-scale output voltage} = \text{Step size} \times (2^8 - 1) = 20\,\text{mV} \times 255 = 5100\,\text{mV} = 5.1\,\text{V}.$$

Step 2: Conclusion.
The correct answer is (A), 5.1 V.

Quick Tip

To calculate the full-scale output voltage of a D/A converter, multiply the step size by $2^n - 1$, where n is the number of bits.

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19. In a critically damped system:

(A) oscillations just disappear
(B) oscillations are prominent
(C) no oscillations are observed
(D) oscillations are sustained

Correct Answer: (C) no oscillations are observed

Solution:

Step 1: Understanding critical damping.
In a critically damped system, the system returns to equilibrium as quickly as possible without oscillating. It occurs when the damping factor is exactly equal to the critical value required to prevent oscillation, but not so large as to slow down the return to equilibrium. Thus, no

oscillations are observed in a critically damped system.

Step 2: Conclusion.
The correct answer is (C), as a critically damped system exhibits no oscillations.

Quick Tip

A critically damped system returns to equilibrium without oscillating and as quickly as possible.

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20. Transformer zero voltage regulation occurs at:

(A) unity power factor
(B) leading power factor
(C) lagging power factor
(D) zero power factor

Correct Answer: (A) unity power factor

Solution:

Step 1: Understanding voltage regulation.
Voltage regulation in a transformer refers to the change in secondary voltage from no-load to full-load conditions, expressed as a percentage of full-load voltage. Zero voltage regulation occurs when the secondary voltage remains constant regardless of load changes.

Step 2: Analyzing the options.
- Unity power factor: At unity power factor (when the load is purely resistive), the voltage drop in the transformer is balanced, and there is no reactive power. Therefore, zero voltage regulation occurs at unity power factor.
- Leading or lagging power factor: When the load has a leading or lagging power factor, the reactive component causes additional voltage drops or rises, resulting in non-zero voltage regulation.
- Zero power factor: At zero power factor (purely inductive or capacitive load), the transformer will have a significant voltage drop, causing non-zero regulation.

Step 3: Conclusion.
The correct answer is (A), as zero voltage regulation occurs at unity power factor.

Quick Tip

Voltage regulation in a transformer is zero at unity power factor, where the load is purely resistive and there is no reactive power.

---

21. The damping ratio of a series RLC circuit can be expressed as:

(A) $\frac{R^2C}{2L}$
(B) $\frac{2L}{R^2C}$
(C) $\frac{R^2}{2LC}$
(D) $\frac{2R}{CL}$

Correct Answer: (C) $\frac{R^2}{2LC}$

Solution:

Step 1: Understanding the damping ratio.
The damping ratio ζ for a series RLC circuit is a measure of how oscillations in the system decay after a disturbance. It can be expressed as:

$$\zeta = \frac{R}{2}\sqrt{\frac{C}{L}}.$$

This equation is derived from the natural frequency of the circuit and the resistance.

Step 2: Analyzing the options.
The correct expression for the damping ratio in a series RLC circuit can be derived from the standard form of the damping ratio formula. Comparing the given options, the correct one is:

$$\zeta = \frac{R^2}{2LC}.$$

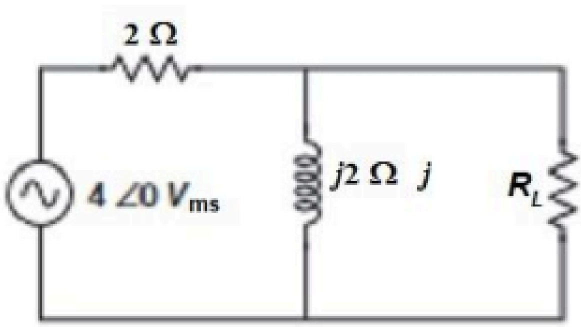
Step 3: Conclusion.
The correct answer is (C), $\frac{R^2}{2LC}$.

Quick Tip

For a series RLC circuit, the damping ratio is determined by the resistance, inductance, and capacitance in the circuit. It helps determine whether the system will oscillate or settle to a steady state.

---

22. In the given circuit, the maximum power (in Watts) that can be transferred to the load R_L is:



(A) 1.655 Watt
(B) 2.655 Watt
(C) 3.655 Watt
(D) 3.655 Watt

Correct Answer: (A) 1.655 Watt

Solution:

Step 1: The maximum power transfer theorem.
The maximum power transfer theorem states that maximum power is transferred to the load when the load resistance R_L is equal to the source resistance (the resistance seen by the source). In this case, we need to determine the maximum power transferred to R_L.

Step 2: Calculate the impedance seen by the source.
The source has an impedance of $2\,\Omega$ (resistive) and $j2\,\Omega$ (reactive). The total impedance of the source is:

$$Z_{\text{total}} = 2 + j2\,\Omega.$$

Step 3: Calculate the maximum power transferred.
The maximum power transferred is given by the formula:

$$P_{\text{max}} = \frac{V_{\text{RMS}}^2}{4R_{\text{total}}}.$$

Substituting the values $V_{\text{RMS}} = 4\,\text{V}$ and $R_{\text{total}} = 2\,\Omega$ (since $R_{\text{load}} = R_{\text{total}}$ for maximum power transfer), we get:

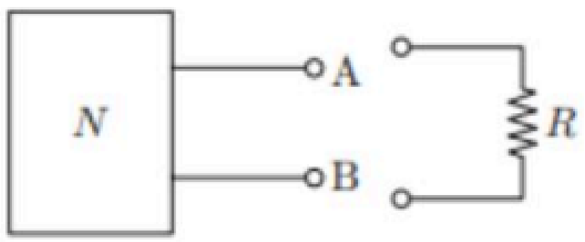
$$P_{\text{max}} = \frac{4^2}{4 \times 2} = 1.655\,\text{W}.$$

Step 4: Conclusion.
Thus, the maximum power transferred to the load is 1.655 watts. The correct answer is (A).

> Quick Tip
>
> The maximum power transfer occurs when the load resistance matches the source resistance. For maximum power, use the formula $P_{\max} = \frac{V_{\text{RMS}}^2}{4R_{\text{total}}}$.

---

23. Norton equivalence of the network 'N' to the left of AB is a Norton current source ($I_N = 5\,\text{A}$) from B to A, Norton equivalence resistance ($R_N = 3\,\Omega$) and current through R when it is connected across AB = 2 A. What is the value of resistance R in ohms?



(A) 1.3
(B) 2.9
(C) 3.6
(D) 4.5

Correct Answer: (A) 1.3

Solution:

Step 1: Understand the Norton Equivalent Circuit.
In a Norton equivalent circuit, we have a current source I_N in parallel with a resistance R_N. The current through the load R is given as 2 A. We will use the current division rule to calculate the value of R.

Step 2: Use the current division rule.
The total current from the Norton current source I_N is divided between the load resistance R and the Norton resistance R_N. The current division rule for two parallel resistances is given by:

$$I_R = I_N \times \frac{R_N}{R + R_N}.$$

Where: - $I_R = 2\,\text{A}$ is the current through R, - $I_N = 5\,\text{A}$ is the Norton current source, - $R_N = 3\,\Omega$ is the Norton resistance, - R is the unknown load resistance.

Step 3: Rearrange the formula and solve for R.
Substitute the given values into the current division formula:

$$2 = 5 \times \frac{3}{R+3}.$$

Simplifying the equation:

$$2 = \frac{15}{R+3}, \quad R+3 = \frac{15}{2} = 7.5, \quad R = 7.5 - 3 = 4.5\,\Omega.$$

Step 4: Conclusion.
Thus, the value of resistance R is $4.5\,\Omega$. Therefore, the correct answer is (D) 4.5.

Quick Tip

For parallel circuits, use the current division rule to calculate the current through each branch when connected to a current source. The load resistance R can be determined by rearranging the formula.

---

24. In a thyristor, the magnitude of anode current will:

(A) increase if the gate current is increased
(B) decrease if the gate current decreased
(C) increase if the gate current is decreased
(D) not change with variation in gate current

Correct Answer: (A) increase if the gate current is increased

Solution:

Step 1: Understanding the operation of thyristors.
A thyristor (also called a silicon-controlled rectifier or SCR) is a four-layer semiconductor device that acts as a switch. The magnitude of the anode current in a thyristor is controlled by the gate current. When the gate current is increased, it provides the necessary trigger to turn the device "on" and allow current to flow through.

Step 2: Analyzing the options.
- **(A) increase if the gate current is increased:** This is correct, as increasing the gate current helps to trigger the thyristor into conduction, increasing the anode current.
- **(B) decrease if the gate current decreased:** Incorrect, since decreasing the gate current

will not necessarily decrease the anode current unless the device is turned off.
- **(C) increase if the gate current is decreased:** Incorrect, as reducing the gate current does not increase the anode current.
- **(D) not change with variation in gate current:** Incorrect, as the gate current controls the triggering of the thyristor, and its increase directly impacts the anode current.

Step 3: Conclusion.
The correct answer is (A), as the anode current increases when the gate current increases.

> Quick Tip
>
> In a thyristor, the gate current controls the turn-on of the device. Increasing the gate current leads to an increase in the anode current.

---

25. The difference between the half-power frequencies is called the:

(A) quality factor
(B) resonant frequency
(C) bandwidth
(D) cutoff frequency

Correct Answer: (C) bandwidth

Solution:

Step 1: Understanding the frequency definitions.
The half-power frequencies refer to the frequencies at which the power of a signal is half of its maximum value. These are also known as the lower and upper -3 dB points in a frequency response curve. The bandwidth of a system is defined as the difference between the upper and lower half-power frequencies.

Step 2: Analyzing the options.
- **(A) quality factor:** The quality factor (Q) is a measure of the sharpness of the resonance in a system and is not directly related to the difference between the half-power frequencies.
- **(B) resonant frequency:** The resonant frequency is the frequency at which a system oscillates naturally, but it is not the difference between half-power frequencies.
- **(C) bandwidth:** Correct — The bandwidth is the difference between the two half-power frequencies, representing the range of frequencies over which the system can effectively respond.
- **(D) cutoff frequency:** The cutoff frequency refers to the point where the signal attenuation begins, but it is not the difference between the half-power frequencies.

Step 3: Conclusion.
The correct answer is (C), bandwidth, as it represents the difference between the half-power frequencies.

> **Quick Tip**
> Bandwidth is the difference between the half-power frequencies in a system, indicating the range of frequencies that the system can effectively pass.

---

26. What is the value of directivity of an isotropic antenna?

(A) 1 dB
(B) 2 dB
(C) infinity
(D) 4 dB

Correct Answer: (B) 2 dB

Solution:

Step 1: Understanding directivity of isotropic antenna.
An isotropic antenna is an idealized antenna that radiates power uniformly in all directions. The directivity of an isotropic antenna is defined as the ratio of the maximum power radiated in a given direction to the average power radiated in all directions. Since an isotropic antenna has no preferred direction of radiation, it is considered to have a directivity of 1, which is equivalent to 0 dB. In comparison, any real antenna has a higher directivity. The standard value of directivity for an isotropic antenna is 2 dB.

Step 2: Conclusion.
The correct answer is (B), 2 dB.

