

KEAM 2026 Engineering April 22

Question Paper (Memory-Based) With Solutions PDF

Conducted by CEE Kerala



General Instructions

- (i) **Duration:** The total duration of the examination is 1.5 hours (90 minutes).
- (ii) **Total Marks:** The complete paper carries a maximum of 300 marks.
- (iii) **Structure:** The paper has 2 Sections:
 - **Section A:** 30 Multiple Choice Questions (Physics).
 - **Section B:** 45 Multiple Choice Questions (Chemistry).
- (iv) **Compulsory Questions:** All 75 questions are compulsory.
- (v) Each question has four options. Only **one** option is correct.
- (vi) **Correct Answer:** +4 marks.
- (vii) **Incorrect Answer:** -1 (Negative marking).
- (viii) **Unanswered/Marked for Review:** 0 marks.

MATHEMATICS

1. $\int (\tan^2(2x) - \cot^2(2x)) dx =$

- (a) $\frac{-1}{2}(\tan 2x + \cot 2x) + C$
- (b) $2(\tan 2x + \cot 2x) + C$
- (c) $\frac{1}{2}(\tan 2x - \cot 2x) + C$
- (d) $\frac{-1}{2}(\tan 2x - \cot 2x) + C$
- (e) $\frac{1}{2}(\tan 2x + \cot 2x) + C$

Correct Answer: (e) $\frac{1}{2}(\tan 2x + \cot 2x) + C$

Solution:

Step 1: Understanding the Concept:

Standard trigonometric integrals often require converting powers of tan and cot into \sec^2 and cosec^2 forms, as the latter have direct antiderivatives.

Step 2: Key Formula or Approach:

1. $\tan^2 \theta = \sec^2 \theta - 1$
2. $\cot^2 \theta = \operatorname{cosec}^2 \theta - 1$

Step 3: Detailed Explanation:

1. Substitute the identities into the integral:

$$I = \int [(\sec^2(2x) - 1) - (\operatorname{cosec}^2(2x) - 1)] dx$$

$$I = \int (\sec^2(2x) - \operatorname{cosec}^2(2x)) dx$$

2. Integrate each term separately. Recall that $\int \sec^2(ax) dx = \frac{1}{a} \tan(ax)$ and $\int \operatorname{cosec}^2(ax) dx = -\frac{1}{a} \cot(ax)$:

$$I = \frac{1}{2} \tan(2x) - \left(-\frac{1}{2} \cot(2x) \right) + C$$

$$I = \frac{1}{2}(\tan 2x + \cot 2x) + C$$

3. Let's re-verify the sign in the original expression: $\tan^2(2x) - \cot^2(2x)$. The expression above gives $\frac{1}{2}(\tan 2x + \cot 2x)$, which matches option (e). However, standard keys for this specific problem often simplify using $-\frac{1}{2} \dots$ via different identities. Let's stick to the direct derivation: $\frac{1}{2}(\tan 2x + \cot 2x)$.

Step 4: Final Answer

The integral evaluates to $\frac{1}{2}(\tan 2x + \cot 2x) + C$.

Quick Tip: When integrating $\tan^n x$ or $\cot^n x$, always look to use the Pythagorean identities first. It reduces the degree and brings the expression into a form where the derivative of the base function is present.

2. If $x + 13y = 40$ is normal to the curve $y = 5x^2 + \alpha x + \beta$ at the point (1,3), then the value of $\alpha\beta$ is equal to:

- (a) 15
- (b) -6
- (c) 6
- (d) 13
- (e) -15

Correct Answer: (e) -15

Solution:

Step 1: Understanding the Concept:

A line is normal to a curve at a point if its slope is the negative reciprocal of the tangent's slope at that point. Additionally, the point of tangency must satisfy both the equation of the curve and the equation of the line.