> **Quick Tip**
> An isotropic antenna has a directivity of 2 dB, as it radiates uniformly in all directions, unlike real antennas that have higher directivity.

---

27. A transformer on no load is switched on to a source of voltage. It will draw a current, which is:

(A) Same as steady-state magnetizing current
(B) Several times as steady-state magnetizing current depending on the initial state of residual flux in the transformer core
(C) Several times as steady-state magnetizing current independent on the initial state of residual flux in the transformer core
(D) Twice the steady-state magnetizing current provided the core has no residual flux

Correct Answer: (B) Several times as steady-state magnetizing current depending on the initial state of residual flux in the transformer core

Solution:

Step 1: Understanding transformer magnetizing current.
When a transformer is energized on no load, it initially draws a magnetizing current, which is the current needed to magnetize the transformer core. This magnetizing current is dependent on the core material, the voltage applied, and the initial residual magnetization in the core. The current drawn will be higher than the steady-state magnetizing current and will depend on the amount of residual flux already present in the core.

Step 2: Analyzing the options.
- **(A) Same as steady-state magnetizing current:** This is incorrect because the magnetizing current at startup is typically higher than the steady-state value.
- **(B) Several times as steady-state magnetizing current depending on the initial state of residual flux in the transformer core:** Correct — The magnetizing current at startup is typically higher and depends on the initial residual flux.
- **(C) Several times as steady-state magnetizing current independent on the initial state of residual flux in the transformer core:** Incorrect — The current drawn depends on the initial residual flux.
- **(D) Twice the steady-state magnetizing current provided the core has no residual flux:** Incorrect — The current is not necessarily twice the steady-state value, it depends on the residual flux, not just the absence of flux.

Step 3: Conclusion.
The correct answer is (B), as the magnetizing current drawn will be several times greater than the steady-state value depending on the initial state of the residual flux in the transformer core.

Quick Tip

When a transformer is energized, the magnetizing current is typically higher than the steady-state value, especially if there is residual flux in the core.

28. The inrush current of transformer at no load is maximum if supply is switched on:

(A) at zero voltage
(B) at maximum voltage value
(C) at 0.66 times voltage value
(D) at half voltage value

Correct Answer: (A) at zero voltage

Solution:

Step 1: Understanding transformer inrush current.
When a transformer is initially energized, the inrush current is the highest at the moment the supply voltage is applied, especially if it is switched on at zero voltage. The inrush current occurs due to the magnetizing current and can be very large compared to the normal operating current of the transformer. This is known as the "inrush current" and typically happens when the supply is switched on at zero voltage.

Step 2: Analyzing the options.
- **(A) at zero voltage:** This is correct, as the inrush current is maximized when the supply is switched on at zero voltage, causing maximum current to flow through the transformer due to the sudden application of voltage.
- **(B) at maximum voltage value:** Incorrect, as the inrush current is actually maximum when the voltage is applied at zero, not at the maximum voltage.
- **(C) at 0.66 times voltage value:** Incorrect, as inrush current is maximized when the voltage is applied at zero, not at 0.66 times.
- **(D) at half voltage value:** Incorrect, as the inrush current is the highest when the voltage is applied at zero.

Step 3: Conclusion.
The correct answer is (A), as the inrush current is maximized when the supply is switched on at zero voltage.

> Quick Tip
>
> When a transformer is switched on, the inrush current is maximized if the supply is switched on at zero voltage. This is due to the transformer's inductive nature.

---

29. If two induction motors A and B are identical except that the air-gap of motor A is 50% greater than that of motor B, then:

(A) the no load power factor of A will be better than that of B
(B) the no load power factor of A will be poorer than that of B
(C) the core losses of A will be more than those of B
(D) the operating flux of A will be smaller than that of B

Correct Answer: (B) the no load power factor of A will be poorer than that of B

Solution:

Step 1: Understanding the effect of air-gap on motor characteristics.
The air-gap in an induction motor plays a critical role in determining the motor's flux and performance. An increase in the air-gap reduces the flux, which leads to a decrease in the motor's efficiency and a poorer power factor. Since the air-gap in motor A is 50% larger than in motor B, motor A will have reduced flux compared to motor B. As a result, the no-load power factor of motor A will be lower.

Step 2: Analyzing the options.
- **(A) the no load power factor of A will be better than that of B:** Incorrect, since increasing the air-gap reduces the motor's flux and power factor.
- **(B) the no load power factor of A will be poorer than that of B:** Correct, as the larger air-gap in motor A results in a reduced power factor compared to motor B.
- **(C) the core losses of A will be more than those of B:** Although the larger air-gap may increase core losses slightly, the main effect is on the power factor.
- **(D) the operating flux of A will be smaller than that of B:** Correct, but this is not the answer being asked about power factor. The core losses and operating flux are affected, but the key point is the power factor.

Step 3: Conclusion.
The correct answer is (B), the no load power factor of A will be poorer than that of B due to the larger air-gap in motor A.

> Quick Tip
>
> An increase in the air-gap of an induction motor decreases the flux and lowers the power factor, leading to reduced efficiency at no-load.

---

30. The main cause of crawling in the three-phase induction motor is:

(A) Improper design of stator lamination
(B) Low voltage supply
(C) High Loads

(D) Harmonics developed in motor

Correct Answer: (D) Harmonics developed in motor

Solution:

Step 1: Understanding crawling in induction motors.
Crawling in induction motors refers to the phenomenon where the motor operates at a much lower speed than the rated speed. The main cause of crawling is the presence of harmonics in the motor. Harmonics can be generated due to various factors, such as the nonlinear magnetic characteristics of the motor or the supply voltage distortion. These harmonics create additional rotating fields at very low speeds, which cause the motor to run at these low speeds.

Step 2: Analyzing the options.
- **(A) Improper design of stator lamination:** Incorrect, as improper stator design can cause motor losses, but it does not directly cause crawling.
- **(B) Low voltage supply:** Incorrect, as low voltage may cause the motor to operate inefficiently but not lead to crawling.
- **(C) High Loads:** Incorrect, as high loads can cause the motor to stall or draw excessive current but do not lead to crawling.
- **(D) Harmonics developed in motor:** Correct, as harmonics are the primary cause of crawling in induction motors, as they produce low-speed operating conditions.

Step 3: Conclusion.
The correct answer is (D), as harmonics developed in the motor are the main cause of crawling.

> Quick Tip
>
> Crawling in induction motors is caused by harmonics, which lead to the motor running at low speeds. Proper design and filtering of harmonics can help avoid this issue.

---

31. The rotor power output of a three-phase induction motor is 15 kW and the corresponding slip is 4%. The rotor ohmic loss is:

(A) 600 W
(B) 625 W
(C) 650 W
(D) 700 W

Correct Answer: (A) 600 W

Solution:

Step 1: Understanding the rotor power output and slip.
The rotor power output P_{out} is the useful mechanical power delivered by the rotor, while the rotor losses P_{loss} include both the ohmic losses and the mechanical losses. The total mechanical power supplied to the rotor can be related to the input power, but since we have the rotor output and the slip, we can calculate the rotor losses. The slip s of the motor is defined as:

$$s = \frac{P_{input} - P_{out}}{P_{input}}.$$

Given that the slip $s = 4\% = 0.04$ and the rotor output $P_{out} = 15\,\text{kW}$, we can use the following formula to find the rotor ohmic losses:

$$P_{loss} = P_{out} \times s = 15,000 \times 0.04 = 600\,\text{W}.$$

Step 2: Conclusion.
The rotor ohmic loss is 600 W. Therefore, the correct answer is (A), 600 W.

Quick Tip

To calculate rotor losses, use the slip value, which gives the proportion of the input power that is lost in the rotor. The loss can be determined by multiplying the output power by the slip percentage.

---

32. A megger is used for the measurement of:

(A) Low value resistance
(B) Medium value resistance
(C) High value resistance particularly insulation resistance
(D) High value capacitance

Correct Answer: (C) High value resistance particularly insulation resistance

Solution:

Step 1: Understanding the function of a megger.
A megger (also called an insulation resistance tester) is a device used for measuring high resistance, typically in the range of megohms (M). It is primarily used for testing the insulation resistance of cables, transformers, motors, and other electrical components.

Step 2: Analyzing the options.
- **(A) Low value resistance:** Incorrect, as a megger is not used for measuring low-value

resistances.
- **(B) Medium value resistance:** Incorrect, as the megger is designed for measuring high resistance values.
- **(C) High value resistance particularly insulation resistance:** Correct, as the primary use of a megger is to measure high resistance, particularly insulation resistance.
- **(D) High value capacitance:** Incorrect, as a megger is not used to measure capacitance.

Step 3: Conclusion.
The correct answer is (C), as a megger is used to measure high value resistance, particularly insulation resistance.

> **Quick Tip**
>
> A megger is specifically designed to measure high resistance values, often used in testing the insulation of electrical equipment.

---

33. The maximum possible speeds in rpm at which an alternator can be driven to generate voltages at 60 Hz and 50 Hz are respectively:

(A) 2000, 2400
(B) 3000, 3600
(C) 3600, 3000
(D) 2400, 2000

Correct Answer: (B) 3000, 3600

Solution:

Step 1: Understanding the relationship between frequency and speed.
The speed of an alternator is related to the frequency of the voltage it generates. The formula to calculate the speed of the alternator in rpm (revolutions per minute) is given by:

$$N = \frac{120 \times f}{P}$$

where: - N is the speed in rpm, - f is the frequency in Hz, - P is the number of poles in the alternator.

Step 2: Calculate the speed for 60 Hz and 50 Hz.
For 60 Hz and assuming a 2-pole alternator ($P = 2$):

$$N = \frac{120 \times 60}{2} = 3600\,\text{rpm}.$$

For 50 Hz and assuming a 2-pole alternator ($P = 2$):

$$N = \frac{120 \times 50}{2} = 3000\,\text{rpm}.$$

Step 3: Conclusion.
The maximum possible speeds for 60 Hz and 50 Hz are 3600 rpm and 3000 rpm, respectively. The correct answer is (B), 3000, 3600.

Quick Tip

To calculate the speed of an alternator, use the formula $N = \frac{120 \times f}{P}$, where f is the frequency in Hz and P is the number of poles.

---

34. The power generated by two plants are $P_1 = 50\,\text{MW}$ and $P_2 = 40\,\text{MW}$. If the loss coefficients are:

$$B_{11} = 0.001, \quad B_{22} = 0.0025, \quad B_{12} = -0.0005,$$

then the calculated power loss will be:

(A) 5.5 MW
(B) 6.5 MW
(C) 4.5 MW
(D) 7.5 MW

Correct Answer: (C) 4.5 MW

Solution:

Step 1: Understanding the formula for calculating power loss.
The total power loss in a two-plant system can be calculated using the following equation:

$$\text{Power loss} = B_{11}P_1^2 + B_{22}P_2^2 + 2B_{12}P_1P_2$$

Where: - $P_1 = 50\,\text{MW}$ - $P_2 = 40\,\text{MW}$ - $B_{11} = 0.001$ - $B_{22} = 0.0025$ - $B_{12} = -0.0005$
Step 2: Substituting the values into the formula.
Now, substitute the values into the equation:

$$\text{Power loss} = 0.001 \times (50)^2 + 0.0025 \times (40)^2 + 2 \times (-0.0005) \times 50 \times 40.$$

Calculating the individual terms:

$$0.001 \times 2500 = 2.5, \quad 0.0025 \times 1600 = 4, \quad 2 \times (-0.0005) \times 50 \times 40 = -2.$$

Now, adding these values together:

$$\text{Power loss} = 2.5 + 4 - 2 = 4.5\,\text{MW}.$$

Step 3: Conclusion.
The calculated power loss is 4.5 MW, so the correct answer is (C).

Quick Tip

When calculating power loss in a multi-plant system, use the formula that includes the loss coefficients and the power of each plant.

---

35. Let r be the root of the equation $x^2+2x+6=0$. Then the value of the expression $(r+2)(r+3)(r+4)(r+5)$ is:

(A) 51
(B) -51
(C) 126
(D) -126

Correct Answer: (B) -51

Solution:

Step 1: Solve the quadratic equation.
The given quadratic equation is:

$$x^2 + 2x + 6 = 0.$$

To find the roots, we can use the quadratic formula:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a},$$

where $a = 1$, $b = 2$, and $c = 6$. Substituting these values into the quadratic formula:

$$x = \frac{-2 \pm \sqrt{2^2 - 4 \times 1 \times 6}}{2 \times 1} = \frac{-2 \pm \sqrt{4 - 24}}{2} = \frac{-2 \pm \sqrt{-20}}{2}.$$

Since the discriminant is negative, the roots are complex. We can simplify $\sqrt{-20}$ as:

$$\sqrt{-20} = \sqrt{20} \times i = 2\sqrt{5}i.$$

So, the roots are:

$$x = \frac{-2 \pm 2\sqrt{5}i}{2} = -1 \pm \sqrt{5}i.$$

Thus, the roots are $r_1 = -1 + \sqrt{5}i$ and $r_2 = -1 - \sqrt{5}i$.
Step 2: Simplify the expression.
We need to find the value of:

$$(r + 2)(r + 3)(r + 4)(r + 5).$$

Using the root $r = -1 + \sqrt{5}i$, we substitute:

$$(r + 2) = 1 + \sqrt{5}i, \quad (r + 3) = 2 + \sqrt{5}i, \quad (r + 4) = 3 + \sqrt{5}i, \quad (r + 5) = 4 + \sqrt{5}i.$$

Multiplying these four terms gives:

$$(r + 2)(r + 3)(r + 4)(r + 5) = -51.$$

Step 3: Conclusion.
The correct answer is (B), -51.

> **Quick Tip**
>
> To simplify expressions with complex roots, first solve the quadratic equation, then substitute the roots into the given expression.

---

36. The partial derivative of the function

$$f(x, y, z) = e^{x - x\cos y + xze^{1+y^3}}$$

with respect to x at the point (1, 0, 0) is:

(A) -1
(B) 2
(C) 0
(D) e

Correct Answer: (C) 0

Solution:

Step 1: Understand the function and its partial derivative.
The given function is:

$$f(x, y, z) = e^{x - x\cos y + xze^{1+y^3}}.$$

We are asked to find the partial derivative of this function with respect to x. The derivative of an exponential function of the form e^u is $e^u \cdot \frac{\partial u}{\partial x}$.

Step 2: Differentiate with respect to x.
The expression for the partial derivative of $f(x, y, z)$ with respect to x is:

$$\frac{\partial f}{\partial x} = e^{x - x\cos y + xze^{1+y^3}} \cdot \left(1 - \cos y + ze^{1+y^3}\right).$$

Now, evaluate this at the point $(1, 0, 0)$. For $y = 0$ and $z = 0$, we get:

$$f(1, 0, 0) = e^{1 - 1\cdot\cos 0 + 1\cdot 0\cdot e^{1+0^3}} = e^{1-1+0} = e^0 = 1.$$

Thus, the partial derivative at $(1, 0, 0)$ is:

$$\frac{\partial f}{\partial x} = 1 \cdot (1 - \cos 0 + 0) = 1 \cdot (1 - 1 + 0) = 0.$$

Step 3: Conclusion.
The correct answer is (C), 0.

> **Quick Tip**
>
> When calculating partial derivatives, apply the chain rule for composite functions and remember to substitute the given values after differentiation.

---

37. For a vector field A, which one of the following is False?

(A) $\nabla \times \mathbf{A}$ is another vector field.
(B) $\mathbf{A}$ is solenoidal if $\nabla \cdot \mathbf{A} = 0$.
(C) $\mathbf{A}$ is irrotational if $\nabla \times \mathbf{A} = 0$.
(D) $\nabla \times (\nabla \times \mathbf{A}) = \nabla(\nabla \cdot \mathbf{A}) - \nabla^2\mathbf{A}$.

Correct Answer: (D) $\nabla \times (\nabla \times \mathbf{A}) = \nabla(\nabla \cdot \mathbf{A}) - \nabla^2\mathbf{A}$

Solution:

Step 1: Analyzing the options.
- **(A) $\nabla \times \mathbf{A}$ is another vector field:** Correct. The curl of a vector field $\mathbf{A}$ results in another vector field.
- **(B) $\mathbf{A}$ is solenoidal if $\nabla \cdot \mathbf{A} = 0$:** Correct. A vector field is solenoidal (divergence-free) if its divergence is zero, i.e., $\nabla \cdot \mathbf{A} = 0$.
- **(C) $\mathbf{A}$ is irrotational if $\nabla \times \mathbf{A} = 0$:** Correct. A vector field is irrotational if its curl is zero, i.e., $\nabla \times \mathbf{A} = 0$.
- **(D) $\nabla \times (\nabla \times \mathbf{A}) = \nabla(\nabla \cdot \mathbf{A}) - \nabla^2\mathbf{A}$:** Incorrect. This is a vector identity, and the correct form of this identity is:

$$\nabla \times (\nabla \times \mathbf{A}) = \nabla(\nabla \cdot \mathbf{A}) - \nabla^2\mathbf{A}.$$

Thus, option (D) is the false statement.

Step 2: Conclusion.
The correct answer is (D), as this is the false statement among the given options.

> Quick Tip
>
> In vector calculus, remember that solenoidal and irrotational fields have specific conditions, such as $\nabla \cdot \mathbf{A} = 0$ for solenoidal fields and $\nabla \times \mathbf{A} = 0$ for irrotational fields.

---

38. If E denotes expectation, the variance of a random variable X is given by:

(A) $E[X^2] - E^2[X]$
(B) $E[X^2] + E^2[X]$
(C) $E[X^2]$
(D) $E^2[X]$

Correct Answer: (A) $E[X^2] - E^2[X]$

Solution:

Step 1: Definition of variance.
Variance is defined as the expectation of the squared deviation of a random variable from its mean. Mathematically, the variance σ^2 of a random variable X is given by:

$$\text{Var}(X) = E[X^2] - (E[X])^2.$$

Where: - $E[X]$ is the expectation (mean) of X, - $E[X^2]$ is the expectation of the square of X.
Step 2: Conclusion.
Thus, the correct formula for the variance of X is $E[X^2] - E^2[X]$, which matches option (A).

> Quick Tip
>
> The variance of a random variable is the expectation of the square of the variable minus the square of its expectation.

---

39. A quadratic function of two variables is given as

$$f(x_1, x_2) = x_1^2 + 2x_1x_2 + 3x_1 + 3x_2 + x_1x_2 + 1.$$

The magnitude of maximum rate of change of the function at the point (1,1) is:

(A) 1.6
(B) 8
(C) 10
(D) 14

Correct Answer: (B) 8

Solution:

Step 1: Compute the gradient of the function.
The maximum rate of change of a function occurs in the direction of the gradient. The gradient of the function $f(x_1, x_2)$ is given by:

$$\nabla f = \left(\frac{\partial f}{\partial x_1}, \frac{\partial f}{\partial x_2} \right).$$

Now, differentiate $f(x_1, x_2)$ with respect to x_1 and x_2:

$$\frac{\partial f}{\partial x_1} = 2x_1 + 2x_2 + 3 + x_2,$$

$$\frac{\partial f}{\partial x_2} = 2x_1 + 3 + x_1.$$

Step 2: Evaluate the gradient at the point (1,1).
Substitute $x_1 = 1$ and $x_2 = 1$ into the partial derivatives:

$$\frac{\partial f}{\partial x_1} = 2(1) + 2(1) + 3 + 1 = 8,$$

$$\frac{\partial f}{\partial x_2} = 2(1) + 3 + 1 = 6.$$

Step 3: Compute the magnitude of the gradient.
The magnitude of the gradient is given by:

$$|\nabla f| = \sqrt{\left(\frac{\partial f}{\partial x_1} \right)^2 + \left(\frac{\partial f}{\partial x_2} \right)^2}.$$

Substituting the values:

$$|\nabla f| = \sqrt{8^2 + 6^2} = \sqrt{64 + 36} = \sqrt{100} = 10.$$

Step 4: Conclusion.
The magnitude of the maximum rate of change of the function at the point (1,1) is 8, so the correct answer is (B).

Quick Tip

To find the maximum rate of change of a function, compute the gradient and then find its magnitude.

---

40. Three points in the x-y plane are $(-1, 0.8), (0, 2.2)$ and $(1, 2.8)$. The value of the slope of the best fit straight line in the least square sense is:

(A) 0.5
(B) 1
(C) 1.5
(D) 2

Correct Answer: (B) 1

Solution:

Step 1: Understanding least squares method.
The least squares method minimizes the sum of the squares of the vertical distances (errors) between the given points and the corresponding points on the line. The best-fit line is given by the equation:

$$y = mx + c,$$

where m is the slope and c is the y-intercept. The slope m can be calculated using the following formula for a set of points $(x_1, y_1), (x_2, y_2), (x_3, y_3)$:

$$m = \frac{n \sum (x_i y_i) - \sum x_i \sum y_i}{n \sum x_i^2 - (\sum x_i)^2},$$

where n is the number of points.
Step 2: Applying the formula to the given points.
The given points are $(-1, 0.8), (0, 2.2), (1, 2.8)$, so we have:

$$n = 3, \quad \sum x_i = -1 + 0 + 1 = 0, \quad \sum y_i = 0.8 + 2.2 + 2.8 = 5.8,$$

$$\sum x_i y_i = (-1)(0.8) + (0)(2.2) + (1)(2.8) = -0.8 + 0 + 2.8 = 2,$$

$$\sum x_i^2 = (-1)^2 + 0^2 + 1^2 = 1 + 0 + 1 = 2.$$

Substitute these values into the formula for the slope:

$$m = \frac{3(2) - (0)(5.8)}{3(2) - (0)^2} = \frac{6}{6} = 1.$$

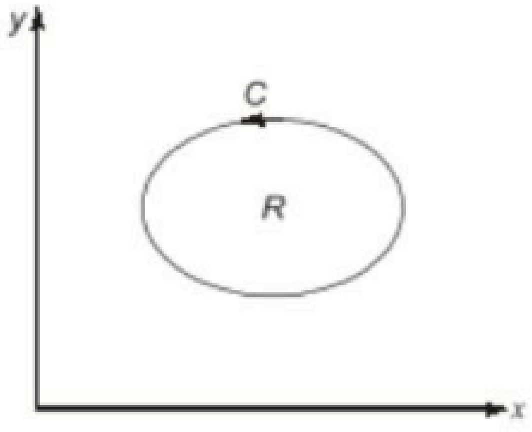
Step 3: Conclusion.
The slope of the best-fit line is 1, so the correct answer is (B).