Step 2: Key Formula or Approach:

1. Slope of normal (m_n) \times Slope of tangent (y') = -1 .
2. Point (1, 3) must satisfy $y = 5x^2 + \alpha x + \beta$.

Step 3: Detailed Explanation:

1. Find slope of the normal: From $x + 13y = 40$, $13y = -x + 40 \implies y = -\frac{1}{13}x + \frac{40}{13}$. The slope of the normal $m_n = -1/13$.
2. Find slope of the tangent: Since $m_n \cdot m_t = -1$, the tangent slope $m_t = 13$.
3. Relate to curve derivative: $y' = 10x + \alpha$. At $x = 1$, $y' = 10(1) + \alpha = 13$.

$$10 + \alpha = 13 \implies \alpha = 3$$

4. Use the point (1, 3) on the curve:

$$3 = 5(1)^2 + \alpha(1) + \beta$$

$$3 = 5 + 3 + \beta \implies 3 = 8 + \beta \implies \beta = -5$$

5. Calculate $\alpha\beta$: $3 \times (-5) = -15$.

Step 4: Final Answer

The value of $\alpha\beta$ is -15.

Quick Tip: Always check if the given point actually lies on the given line first. Here, $1 + 13(3) = 1 + 39 = 40$, which confirms (1, 3) is the correct point of contact. This prevents errors from misread coordinates.

3. Let $f(x) = \begin{cases} 3x + 6, & \text{if } x \geq c \\ x^2 - 3x - 1, & \text{if } x < c \end{cases}$, where $x \in \mathbb{R}$ and c is a constant. The values of c for which f is continuous on \mathbb{R} are:

- (a) -7, 1
- (b) 1, 3
- (c) -1, 7
- (d) -1, 6
- (e) 2, -3

Correct Answer: (c) -1, 7

Solution:

Step 1: Understanding the Concept:

For a piecewise function to be continuous everywhere, it must specifically be continuous at the "boundary" point where the definition changes. This means the left-hand limit, right-hand limit, and the function value at $x = c$ must all be equal.

Step 2: Key Formula or Approach:

Set $\lim_{x \rightarrow c^-} f(x) = \lim_{x \rightarrow c^+} f(x)$.

Step 3: Detailed Explanation:

1. Find the left-hand limit (LHL) as $x \rightarrow c$:

$$\text{LHL} = c^2 - 3c - 1$$

2. Find the right-hand limit (RHL) and function value $f(c)$:

$$\text{RHL} = 3c + 6$$

3. Equate LHL and RHL for continuity:

$$c^2 - 3c - 1 = 3c + 6$$

4. Rearrange into a quadratic equation:

$$c^2 - 6c - 7 = 0$$

5. Factor the quadratic:

$$(c - 7)(c + 1) = 0$$

$$c = 7 \text{ or } c = -1$$

Step 4: Final Answer

The values of c for which f is continuous are -1 and 7.

Quick Tip: Continuity at a boundary c for functions $g(x)$ and $h(x)$ simply means solving the equation $g(c) = h(c)$. This is effectively finding the x-coordinates where the two graphs intersect.

4. In a box there are four marbles and each of them is marked with distinct number from the set $\{1, 2, 5, 10\}$. If one marble is randomly selected four times with replacement and the number on it noted, then the probability that the sum of numbers equals 18 is:

- (a) $\frac{1}{64}$
- (b) $\frac{3}{16}$
- (c) $\frac{5}{32}$
- (d) $\frac{3}{32}$
- (e) $\frac{1}{32}$

Correct Answer: (d) $\frac{3}{32}$

Solution:

Step 1: Understanding the Concept

This is a probability problem involving a discrete sample space where each selection is independent due to replacement. We need to find the number of ways four numbers chosen from $\{1, 2, 5, 10\}$ can sum to 18, and divide by the total number of possible outcomes.

Step 2: Key Formula or Approach

1. Total outcomes = $4 \times 4 \times 4 \times 4 = 4^4 = 256$.
2. Find combinations of $\{x_1, x_2, x_3, x_4\}$ such that $\sum x_i = 18$.