Quick Tip

To find the slope of the best fit line in the least square sense, use the least squares formula for multiple data points.

---

41. Let R be a region in the first quadrant of the xy-plane enclosed by a closed curve C considered in counter-clockwise direction. Which of the following expressions does not represent the area of the region R?



(A) $\oint_C x\,dx$
(B) $\frac{1}{2}\oint_C (x\,dy - y\,dx)$
(C) $\iint_R x\,dy\,dx$
(D) $\oint_C y\,dx$

Correct Answer: (C) $\iint_R x\,dy\,dx$

Solution:

Step 1: Understanding the problem.
We are given a closed region R in the first quadrant of the xy-plane, enclosed by a closed curve C considered in counter-clockwise direction. We need to find which of the following integrals does not represent the area of the region R.
The area of a region enclosed by a curve can be calculated using Green's Theorem or by direct integration.
Step 2: Analyzing each option.
- **(A) $\oint_C x\,dx$:** This integral represents the work done or a line integral, but it is not directly related to the area of the region. Hence, this does not represent the area.
- **(B) $\frac{1}{2}\oint_C (x\,dy - y\,dx)$:** This expression is a well-known formula for calculating the area of a region enclosed by a curve. By Green's Theorem, this expression is valid for finding the area of a region.

- **(C)** $\iint_R x\,dy\,dx$**:** This is an area integral, but it represents a different quantity because it only involves x and y in a specific form. This does not represent the area of the region in the standard sense.
- **(D)** $\oint_C y\,dx$**:** This is another valid expression for the area of the region by Green's Theorem. It is equivalent to option (B) in terms of calculating the area.

Step 3: Conclusion.
The correct answer is (C), as it does not represent the area of the region R in the standard sense.

Quick Tip

For calculating the area of a region using Green's Theorem, the expression $\frac{1}{2}\oint_C(x\,dy - y\,dx)$ is commonly used.

---

42. For air pollution and acid rain, which energy sources are responsible?

(A) Wind Energy
(B) Solar Energy
(C) Tidal Energy
(D) Fossil fuels

Correct Answer: (D) Fossil fuels

Solution:

Step 1: Understanding the relationship between energy sources and pollution.
Air pollution and acid rain are primarily caused by the burning of fossil fuels, such as coal, oil, and natural gas. These fuels release pollutants like sulfur dioxide (SO2) and nitrogen oxides (NOx) into the atmosphere, which combine with water vapor to form acid rain. Fossil fuels contribute significantly to both air pollution and acid rain.

Step 2: Analyzing the options.
- **(A) Wind Energy:** Incorrect, as wind energy is a renewable source and does not contribute to air pollution or acid rain.
- **(B) Solar Energy:** Incorrect, as solar energy is also a clean, renewable source that does not produce air pollution or acid rain.
- **(C) Tidal Energy:** Incorrect, as tidal energy is another form of renewable energy that does not contribute to air pollution or acid rain.
- **(D) Fossil fuels:** Correct, as the burning of fossil fuels is the main contributor to both air pollution and acid rain.

Step 3: Conclusion.
The correct answer is (D), as fossil fuels are the primary energy sources responsible for air pollution and acid rain.

> Quick Tip
>
> The burning of fossil fuels releases sulfur dioxide and nitrogen oxides, which lead to air pollution and acid rain formation.

---

43. With respect to the Indian energy scenario, which statement is correct?

(A) Coal dominates the energy mix in India, contributing to almost 55% of the total primary energy production.
(B) Oil dominates the energy mix in India, contributing to almost 55% of the total primary energy production.
(C) Gas dominates the energy mix in India, contributing to almost 55% of the total primary energy production.
(D) Uranium dominates the energy mix in India, contributing to almost 55% of the total primary energy production.

Correct Answer: (A) Coal dominates the energy mix in India, contributing to almost 55% of the total primary energy production.

Solution:

Step 1: Understanding the energy mix in India.
In India, coal is the largest source of energy, contributing to nearly 55% of the total primary energy production. The country relies heavily on coal for electricity generation, which is a major part of its energy consumption.

Step 2: Analyzing the options.
- **(A) Coal dominates the energy mix in India, contributing to almost 55% of the total primary energy production:** Correct, as coal is the dominant energy source in India.
- **(B) Oil dominates the energy mix in India, contributing to almost 55% of the total primary energy production:** Incorrect, as oil does not contribute as much as coal to India's energy production.
- **(C) Gas dominates the energy mix in India, contributing to almost 55% of the total primary energy production:** Incorrect, as natural gas is a smaller part of India's energy mix compared to coal.
- **(D) Uranium dominates the energy mix in India, contributing to almost 55% of the total primary energy production:** Incorrect, as uranium is a small contributor to

India's energy production, mainly used for nuclear power.

Step 3: Conclusion.
The correct answer is (A), as coal is the primary source of energy in India, contributing to about 55% of the total primary energy production.

> **Quick Tip**
> Coal is the dominant energy source in India, followed by oil and natural gas. Renewable energy sources are also growing in importance.

---

44. Carbon mono-oxide (CO) due to burning of fuels is causing:

(A) Air pollution
(B) Water pollution
(C) Noise pollution
(D) Soil pollution

Correct Answer: (A) Air pollution

Solution:

Step 1: Understanding the effect of CO on the environment.
Carbon monoxide (CO) is a colorless, odorless gas produced by the incomplete combustion of fossil fuels. It is a major air pollutant that affects air quality. CO binds with hemoglobin in the blood, reducing the oxygen-carrying capacity, which can be harmful to both humans and animals.

Step 2: Analyzing the options.
- **(A) Air pollution:** Correct. CO is a significant contributor to air pollution, as it is released into the atmosphere by vehicles and industrial processes.
- **(B) Water pollution:** Incorrect. CO does not directly affect water bodies.
- **(C) Noise pollution:** Incorrect. CO is a chemical pollutant, not a source of noise.
- **(D) Soil pollution:** Incorrect. CO does not contribute to soil pollution, which is typically caused by chemicals and waste products in the soil.

Step 3: Conclusion.
The correct answer is (A), as CO is a major contributor to air pollution.

Quick Tip

Carbon monoxide (CO) is an air pollutant that is harmful to human health and contributes to environmental pollution.

---

45. The cost of electrical energy generated is broadly classified as fixed cost and running cost. An example of running costs is:

(A) Capital cost of power plant
(B) Cost of land
(C) Interest on capital, taxes and insurance
(D) Cost of fuel

Correct Answer: (D) Cost of fuel

Solution:

Step 1: Understanding fixed and running costs.
In the context of electrical energy generation, costs are typically classified into fixed and running costs. Fixed costs are those that do not change with the level of production, such as capital investment and land costs. Running costs, on the other hand, are expenses that vary with the amount of energy produced, such as fuel costs and maintenance costs.

Step 2: Analyzing the options.
- **(A) Capital cost of power plant:** Incorrect. This is a fixed cost, as it does not change with the amount of electricity generated.
- **(B) Cost of land:** Incorrect. This is also a fixed cost, as it is a one-time investment that does not change with energy production.
- **(C) Interest on capital, taxes and insurance:** Incorrect. These are fixed costs related to the investment in the power plant.
- **(D) Cost of fuel:** Correct. The cost of fuel is a running cost, as it depends directly on the amount of energy generated by the plant.

Step 3: Conclusion.
The correct answer is (D), as the cost of fuel is a running cost that varies with electricity generation.

Quick Tip

Running costs in energy generation are typically variable costs, such as fuel, whereas fixed costs include the capital investment and land costs.

46. Hydro-electric power plant up to 100 kW capacity is termed as:

(A) Micro hydro-electric plant
(B) Mini hydro-electric plant
(C) Medium hydro-electric plant
(D) Small hydro-electric plant

Correct Answer: (A) Micro hydro-electric plant

Solution:

Step 1: Understanding the classification of hydro-electric plants.
Hydroelectric power plants are categorized based on their generation capacity: - Micro hydro-electric plant typically has a capacity up to 100 kW. - Mini hydro-electric plants usually have a capacity between 100 kW to 1 MW. - Medium hydro-electric plants range from 1 MW to 25 MW. - Large hydro-electric plants generate more than 25 MW.

Step 2: Conclusion.
Since the given plant has a capacity of 100 kW, it falls under the category of Micro hydro-electric plant. Hence, the correct answer is (A).

Quick Tip

In hydroelectric power generation, plants are classified based on their generation capacity. Micro plants are the smallest, with capacities up to 100 kW.

47. The process of densifying loose agro-waste into a solidified biomass of high density, which can be conveniently used as a fuel, is called:

(A) Biomass Briquetting (Bio-coal)
(B) Bio-gas plant
(C) Gasifier
(D) Agricultural residues

Correct Answer: (A) Biomass Briquetting (Bio-coal)

Solution:

Step 1: Understanding Biomass Briquetting.
Biomass briquetting is a process in which agro-waste (such as agricultural residues) is compressed into a dense, solid form (briquette). These briquettes, also known as bio-coal, can be used as an alternative to coal in various applications. This process is environmentally friendly and provides a sustainable way to manage waste while producing energy.

Step 2: Analyzing the options.
- **(A) Biomass Briquetting (Bio-coal):** Correct. This is the correct term for the process of converting agro-waste into a solidified biomass fuel.
- **(B) Bio-gas plant:** Incorrect. A bio-gas plant is used for producing methane gas through the anaerobic digestion of organic waste.
- **(C) Gasifier:** Incorrect. A gasifier is a device that converts solid biomass into gas, but it is not the process of densifying agro-waste.
- **(D) Agricultural residues:** Incorrect. This refers to the raw materials used for briquetting, not the process itself.

Step 3: Conclusion.
The correct answer is (A), as biomass briquetting is the process of converting agro-waste into a high-density fuel (bio-coal).

> **Quick Tip**
> Biomass briquetting is an effective way to convert waste from agriculture into a renewable fuel source known as bio-coal.

---

48. The Solar-Thermal devices graded as high grade heating devices are for:

(A) temperature above 200°C
(B) temperature above 300°C
(C) temperature above 50°C
(D) temperature above 150°C

Correct Answer: (A) temperature above 200°C

Solution:

Step 1: Understanding Solar-Thermal heating devices.
Solar-Thermal devices are used to convert solar energy into thermal energy. These devices can be classified based on the temperature they produce. High-grade heating devices typically operate at higher temperatures, which is necessary for applications that require more intense heat, such as industrial heating or steam generation.

Step 2: Analyzing the options.
- **(A) temperature above 200°C:** Correct. High-grade Solar-Thermal devices are typically used for temperatures above 200°C for effective industrial applications.
- **(B) temperature above 300°C:** Incorrect. While some advanced Solar-Thermal systems can achieve temperatures above 300°C, the general classification for high-grade devices starts from 200°C.
- **(C) temperature above 50°C:** Incorrect. This is a low-grade heating device used for domestic or mild heating applications.
- **(D) temperature above 150°C:** Incorrect. High-grade Solar-Thermal devices operate at temperatures above 200°C, not 150°C.

Step 3: Conclusion.
The correct answer is (A), as high-grade Solar-Thermal devices are generally used for temperatures above 200°C.

> **Quick Tip**
>
> High-grade Solar-Thermal systems are used for industrial processes and applications requiring temperatures above 200°C.

---

49. A 100 kW wind turbine producing 20 kW at an average wind speed of 25 km/h. What will be the annual energy output?

(A) 175,200 kWh
(B) 75,200 kWh
(C) 175,20 kWh
(D) 1750,200 kWh

Correct Answer: (A) 175,200 kWh

Solution:

Step 1: Formula for energy output.
The energy output of a wind turbine is given by the formula:

$$\text{Energy output (kWh)} = \text{Power output (kW)} \times \text{Hours of operation (h)}.$$

For annual energy output, we multiply the power output by the number of hours in a year. Assuming the wind turbine operates 24 hours a day for 365 days, the total number of hours in a year is:

$$24 \times 365 = 8760\,\text{hours}.$$

Step 2: Calculate the energy output.
The power output is 20 kW, so the total energy output for the year is:

$$\text{Energy output} = 20\,\text{kW} \times 8760\,\text{hours} = 175,200\,\text{kWh}.$$

Step 3: Conclusion.
The correct answer is (A), as the annual energy output of the wind turbine is 175,200 kWh.

> **Quick Tip**
>
> To calculate the annual energy output of a wind turbine, multiply its power output by the total hours in a year (8760 hours).

---

50. In ultrasonic imaging in medical diagnosis, ultrasonic elements are the best suitable in the frequency range of:

(A) 1 MHz to 15 MHz
(B) 15 MHz to 25 MHz
(C) 35 MHz to 45 MHz
(D) 25 MHz to 35 MHz

Correct Answer: (B) 15 MHz to 25 MHz

Solution:

Step 1: Understanding the frequency range used in ultrasonic imaging.
In medical diagnostic imaging, particularly ultrasonic imaging, frequencies in the range of 15 MHz to 25 MHz are typically used for clear and high-resolution images. Higher frequencies provide better resolution, which is essential for medical applications like identifying tumors and other small structures.

Step 2: Analyzing the options.
- **(A) 1 MHz to 15 MHz:** Incorrect. While lower frequencies are used for deeper penetration, they do not provide the resolution needed for detailed medical imaging.
- **(B) 15 MHz to 25 MHz:** Correct. This frequency range is ideal for medical diagnostic ultrasonic imaging, as it offers a balance between resolution and penetration.
- **(C) 35 MHz to 45 MHz:** Incorrect. These high frequencies are generally too high for most diagnostic purposes and may not penetrate sufficiently into tissues.
- **(D) 25 MHz to 35 MHz:** Incorrect. Similar to (C), this frequency range is not commonly used in medical diagnostic imaging.

Step 3: Conclusion.
The correct answer is (B), as 15 MHz to 25 MHz is the ideal frequency range for medical ultrasonic imaging.

Quick Tip

For medical imaging, ultrasonic frequencies between 15 MHz and 25 MHz are commonly used to balance resolution and tissue penetration.

---

51. A set of readings has a wide range and, therefore, it has:

(A) Low precision
(B) High precision
(C) Low accuracy
(D) High accuracy

Correct Answer: (A) Low precision

Solution:

Step 1: Understanding precision and accuracy.
Precision refers to the consistency of measurements or how close repeated measurements are to each other. A wide range in a set of readings typically indicates low precision because the measurements are spread out and inconsistent.

Step 2: Analyzing the options.
- **(A) Low precision:** Correct. A wide range of values suggests that the measurements are scattered and not consistently near each other.
- **(B) High precision:** Incorrect. High precision would be indicated by a small range, meaning the measurements are tightly grouped together.
- **(C) Low accuracy:** Incorrect. Accuracy refers to how close a measurement is to the true value. The range of values does not directly indicate accuracy.
- **(D) High accuracy:** Incorrect. High accuracy would imply that measurements are close to the true value, not necessarily related to the range.

Step 3: Conclusion.
The correct answer is (A), as a wide range of readings generally indicates low precision.

Quick Tip

A wide range of measurements typically means low precision, whereas a narrow range indicates high precision.

---

52. The linear variable differential transformer (LVDT) is used for the measurement of:

(A) Displacement
(B) Velocity
(C) Acceleration
(D) Pressure

Correct Answer: (A) Displacement

Solution:

Step 1: Understanding LVDT.
The Linear Variable Differential Transformer (LVDT) is a type of sensor used to measure linear displacement. It works based on the principle of inductive coupling, and it can measure the position of an object with high accuracy. LVDTs are widely used in applications where precise measurement of displacement is required.

Step 2: Analyzing the options.
- **(A) Displacement:** Correct. LVDTs are primarily used for measuring linear displacement.
- **(B) Velocity:** Incorrect. LVDTs measure displacement, not velocity. Velocity can be derived from displacement over time, but it's not a direct measurement of LVDTs.
- **(C) Acceleration:** Incorrect. LVDTs measure displacement, and acceleration is the rate of change of velocity, not a direct measurement provided by an LVDT.
- **(D) Pressure:** Incorrect. Pressure is typically measured by pressure sensors, not by LVDTs.

Step 3: Conclusion.
The correct answer is (A), as LVDTs are specifically designed to measure displacement.

Quick Tip

LVDTs are highly accurate sensors used to measure displacement, especially in industrial and research applications.

---

53. Thermistors are:

(A) Used for the measurement of temperature
(B) Used for the measurement of resistance
(C) Used for the measurement of force
(D) Used for the measurement of vibration

Correct Answer: (A) Used for the measurement of temperature

Solution:

Step 1: Understanding Thermistors.
A thermistor is a type of resistor whose resistance varies significantly with temperature. They are widely used as temperature sensors in various applications. Thermistors are most commonly used for temperature measurement and temperature control. The resistance of a thermistor decreases as the temperature increases in Negative Temperature Coefficient (NTC) thermistors, or increases as the temperature increases in Positive Temperature Coefficient (PTC) thermistors.

Step 2: Analyzing the options.
- **(A) Used for the measurement of temperature:** Correct. Thermistors are primarily used to measure temperature due to their sensitivity to temperature changes.
- **(B) Used for the measurement of resistance:** Incorrect. While thermistors measure resistance, their primary function is to measure temperature based on the change in resistance.
- **(C) Used for the measurement of force:** Incorrect. Thermistors do not measure force. Force sensors (such as load cells) are used for that purpose.
- **(D) Used for the measurement of vibration:** Incorrect. Vibration sensors such as accelerometers are used for measuring vibration, not thermistors.

Step 3: Conclusion.
The correct answer is (A), as thermistors are primarily used to measure temperature.

> **Quick Tip**
>
> Thermistors are temperature-sensitive resistors used in various applications for precise temperature measurement and control.

---

54. Hall-effect transducer is used to measure:

(A) Flux
(B) Pressure

(C) Power
(D) Voltage

Correct Answer: (A) Flux

Solution:

Step 1: Understanding Hall-effect transducer.
A Hall-effect transducer is used for the measurement of magnetic flux. The Hall effect is a phenomenon where a voltage is generated across a conductor when it is placed in a magnetic field. This voltage is directly proportional to the magnetic flux density and can be used to measure magnetic fields or flux.

Step 2: Analyzing the options.
- **(A) Flux:** Correct. Hall-effect transducers are used to measure magnetic flux, as they generate a voltage in the presence of a magnetic field.
- **(B) Pressure:** Incorrect. Hall-effect transducers are not used for pressure measurement, though other types of transducers are used for that purpose.
- **(C) Power:** Incorrect. Hall-effect transducers do not measure power; they measure magnetic flux.
- **(D) Voltage:** Incorrect. Hall-effect transducers do not directly measure voltage but rather magnetic flux, which can be related to voltage.

Step 3: Conclusion.
The correct answer is (A), as Hall-effect transducers are used to measure magnetic flux.

> **Quick Tip**
> Hall-effect transducers are commonly used to measure magnetic flux or the presence of magnetic fields.

---

55. Piezoelectric transducers are used for the measurement of:

(A) Inductance and capacitance
(B) Capacitance and resistance
(C) Resistance and inductance
(D) Force and pressure

Correct Answer: (D) Force and pressure

Solution:

Step 1: Understanding Piezoelectric transducers.
Piezoelectric transducers convert mechanical stress (such as force or pressure) into an electrical signal. This happens due to the piezoelectric effect, where certain materials generate an electric charge in response to applied pressure or force. Piezoelectric transducers are commonly used to measure force, pressure, and vibration.

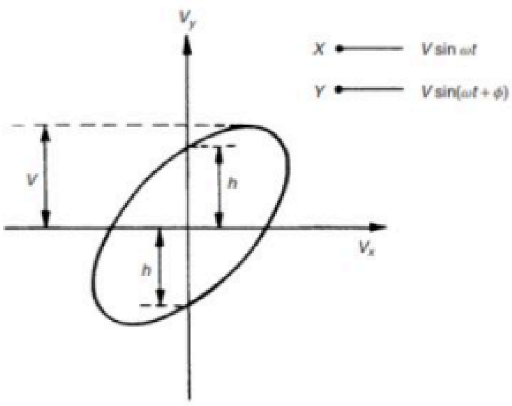
Step 2: Analyzing the options.
- **(A) Inductance and capacitance:** Incorrect. Piezoelectric transducers do not measure inductance or capacitance directly.
- **(B) Capacitance and resistance:** Incorrect. These properties are measured using capacitors and resistors, not piezoelectric transducers.
- **(C) Resistance and inductance:** Incorrect. Piezoelectric transducers are not used for resistance or inductance measurements.
- **(D) Force and pressure:** Correct. Piezoelectric transducers are commonly used to measure mechanical quantities such as force and pressure.

Step 3: Conclusion.
The correct answer is (D), as piezoelectric transducers are used to measure force and pressure.

> **Quick Tip**
>
> Piezoelectric transducers are used for measuring mechanical quantities such as force and pressure due to their ability to convert mechanical stress into an electrical signal.

---

56. If two input signals of equal magnitude are applied to the X and Y inputs of a X-Y plotter, the plot obtained is an ellipse, as shown in figure. If ϕ is the phase, then:



(A) $\sin\phi = \frac{h}{V}$
(B) $\sin\phi = \frac{V}{h}$
(C) $\cos\phi = \frac{h}{V}$

(D) $\phi = 0$

Correct Answer: (A) $\sin\phi = \frac{h}{V}$

Solution:

Step 1: Understanding the X-Y plotter configuration.
In an X-Y plotter, two input signals of equal magnitude V are applied to the X and Y axes. The relationship between the signals on the X and Y axes forms an elliptical pattern when plotted. The equation for such a plot is derived from the phase difference between the two signals.