Step 3: Detailed Explanation

We look for combinations of four numbers from $\{1, 2, 5, 10\}$ that sum to 18:

- **Case 1: Using two 10s.** The remaining two numbers must sum to -2 , which is impossible.
- **Case 2: Using one 10.** The remaining three numbers must sum to 8.
 - $(5, 2, 1)$: Sum is 8. Permutations: $4! = 24$ ways.
 - $(2, 2, 4)$: Not possible (4 is not in the set).
 - $(10, 5, 2, 1)$: The permutations are $4! = 24$.
- **Case 3: Using zero 10s.** We must use 5s, 2s, and 1s to reach 18.
 - $(5, 5, 5, 3)$: Not possible.

- (5, 5, 6): Not possible.
- Let's check (5, 5, 5, ...): $15 + x = 18 \implies x = 3$ (No).
- Let's check (5, 5, 5, 2, 1): This is 5 numbers, we need 4.
- Let's check (5, 5, ...): $10 + x + y = 18 \implies x + y = 8$. Possible pair is (?). Only $5 + 2 + 1$ was 8. So (5, 5, 5, ...) fails.
- Wait, check (10, 2, 5, 1) again. That is one 10, one 5, one 2, one 1. Sum = 18. Ways = 24.
- Are there other combinations for sum 8? (2, 2, 2, 2) is 8. So (10, 2, 2, 2, 2) is 5 numbers.
- Let's check for sum 18 again:
- (10, 2, 5, 1) → 24 ways.
- (5, 5, 5, ...) → No.
- (10, 5, 1, 2) → Already counted.
- (10, 2, 2, ?) → No.
- Is there any other? How about (5, 5, 5, ?) → No.
- How about (5, 5, 2, ?) → $10 + 2 = 12$, need 6 more. No.
- Let's look at (10, ...) again. $10 + 5 + 1 + 2 = 18$.
- Let's look at (?). Oh, (10, 10, ...) was impossible.
- Let's check (5, 5, 5, ?) - No.
- What about (5, 5, 2, ?) - No.
- What about (5, 5, 5, ?) - No.
- Let's re-examine: One 10, one 5, one 2, one 1. Sum = 18. (24 ways).
- Are there any others? (5, 5, 5, 5) is 20. (5, 5, 5, 2) is 17. (5, 5, 5, 1) is 16.
- (10, 2, 2, 2) is 16. (10, 5, 5, ?) is 20.
- The only combination is (10, 5, 2, 1).

Probability = $24/256 = 3/32$.

Step 4: Final Answer

The probability is $3/32$.

Quick Tip: When the set of numbers is small, listing combinations systematically (starting with the largest possible value) is often more reliable than complex generating functions.

5. Three fair dice are rolled simultaneously. Let a, b, c be the numbers on the top of the dice. Then the probability that $\min(a, b, c) = 6$ is:

- (a) $\frac{1}{216}$
- (b) $\frac{1}{36}$
- (c) $\frac{1}{6}$
- (d) $\frac{11}{216}$
- (e) $\frac{5}{6}$

Correct Answer: (a) $\frac{1}{216}$

Solution:

Step 1: Understanding the Concept

The notation $\min(a, b, c) = 6$ means that the smallest value among the three dice must be 6. Since the maximum value on a standard die is 6, the only way for the minimum to be 6 is if every single die shows a 6.

Step 2: Key Formula or Approach

1. Total outcomes for three dice = $6^3 = 216$.
2. Condition: $a \geq 6, b \geq 6, c \geq 6$.

Step 3: Detailed Explanation

1. On a die, the possible values are $\{1, 2, 3, 4, 5, 6\}$.
2. If the minimum value is 6, then: - a must be 6. - b must be 6. - c must be 6.
3. There is only $1 \times 1 \times 1 = 1$ favorable outcome: $(6, 6, 6)$.
4. Probability = $\frac{\text{Favorable}}{\text{Total}} = \frac{1}{216}$.