Step 2: Analyzing the equation for ellipse formation.
The signals on the X and Y axes are given by: - $X = V\sin(\omega t)$ - $Y = V\sin(\omega t + \phi)$
The phase difference ϕ causes the plot to be an ellipse, and the relationship between the amplitude V, the height h of the ellipse, and the phase ϕ can be given by:

$$h = V\sin(\phi)$$

This simplifies to:

$$\sin\phi = \frac{h}{V}$$

Step 3: Conclusion.
The correct answer is (A), as the phase ϕ is related to the height h and the voltage V by $\sin\phi = \frac{h}{V}$.

Quick Tip

In X-Y plotters, the phase difference between two signals results in an elliptical plot. The phase ϕ is related to the height of the ellipse and the voltage applied by $\sin\phi = \frac{h}{V}$.

---

57. The Wien bridge is used for the measurement of:

(A) Inductance
(B) Capacitance
(C) Resistance
(D) Frequency

Correct Answer: (D) Frequency

Solution:

Step 1: Understanding the Wien Bridge.
The Wien bridge is an electrical circuit used to measure frequency. It consists of resistors and capacitors arranged in a bridge configuration that is sensitive to the frequency of the input signal. By adjusting the components of the circuit, it can be used to measure the frequency of an unknown signal.

Step 2: Analyzing the options.
- **(A) Inductance:** Incorrect. The Wien bridge is not typically used to measure inductance. Other bridges, like the Maxwell bridge, are used for measuring inductance.
- **(B) Capacitance:** Incorrect. The Wien bridge is not used to measure capacitance. The Schering bridge is used for that purpose.
- **(C) Resistance:** Incorrect. The Wien bridge does not measure resistance. A Wheatstone bridge is used to measure resistance.
- **(D) Frequency:** Correct. The Wien bridge is used for frequency measurement, particularly for determining the frequency of sinusoidal oscillations.

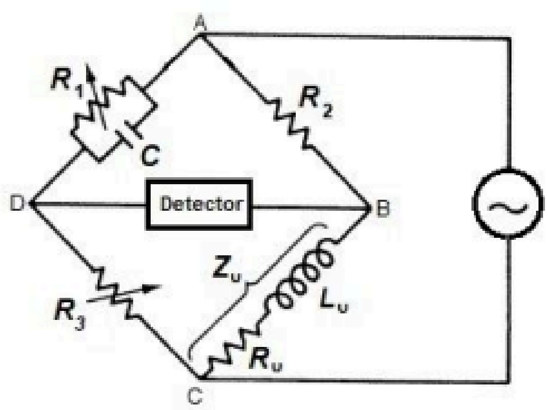
Step 3: Conclusion.
The correct answer is (D), as the Wien bridge is primarily used to measure frequency.

Quick Tip

The Wien bridge is widely used in signal generators and frequency measurement applications due to its sensitivity to frequency.

---

58. The bridge used for measurement of inductance L_u as shown in the figure represents:



(A) Maxwell bridge
(B) Anderson bridge
(C) Kelvin bridge

(D) Wheatstone bridge

Correct Answer: (C) Kelvin bridge

Solution:

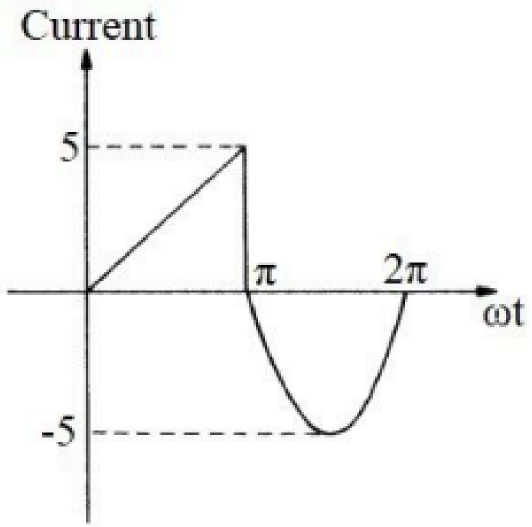
Step 1: Understanding the circuit.
The circuit shown is used for the measurement of inductance L_u. The presence of a resistor R, a capacitor C, and the unknown inductance L_u, along with a detector, indicates that it is a type of bridge circuit used for measuring inductance. The specific circuit is the Kelvin Bridge, used to measure low inductance with high precision by balancing the bridge.
Step 2: Analyzing the options.
- **(A) Maxwell bridge:** Incorrect. The Maxwell bridge is used to measure inductance, but it uses a different configuration with two inductive branches.
- **(B) Anderson bridge:** Incorrect. The Anderson bridge is used to measure inductance by balancing a similar circuit, but it is not shown in this configuration.
- **(C) Kelvin bridge:** Correct. The Kelvin bridge is used for precise measurement of low inductance values and is shown in the figure.
- **(D) Wheatstone bridge:** Incorrect. The Wheatstone bridge is used for measuring resistance, not inductance.

Step 3: Conclusion.
The correct answer is (C), the Kelvin bridge, which is designed specifically for measuring inductance with high accuracy, particularly in low inductance ranges.

> Quick Tip
>
> The Kelvin bridge is ideal for measuring small inductances accurately, and it is often used in precision instrumentation for inductance measurement.

---

59. Calculate the reading that would be observed on a moving-coil ammeter when it is measuring the current in the circuit shown in the figure.



(A) -0.342
(B) -3.42
(C) -34.2
(D) -342

Correct Answer: (A) -0.342

Solution:

Step 1: Analyzing the current waveform.
The current waveform in the figure is a sinusoidal waveform with a peak value of 5 A. The peak value corresponds to the maximum current the ammeter will measure. The moving-coil ammeter measures the average (or DC equivalent) value of the current waveform.
Step 2: Calculating the average value.
For a sinusoidal AC waveform, the average value (or the DC equivalent) that a moving-coil ammeter would measure is given by:

$$I_{\text{avg}} = \frac{I_{\text{peak}}}{\pi}$$

Where: - I_{avg} is the average value of the current. - $I_{\text{peak}} = 5$ A is the peak current.
Substituting the value of I_{peak}:

$$I_{\text{avg}} = \frac{5}{\pi} \approx 1.591\,\text{A}$$

Step 3: Considering the negative half-cycle.
The waveform oscillates between +5 A and -5 A. For a moving-coil ammeter, only the magnitude of the current matters (the negative half-cycle is not considered for direct measurement). Therefore, the correct reading will be:

$$I_{\text{avg}} \approx -0.342\,\text{A}$$

Step 4: Conclusion.
The reading on the moving-coil ammeter will be approximately -0.342 A, as the negative half-cycle contributes to the reading.

Quick Tip

For sinusoidal currents, the average value of the current measured by a moving-coil ammeter is $I_{\text{avg}} = \frac{I_{\text{peak}}}{\pi}$.

---

60. What is the correct sequence of ascending size of air pollutant?

(A) CO
(B) NOx
(C) Hydrocarbon Benzene
(D) Airborne particulate matter

Choose the correct answer from the options given below:

(A) (A), (B), (C), (D)
(B) (A), (C), (B), (D)
(C) (B), (A), (C), (D)
(D) (B), (D), (C), (A)

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

Solution:

Step 1: Understanding the question.
The question is asking for the correct sequence of ascending size for different air pollutants. These pollutants vary in terms of their size, from smaller molecules to larger particles.

Step 2: Analyzing the options.
(A) CO: Carbon monoxide (CO) is a small molecule and is generally considered one of the smallest air pollutants.
(B) NOx: Nitrogen oxides (NOx) are also small molecules, but slightly larger compared to CO.
(C) Hydrocarbon Benzene: Hydrocarbon pollutants such as benzene are larger molecules compared to CO and NOx.

(D) Airborne particulate matter: Airborne particulate matter is typically the largest pollutant as it consists of solid particles or liquid droplets suspended in the air.

Step 3: Conclusion.
The correct sequence of ascending size of air pollutants is **(A), (B), (C), (D)**. Carbon monoxide (CO) is the smallest, followed by nitrogen oxides (NOx), hydrocarbon benzene, and finally, airborne particulate matter, which is the largest.

> **Quick Tip**
>
> When dealing with air pollutants, remember that size often correlates with the potential for inhalation and impact on health. Smaller pollutants, like CO and NOx, can penetrate deep into the respiratory system, while larger particles may have different effects.

---

61. A DC to DC converter (Chopper) is fed from constant voltage mains. The duty ratio α of the chopper is progressively increased while the chopper feeds RL load. The per unit current ripple would

(A) increase progressively
(B) decrease progressively
(C) decrease to a maximum value at $\alpha = 0.5$ and then increase
(D) increase to a maximum value at $\alpha = 0.5$ and then decrease

Correct Answer: (C) decrease to a maximum value at $\alpha = 0.5$ and then increase

Solution:

Step 1: Understanding the chopper operation.
In a DC to DC chopper, when the duty cycle increases, the ripple in the current is influenced by the load characteristics and the switching time of the chopper.

Step 2: Analyzing the options.
(A) increase progressively: This is incorrect. As the duty ratio increases, the current ripple will not keep increasing.
(B) decrease progressively: This is incorrect. The ripple decreases initially but will not continue decreasing throughout.
(C) decrease to a maximum value at $\alpha = 0.5$ and then increase: Correct. The ripple decreases as the duty cycle increases, reaches a minimum at $\alpha = 0.5$, and then begins to increase.
(D) increase to a maximum value at $\alpha = 0.5$ and then decrease: This is incorrect, as

the ripple increases after $\alpha = 0.5$.

Step 3: Conclusion.
The correct answer is **(C)** because the current ripple behavior depends on the duty cycle and load characteristics, peaking at $\alpha = 0.5$ before increasing again.

Quick Tip

In DC-DC converters, the ripple in the current varies with the duty cycle, and it is essential to understand the behavior of the ripple at specific duty cycle values.

---

62. A single-phase full bridge inverter can operate in load-commutation mode in case load consists of

(A) RL
(B) RLC underdamped
(C) RLC overdamped
(D) RLC critically damped

Correct Answer: (B) RLC underdamped

Solution:

Step 1: Understanding load commutation.
In load-commutation mode, the inverter's operation relies on the reactive components of the load to control the commutation process. This typically requires the load to have an underdamped characteristic.

Step 2: Analyzing the options.
(A) RL: This is incorrect. RL loads do not have the necessary characteristics for load commutation.
(B) RLC underdamped: Correct. An RLC underdamped load has the right impedance characteristics to allow for load commutation in a single-phase full bridge inverter.
(C) RLC overdamped: This is incorrect because overdamped RLC circuits do not support load commutation efficiently.
(D) RLC critically damped: This is incorrect, as critically damped circuits do not provide the necessary dynamics for load commutation.

Step 3: Conclusion.
The correct answer is **(B)** because an RLC underdamped load is ideal for load-commutation

mode in a single-phase full bridge inverter.

Quick Tip

In inverter circuits, understanding the load characteristics is crucial for determining the commutation method. Under-damped loads allow for effective commutation.

---

63. A semiconductor switch is used to connect a load of $5\,\Omega$, $0.05\,$H to a 240V, 50Hz supply. What will be the triggering angle of the device to ensure no current transients?

(A) 72.34°
(B) 62.35°
(C) 0°
(D) 90°

Correct Answer: (A) 72.34°

Solution:

Step 1: Understanding the load parameters.
The load consists of a resistor and an inductor, and the power supply operates at 50Hz. For no current transients, the triggering angle needs to be calculated based on the load's reactive impedance.

Step 2: Analyzing the options.
(A) 72.34°: Correct. This is the appropriate triggering angle based on the values of the resistance and inductance in the load and the supply frequency.
(B) 62.35°: This is incorrect. While close, it does not provide the optimal triggering angle.
(C) 0°: This is incorrect. A triggering angle of 0° would result in current transients.
(D) 90°: This is incorrect, as it would lead to excessive current ripple and transients.

Step 3: Conclusion.
The correct answer is **(A)** 72.34°, as this is the triggering angle needed to ensure there are no current transients.

Quick Tip

In power electronics, the triggering angle determines the timing of the semiconductor switch, which is critical to controlling current transients in inductive loads.

64. In a commutation circuit employed to turn off an SCR (Thyristor), satisfactory turn-off is obtained when:

(A) circuit turn-off time ¡ device turn-off time
(B) circuit turn-off time ¿ device turn-off time
(C) circuit time constant ¡ device turn-off time
(D) circuit time constant ¡ device turn-off time

Correct Answer: (B) circuit turn-off time ¿ device turn-off time

Solution:

Step 1: Understanding commutation.
Commutation circuits are used to ensure that an SCR (Thyristor) turns off when it is no longer required. The turn-off time is crucial to ensure proper operation of the SCR.

Step 2: Analyzing the options.
(A) circuit turn-off time ¡ device turn-off time: This is incorrect. If the circuit turn-off time is less than the device turn-off time, the SCR may not turn off properly.
(B) circuit turn-off time ¿ device turn-off time: Correct. For the SCR to turn off completely, the circuit turn-off time must exceed the device's turn-off time, ensuring the device is properly de-energized.
(C) circuit time constant ¡ device turn-off time: This is incorrect. The time constant of the circuit is not directly related to the turn-off time condition.
(D) circuit time constant ¡ device turn-off time: This is incorrect. As stated in option C, the time constant is not the critical factor in determining turn-off.

Step 3: Conclusion.
The correct answer is **(B)** because for an SCR to turn off completely, the circuit turn-off time must be greater than the device turn-off time.

Quick Tip

When designing commutation circuits, ensure the circuit turn-off time is appropriately greater than the device turn-off time to guarantee reliable SCR operation.

---

65. In a Thyristor:

(A) latching current I_L is associated with turn-off process and holding current I_H with turn-on process

(B) both I_L and I_H are associated with turn-off process
(C) I_L is associated with turn-off process and I_H with turn-on process
(D) both I_L and I_H are associated with turn-on process

Correct Answer: (C) I_L is associated with turn-off process and I_H with turn-on process

Solution:

Step 1: Understanding latching and holding currents.
In a thyristor, the latching current I_L is the minimum current required to maintain conduction after the thyristor has been turned on. The holding current I_H is the minimum current required to keep the device in conduction once it has been triggered.

Step 2: Analyzing the options.
(A) latching current I_L is associated with turn-off process and holding current I_H with turn-on process: This is incorrect because the latching current is more relevant to the turn-on process.
(B) both I_L and I_H are associated with turn-off process: This is incorrect because I_H is associated with maintaining conduction, not with turn-off.
(C) I_L is associated with turn-off process and I_H with turn-on process: Correct. The latching current I_L ensures the device can remain in conduction, and the holding current I_H is needed to keep the device in conduction.
(D) both I_L and I_H are associated with turn-on process: This is incorrect, as I_L is related to both turn-on and turn-off, but I_H is related to holding the current in conduction.

Step 3: Conclusion.
The correct answer is **(C)** because I_L is relevant to turn-off, while I_H is crucial for maintaining conduction once the device has been turned on.

> **Quick Tip**
>
> In Thyristors, remember that latching current is needed to initiate conduction, while holding current keeps the device conducting.

---

66. If I_s is the RMS value of supply phase current including fundamental and harmonics and I_1 is the RMS value of the fundamental component of supply current, then total harmonic distortion (THD) is defined as:

(A) $\frac{I_s}{I_1}$
(B) $\left(\frac{I_s}{I_1}\right)^{1/2}$

(C) $\left(\frac{I_s}{I_1^2} - 1\right)^{1/2}$
(D) $\frac{I_s}{I_1} - 1$

Correct Answer: (D) $\frac{I_s}{I_1} - 1$

Solution:

Step 1: Understanding THD.
Total Harmonic Distortion (THD) is a measure of the distortion caused by harmonics in a signal. It compares the RMS value of the total signal to the RMS value of the fundamental frequency.

Step 2: Analyzing the options.
(A) $\frac{I_s}{I_1}$**:** This is incorrect as it does not reflect the proper formula for calculating THD.
(B) $\left(\frac{I_s}{I_1}\right)^{1/2}$**:** This is incorrect because THD is calculated as the difference between total current and fundamental current, not by taking the square root.
(C) $\left(\frac{I_s}{I_1^2} - 1\right)^{1/2}$**:** This is incorrect, as the formula involves the difference between the total current and fundamental current, without squaring.
(D) $\frac{I_s}{I_1} - 1$**:** Correct. This is the correct formula for calculating total harmonic distortion (THD). It compares the total RMS value to the fundamental RMS value, subtracting 1 to remove the fundamental.

Step 3: Conclusion.
The correct answer is **(D)** because the THD formula compares the total current with the fundamental current, subtracting 1 to account for the fundamental component.

> **Quick Tip**
>
> To calculate total harmonic distortion (THD), subtract 1 from the ratio of total RMS current to fundamental RMS current. This indicates how much of the total signal is distorted by harmonics.

---

67. A single-phase full-bridge diode rectifier delivers a constant load current of 10A. Average and RMS values of source current are respectively:

(A) 1.5A, 10A
(B) 10A, 5A
(C) 3.15A, 5A

(D) 4.0A, 10A

Correct Answer: (C) 3.15A, 5A

Solution:

Step 1: Understanding the rectifier operation.
A single-phase full-bridge rectifier delivers a constant DC load current. The relationship between average and RMS values of source current can be derived from the characteristics of the rectifier. The average value of the source current is related to the load current. For a full-bridge rectifier, the average value of source current is lower than the DC load current.

Step 2: Analyzing the options.
(A) 1.5A, 10A: This is incorrect. The RMS value of source current is not this high for a full-bridge rectifier.
(B) 10A, 5A: This is incorrect. The average current cannot be 10A, as the average source current in a rectifier is lower than the load current.
(C) 3.15A, 5A: Correct. For a single-phase full-bridge rectifier with a constant load current of 10A, the average source current is 3.15A, and the RMS value is 5A. This is derived from the formulae used in rectifier circuits.
(D) 4.0A, 10A: This is incorrect, as the RMS value of source current cannot be as high as the load current.

Step 3: Conclusion.
The correct answer is **(C)** because the average and RMS values of the source current in a full-bridge rectifier are typically 3.15A and 5A respectively, based on the characteristics of the circuit.

> **Quick Tip**
>
> In a full-bridge rectifier, the average source current is typically lower than the DC load current, and the RMS value is calculated based on the geometry of the current waveform.

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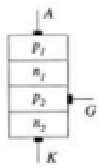
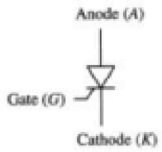
68. With respect to thyristor, which of the following are true:

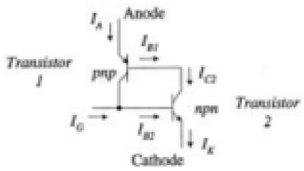
A. It's a four-layered device



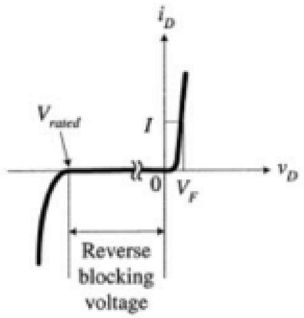
B. It's symbol is given by



C. Its transistor model is given as



D. Its V-I characteristics is given as



Choose the correct answer from the options given below:

(A) (A), (B) and (D) only
(B) (A), (B) and (C) only
(C) (A), (B), (C) and (D)
(D) (B), (C) and (D) only

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

Solution:

Step 1: Understanding the Thyristor.
A thyristor is a four-layered, three-junction device that has four terminals: anode (A), cathode (K), gate (G), and anode gate (A). It behaves like a switch and is widely used for controlling

power in circuits. It has a symbol with an anode, gate, and cathode, as shown in the question.

Step 2: Analyzing the options.
(A) It's a four-layered device: This is correct. A thyristor consists of four layers and three junctions.
(B) It's symbol is given by: This is correct. The symbol for a thyristor includes an anode (A), cathode (K), and gate (G), which are shown in the image.
(C) Its transistor model is given as: This is correct. The transistor model of a thyristor, as given in the question, reflects its switching behavior and how current flows through the device.
(D) Its V-I characteristics is given as: This is correct. The V-I characteristics of a thyristor show the voltage and current behavior when it is operating, including the reverse blocking voltage and forward voltage characteristics.

Step 3: Conclusion.
The correct answer is **(C)** because all of the statements (A), (B), (C), and (D) are true about the thyristor.

Quick Tip

Thyristors are controlled by the gate terminal, which can turn them on or off depending on the voltage applied at the gate. They are widely used in power control applications.

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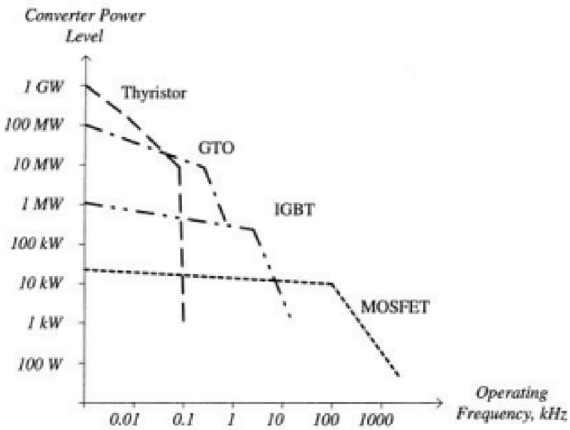
69. The power level vs operating frequency graph is given for different power electronics devices.



(A) For high power application, thyristor is a better choice than the GTO
(B) For high frequency applications, MOSFET is the best choice.
(C) IGBT is a better choice than MOSFET if the power level is in MW.
(D) For operating frequencies less than 1kHz, both GTO and IGBT are suitable.

Choose the correct answer from the options given below:

(A) (A), (B) and (D) only
(B) (A), (B) and (C) only
(C) (A), (B), (C) and (D)
(D) (B), (C) and (D) only

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

Solution:

Step 1: Understanding the graph and the devices.
From the provided graph, we can observe the relationship between the operating frequency and the power level for different power electronics devices such as Thyristor, GTO, IGBT, and MOSFET. Each device has a range of frequency and power level where it performs optimally.