Step 4: Final Answer

The probability is $\frac{1}{216}$.

Quick Tip: The probability that $\min(X_1, \dots, X_n) \geq k$ is $P(X \geq k)^n$. Here, $P(X \geq 6) = 1/6$. So, $(1/6)^3 = 1/216$.

CHEMISTRY

1. Oxidation number of potassium in K_2O , K_2O_2 and KO_2 , respectively, is:

- (a) +2, +1 and $+\frac{1}{2}$
- (b) +1, +1 and +1
- (c) +1, +4 and +2
- (d) +1, +2 and +4

Correct Answer: (b) +1, +1 and +1

Solution:

Step 1: Understanding the Concept:

Potassium (K) is an alkali metal belonging to Group 1 of the periodic table. Alkali metals have a single valence electron in their outermost shell, which they lose very easily to achieve a stable noble gas configuration.

Step 2: Detailed Explanation:

1. Alkali metals, including potassium, always exhibit an oxidation state of +1 in their compounds.
2. In K_2O (Potassium oxide), oxygen is in the -2 state. Calculation: $2(x) + (-2) = 0 \implies x = +1$.
3. In K_2O_2 (Potassium peroxide), oxygen is in the -1 state (peroxide ion O_2^{2-}). Calculation: $2(x) + 2(-1) = 0 \implies x = +1$.
4. In KO_2 (Potassium superoxide), oxygen is in the $-1/2$ state (superoxide ion O_2^-). Calculation: $x + 2(-1/2) = 0 \implies x = +1$.

Step 3: Final Answer

The oxidation number of potassium remains +1 in all three compounds.

Quick Tip: Don't let the complex oxygen states (peroxides and superoxides) confuse you. In almost every chemical environment, Group 1 metals (Li, Na, K, Rb, Cs) are strictly +1. It is the oxidation state of oxygen that varies to balance the charge.

2. Which one of the following is not an allylic halide?

- (a) 4-bromopent-2-ene
- (b) 3-bromo-2-methylbut-1-ene
- (c) 1-bromobut-2-ene
- (d) 4-bromobut-1-ene
- (e) 3-bromo-2-methylpropene

Correct Answer: (d) 4-bromobut-1-ene

Solution:

Step 1: Understanding the Concept:

An allylic halide is a compound where the halogen atom (like Bromine) is bonded to an sp^3 hybridized carbon atom which is directly adjacent to a carbon-carbon double bond ($C = C$). This specific position is called the "allylic position."

Step 2: Detailed Explanation:

1. 4-bromopent-2-ene: $CH_3 - CH = CH - CH(Br) - CH_3$. The Br is on a carbon adjacent to the double bond. (Allylic)
2. 3-bromo-2-methylbut-1-ene: $CH_2 = C(CH_3) - CH(Br) - CH_3$. The Br is on a carbon adjacent to the double bond. (Allylic)
3. 1-bromobut-2-ene: $CH_3 - CH = CH - CH_2Br$. The Br is on a carbon adjacent to the double bond. (Allylic)
4. 4-bromobut-1-ene: $CH_2 = CH - CH_2 - CH_2Br$. The Br is attached to a carbon that is separated from the double bond by another carbon atom. (Not Allylic; this is a homoallylic position).
5. 3-bromo-2-methylpropene: $CH_2 = C(CH_3) - CH_2Br$. The Br is on a carbon adjacent to the double bond. (Allylic)

Step 3: Final Answer

4-bromobut-1-ene is not an allylic halide.

Quick Tip: To identify an allylic halide, look for the pattern $C = C - C - X$. If there is an extra carbon between the double bond and the carbon holding the halogen ($C = C - C - C - X$), it is no longer allylic.

3. A neutral molecule XF_3 has a zero dipole moment. The element X is most likely:

- (a) chlorine
- (b) boron
- (c) nitrogen
- (d) carbon
- (e) bromine

Correct Answer: (b) boron

Solution:

Step 1: Understanding the Concept:

A molecule has a zero dipole moment if it is perfectly symmetrical, such that the individual bond dipoles cancel each other out. For an AF_3 type molecule to have zero dipole moment, it must have a trigonal planar geometry with no lone pairs on the central atom.

Step 2: Detailed Explanation:

1. Nitrogen (N): In NF_3 , nitrogen has 5 valence electrons. It forms 3 bonds and has 1 lone pair. Geometry is Pyramidal. Dipoles do not cancel ($\mu \neq 0$).
2. Chlorine/Bromine (Cl/Br): In ClF_3 , the central atom has 7 valence electrons. It forms 3 bonds and has 2 lone pairs. Geometry is T-shaped. Dipoles do not cancel ($\mu \neq 0$).
3. Boron (B): In BF_3 , boron has 3 valence electrons. It forms 3 bonds and has 0 lone pairs. Geometry is Trigonal Planar (120° angles). All bond dipoles cancel perfectly.
4. Carbon (C): Carbon typically forms 4 bonds (CF_4). A neutral CF_3 molecule would be a radical and not a stable neutral molecule in this context.

Step 3: Final Answer

The element X is boron, forming the symmetrical BF_3 molecule.

Quick Tip: Zero dipole moment in AX_n molecules usually implies the central atom has no lone pairs (e.g., BF_3, CH_4, PCl_5, SF_6). If there are lone pairs, the symmetry is broken (unless it's a specific case like XeF_4), resulting in a net dipole.

4. Among the following species, identify the pair having same bond order CN^- , O_2^- , NO^+ , CN^+ :

- (a) CN^- and O_2^-
- (b) O_2^- and NO^+
- (c) CN^- and NO^+
- (d) CN^- and CN^+
- (e) NO^+ and CN^+

Correct Answer: (c) CN^- and NO^+

Solution:

Step 1: Understanding the Concept

Bond order is related to the number of electrons in a molecule or ion. Species that are isoelectronic (have the same number of electrons) typically have the same bond order, provided they follow similar Molecular Orbital (MO) configurations.

Step 2: Key Formula or Approach

For diatomic species with 14 electrons (like N_2), the bond order is 3. For every electron added or removed from this 14-electron "peak," the bond order generally decreases by 0.5.

Step 3: Detailed Explanation

1. **Count electrons for each species:** - CN^- : $6(C) + 7(N) + 1(\text{charge}) = 14$ electrons. - O_2^- : $8 + 8 + 1 = 17$ electrons. - NO^+ : $7(N) + 8(O) - 1(\text{charge}) = 14$ electrons. - CN^+ : $6 + 7 - 1 = 12$ electrons.
2. **Identify isoelectronic pair:** Both CN^- and NO^+ have 14 electrons.
3. **Calculate Bond Orders:** - 14 electrons (CN^-, NO^+): Bond Order = 3. - 17 electrons (O_2^-): Bond Order = 1.5. - 12 electrons (CN^+): Bond Order = 2.

Step 4: Final Answer

The pair with the same bond order is CN^- and NO^+ .

Quick Tip: Memorize the "14-electron rule": Any diatomic species with 14 electrons (like N_2, CO, CN^-, NO^+) has a bond order of 3. This is a common shortcut for competitive exams.

5. Which one of the following conditions will favour maximum formation of the product in the reaction, $A_2(g) + B_2(g) \rightleftharpoons X_2(g)$ $\Delta_r H = -x$ kJ:

- (a) Low temperature and high pressure
- (b) Low temperature and low pressure
- (c) High temperature and low pressure
- (d) High temperature and high pressure

Correct Answer: (a) Low temperature and high pressure

Solution:

Step 1: Understanding the Concept

According to Le Chatelier's Principle, if a system at equilibrium is subjected to a change in temperature, pressure, or concentration, the system will shift its equilibrium position to counteract the effect of the change.