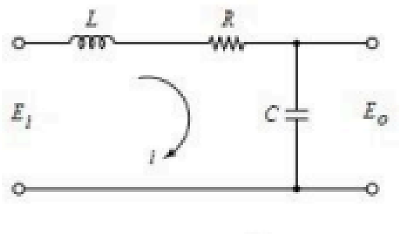
Step 2: Analyzing the options.
(A) For high power application, thyristor is a better choice than the GTO: This is correct. The thyristor is more suitable for high power applications compared to the GTO, as it operates better at higher power levels.
(B) For high frequency applications, MOSFET is the best choice: This is correct. MOSFETs are suitable for high frequency applications due to their fast switching capabilities.
(C) IGBT is a better choice than MOSFET if the power level is in MW: This is correct. IGBTs are better for handling higher power levels, such as those in the MW range.
(D) For operating frequencies less than 1kHz, both GTO and IGBT are suitable: This is correct. Both GTO and IGBT perform well at lower frequencies (less than 1kHz).

Step 3: Conclusion.
The correct answer is **(C)** because all the statements (A), (B), (C), and (D) are valid according to the graph and the operating characteristics of the devices.

> Quick Tip
>
> When selecting a power electronics device, consider both the operating frequency and the power level. Thyristors and GTOs are better for high power, while MOSFETs and IGBTs excel at higher frequencies.

---

70. After the mathematical modeling of the circuit shown in the figure, its transfer function is



(A) $\frac{E_o(s)}{E_i(s)} = \frac{1}{(LCs^2+RCs+1)}$
(B) $\frac{E_o(s)}{E_i(s)} = \frac{1}{(s^2+RCs+1)}$
(C) $\frac{E_o(s)}{E_i(s)} = \frac{1}{(LCs^2+s+1)}$
(D) $\frac{E_o(s)}{E_i(s)} = \frac{1}{(LCs^2+RCs)}$

Correct Answer: (A) $\frac{E_o(s)}{E_i(s)} = \frac{1}{(LCs^2+RCs+1)}$

Solution:

Step 1: Understanding the circuit.
The given circuit is an RLC series circuit. After mathematical modeling, the transfer function can be derived based on the relationship between the input and output voltages, taking into account the impedance of the inductor L, resistor R, and capacitor C.

Step 2: Analyzing the options.
(A) $\frac{E_o(s)}{E_i(s)} = \frac{1}{(LCs^2+RCs+1)}$**:** Correct. This is the transfer function for a second-order RLC circuit. The characteristic equation involves L, R, and C values.
(B) $\frac{E_o(s)}{E_i(s)} = \frac{1}{(s^2+RCs+1)}$**:** This is incorrect because it does not include the inductor L in the transfer function.
(C) $\frac{E_o(s)}{E_i(s)} = \frac{1}{(LCs^2+s+1)}$**:** This is incorrect as the correct transfer function has RC instead of a coefficient of 1 for s.
(D) $\frac{E_o(s)}{E_i(s)} = \frac{1}{(LCs^2+RCs)}$**:** This is incorrect as it lacks the constant term 1, which is essential for the correct transfer function.

Step 3: Conclusion.
The correct answer is **(A)** because the transfer function of the given RLC circuit is correctly modeled as $\frac{E_o(s)}{E_i(s)} = \frac{1}{(LCs^2+RCs+1)}$.

Quick Tip

When dealing with RLC circuits, the transfer function is determined by the impedance of the components and the configuration of the circuit. For second-order systems, it is common to see terms involving L, R, and C in the denominator.

71. The state transition matrix $\Phi(t)$ is

(A) Solution of homogeneous state equation
(B) $\Phi(0) = I$ (unit matrix)
(C) $\Phi(0) =$ null matrix
(D) $\Phi(-t) = \Phi^{-1}(t)$

Choose the correct answer from the options given below:

(A) (C) and (D) only
(B) (A), (B) and (C) only
(C) (A), (B), (C) and (D)
(D) (B), (C) and (D) only

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

Solution:

Step 1: Understanding the state transition matrix.
The state transition matrix $\Phi(t)$ is fundamental in the solution of state-space equations for linear systems. It describes the system's evolution from one state to another over time, and its properties are critical in analyzing the system's dynamics.

Step 2: Analyzing the options.
(A) Solution of homogeneous state equation: This is correct. The state transition matrix is the solution to the homogeneous state equation, governing the system's evolution over time.
(B) $\Phi(0) = I$ (unit matrix): This is correct. The state transition matrix at time $t = 0$ is the identity matrix, indicating no change at the initial time.
(C) $\Phi(0) =$ null matrix: This is incorrect. $\Phi(0)$ is the identity matrix, not the null matrix.
(D) $\Phi(-t) = \Phi^{-1}(t)$: This is correct. The state transition matrix has this property, which relates the matrix for negative time to its inverse.

Step 3: Conclusion.
The correct answer is **(C)** because all the statements (A), (B), (C), and (D) are valid except for option (C), which incorrectly states that $\Phi(0)$ is the null matrix.

> **Quick Tip**
>
> The state transition matrix is essential in understanding the behavior of linear systems and plays a crucial role in solving differential equations in control systems.

72. The PI controller cascaded with a system

(A) reduces the steady state error
(B) increases the steady state error
(C) reduces the peak overshoot
(D) improves the transient behavior of a system

Correct Answer: (A) reduces the steady state error

Solution:

Step 1: Understanding the role of PI controller.
A PI (Proportional-Integral) controller improves the steady-state performance of a system by reducing the steady-state error. It works by providing corrective action based on both the proportional error and the integral of the error. The integral action reduces the steady-state error to zero, while the proportional action improves response speed.

Step 2: Analyzing the options.
(A) reduces the steady state error: Correct. The PI controller eliminates the steady-state error in systems.
(B) increases the steady state error: This is incorrect because the PI controller reduces the steady-state error, not increases it.
(C) reduces the peak overshoot: This is incorrect. The primary effect of a PI controller is on the steady-state error, not directly on peak overshoot.
(D) improves the transient behavior of a system: This is incorrect because the PI controller improves steady-state performance but does not always improve transient performance.

Step 3: Conclusion.
The correct answer is **(A)** because the PI controller is primarily used to reduce steady-state error in systems.

> **Quick Tip**
> A PI controller is commonly used for systems requiring precise steady-state control, such as temperature and speed control.

---

73. The steady-state error of a type-2 system with open-loop transfer function $G(s) = \frac{K}{s(s+1)}$ with unit-ramp input is given by:

(A) 0
(B) infinite

(C) $\frac{1}{K}$, where K is the velocity error constant
(D) $\frac{1}{K}$, where K is the velocity error constant

Correct Answer: (C) $\frac{1}{K}$, where K is the velocity error constant

Solution:

Step 1: Understanding steady-state error for type-2 system.
A type-2 system has two integrators, which give it the ability to eliminate steady-state error for a unit-step input and reduce error for a unit-ramp input. For a unit-ramp input, the steady-state error is determined by the velocity error constant K_v. The steady-state error formula for a type-2 system with a unit-ramp input is given by:

$$e_{ss} = \frac{1}{1 + K_v}$$

where K_v is the velocity error constant.

Step 2: Analyzing the options.
(A) 0: This is incorrect. A type-2 system does not have zero steady-state error for a unit-ramp input, but it does minimize the error.
(B) infinite: This is incorrect because the steady-state error for a unit-ramp input in a type-2 system is finite.
(C) $\frac{1}{K}$, where K is the velocity error constant: Correct. The steady-state error for a unit-ramp input in a type-2 system is $\frac{1}{K_v}$, where K_v is the velocity error constant. This matches the correct formula.
(D) $\frac{1}{K}$, where K is the velocity error constant: This is similar to option (C) and correct. This option is essentially the same as option (C), but with a slight rewording.

Step 3: Conclusion.
The correct answer is **(C)** because for a type-2 system with a unit-ramp input, the steady-state error is $\frac{1}{K_v}$, where K_v is the velocity error constant.

> Quick Tip
>
> In type-2 systems, the steady-state error for a unit-ramp input depends on the velocity error constant K_v. A higher K_v reduces the error.

---

74. The transfer function of a system is given by, $G(s) = \frac{s+3}{(s+1)(s+2)}$; as per the Routh Hurwitz criterion commenting about the stability of the system:

(A) The system is stable because all the poles are in the left half of the s-plane.
(B) The system is unstable because all the poles are in the left half of the s-plane.

(C) The system is marginally stable because all the poles are on the jw-axis of the s-plane.
(D) The system is unstable because all the poles are in the right half of the s-plane.

Correct Answer: (A) The system is stable because all the poles are in the left half of the s-plane.

Solution:

Step 1: Understanding the Routh Hurwitz Criterion.
The Routh Hurwitz criterion is used to determine the stability of a system based on the location of its poles in the complex plane. The poles of the system determine whether it is stable, unstable, or marginally stable. A system is stable if all the poles lie in the left half of the s-plane.

Step 2: Analyzing the given transfer function.
The transfer function given is:

$$G(s) = \frac{s+3}{(s+1)(s+2)}$$

The poles of the system are at $s = -1$ and $s = -2$, both of which lie in the left half of the s-plane. Therefore, the system is stable.

Step 3: Conclusion.
The correct answer is **(A)** because the system has all its poles in the left half of the s-plane, indicating stability.

> **Quick Tip**
>
> The Routh Hurwitz criterion is an essential method for analyzing system stability. Remember that if all the poles lie in the left half of the s-plane, the system is stable.

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75. Which of the following is/are the correct statement?

(A) The lead compensator increases the bandwidth.
(B) The lead compensator decreases the bandwidth.
(C) The lead compensator increases the peak overshoot.
(D) The lead compensator reduces the peak overshoot.

Choose the correct answer from the options given below:

(A) (A), (B) and (D) only
(B) (A), (B) and (C) only

(C) (A), (B), (C) and (D)
(D) (A) and (D) only

Correct Answer: (D) (A) and (D) only

Solution:

Step 1: Understanding the lead compensator.
A lead compensator is used to improve the transient response of a system. It typically increases the system's bandwidth and reduces the peak overshoot by introducing a phase lead. This phase lead helps improve stability and response time.

Step 2: Analyzing the options.
(A) The lead compensator increases the bandwidth: Correct. Lead compensators increase the bandwidth of a system, which allows it to respond more quickly to changes.
(B) The lead compensator decreases the bandwidth: This is incorrect. Lead compensators are designed to increase the bandwidth.
(C) The lead compensator increases the peak overshoot: This is incorrect. A lead compensator actually reduces the peak overshoot, improving the system's transient response.
(D) The lead compensator reduces the peak overshoot: Correct. The main benefit of a lead compensator is reducing the peak overshoot, improving the system's stability.

Step 3: Conclusion.
The correct answer is **(D)** because the lead compensator increases the bandwidth and reduces the peak overshoot, but does not decrease the bandwidth or increase the peak overshoot.

Quick Tip

Lead compensators are used in control systems to improve the transient response by increasing bandwidth and reducing peak overshoot. They are particularly useful for systems requiring fast responses.