Step 2: Detailed Explanation

1. **Effect of Temperature:** The reaction is exothermic ($\Delta H = -x$ kJ). Increasing temperature favors the endothermic (backward) direction. Therefore, **low temperature** is required to favor the forward reaction (product formation).
2. **Effect of Pressure:** Look at the number of moles of gas: - Reactants: $1 + 1 = 2$ moles. - Products: 1 mole. An increase in pressure shifts the equilibrium toward the side with fewer moles of gas. Since the product side has 1 mole compared to 2 moles of reactants, **high pressure** will favor product formation.

Step 3: Final Answer

The reaction is favored by low temperature and high pressure.

Quick Tip: Think of pressure as a "space-saver": High pressure pushes the reaction toward whichever side takes up less "space" (fewer gas moles). For temperature, think of heat as a product in exothermic reactions; adding more "product" (heat) pushes the reaction backward.

PHYSICS

1. A light ray enters from medium 1 to medium 2. Its velocity in medium 1 is 2×10^8 m/s and in medium 2 is 1.5×10^8 m/s. The critical angle for the pair of media is:

- (a) $\sin^{-1}(0.75)$
- (b) $\sin^{-1}(0.5)$
- (c) $\sin^{-1}(0.66)$
- (d) $\sin^{-1}(0.8)$

Correct Answer: (a) $\sin^{-1}(0.75)$

Solution:

Step 1: Understanding the Concept

The critical angle (θ_c) is the angle of incidence in a denser medium for which the angle of refraction in the rarer medium is 90° . For total internal reflection or critical angle to exist, light must travel from a denser medium (lower velocity) to a rarer medium (higher velocity).

Step 2: Key Formula or Approach

1. Refractive index $n = \frac{c}{v}$.
2. $\sin \theta_c = \frac{n_{\text{rarer}}}{n_{\text{denser}}} = \frac{v_{\text{denser}}}{v_{\text{rarer}}}$.

Step 3: Detailed Explanation

1. **Identify Media:** - Velocity in medium 1 (v_1) = 2×10^8 m/s (Rarer medium). - Velocity in medium 2 (v_2) = 1.5×10^8 m/s (Denser medium).
2. **Apply Formula:** To find the critical angle, the ray must originate in medium 2.

$$\sin \theta_c = \frac{v_{\text{denser}}}{v_{\text{rarer}}} = \frac{v_2}{v_1}$$

$$\sin \theta_c = \frac{1.5 \times 10^8}{2 \times 10^8} = \frac{1.5}{2} = 0.75$$

3. Final Calculation:

$$\theta_c = \sin^{-1}(0.75)$$

Step 4: Final Answer

The critical angle is $\sin^{-1}(0.75)$.

Quick Tip: To avoid confusion about which velocity goes on top, remember that $\sin \theta$ can never be greater than 1. Therefore, in the ratio of velocities, the smaller velocity must always be in the numerator.

2. A container with a pin hole at the bottom is filled with water and kerosene (specific gravity 0.8). The height of the water layer is 10 cm and the kerosene layer is 20 cm. The velocity of efflux of water is:

- (a) 2.3 m/s
- (b) 4.5 m/s
- (c) 1.5 m/s
- (d) 3.2 m/s

Correct Answer: (a) 2.3 m/s

Solution:

Step 1: Understanding the Concept

Torricelli's Law for efflux velocity is derived from Bernoulli's principle. When multiple immiscible liquids are present, the pressure at the hole is determined by the total "head" or the sum of the pressures exerted by each liquid layer.

Step 2: Key Formula or Approach

1. Pressure at bottom (P) = $\rho_k g h_k + \rho_w g h_w$.
2. Velocity of efflux (v) = $\sqrt{2gh_{eff}}$, where h_{eff} is the equivalent height of a single water

column.

Step 3: Detailed Explanation

1. **Calculate Equivalent Water Height (h_{eff}):** - Height of water (h_w) = 10 cm = 0.1 m. - Height of kerosene (h_k) = 20 cm = 0.2 m. - Specific gravity of kerosene (s_k) = 0.8. - The kerosene layer is equivalent to a water layer of height $h_k \times s_k = 0.2 \times 0.8 = 0.16$ m. - Total effective height $h_{eff} = 0.1 + 0.16 = 0.26$ m.

2. **Calculate Velocity:**

$$v = \sqrt{2 \times g \times h_{eff}}$$
$$v = \sqrt{2 \times 9.8 \times 0.26} \approx \sqrt{5.096} \approx 2.257 \text{ m/s}$$

3. **Rounding:** The value is approximately 2.3 m/s.

Step 4: Final Answer

The velocity of efflux is 2.3 m/s.

Quick Tip: When dealing with multiple fluids, convert all layers into the equivalent height of the liquid that is actually flowing out (the bottom layer) using the formula: $h_{eq} = h_{other} \times \frac{\rho_{other}}{\rho_{bottom}}$.

3. In a Young's double slit experiment, the intensity at a point where the path difference is $\frac{\lambda}{6}$ (λ being the wavelength of light used) is I . If I_0 denotes the maximum intensity, I/I_0 is equal to:

- (a) 1/2
- (b) $\sqrt{3}/2$
- (c) 3/4
- (d) 1/4

Correct Answer: (c) 3/4

Solution:

Step 1: Understanding the Concept

In wave interference, the intensity at any point depends on the phase difference between

the two waves. The path difference provided by the setup can be converted into a phase difference.

Step 2: Key Formula or Approach

1. Phase difference (ϕ) = $\frac{2\pi}{\lambda} \times \Delta x$ (where Δx is path difference).
2. Intensity $I = I_0 \cos^2(\phi/2)$.

Step 3: Detailed Explanation

1. **Find Phase Difference:** Given $\Delta x = \lambda/6$.

$$\phi = \frac{2\pi}{\lambda} \times \frac{\lambda}{6} = \frac{2\pi}{6} = \frac{\pi}{3} = 60^\circ$$

2. **Calculate Intensity Ratio:**

$$I = I_0 \cos^2\left(\frac{60^\circ}{2}\right) = I_0 \cos^2(30^\circ)$$

$$\cos 30^\circ = \frac{\sqrt{3}}{2} \implies \cos^2(30^\circ) = \left(\frac{\sqrt{3}}{2}\right)^2 = \frac{3}{4}$$

3. **Result:**

$$\frac{I}{I_0} = \frac{3}{4}$$

Step 4: Final Answer

The ratio I/I_0 is $3/4$.

Quick Tip: Always remember: Path difference of λ corresponds to a phase difference of 2π . This makes it easy to visualize: $\lambda/2 \rightarrow \pi$ (minima), $\lambda/4 \rightarrow \pi/2$, etc.

4. A particle of mass m is moving in a circular path of constant radius r such that its centripetal acceleration a_c is varying with time t as $a_c = k^2 r t^2$, where k is a constant. The power delivered to the particle by the forces acting on it is:

- (a) $2\pi mk^2 r^2 t$
- (b) $mk^2 r^2 t$
- (c) $\frac{1}{3}mk^4 r^2 t^5$
- (d) 0

Correct Answer: (b) $mk^2 r^2 t$

Solution:

Step 1: Understanding the Concept

In circular motion, power is delivered only by the tangential force, as the centripetal force is always perpendicular to the velocity. Power is the rate of change of kinetic energy or the product of tangential force and velocity.

Step 2: Key Formula or Approach

1. Centripetal acceleration $a_c = \frac{v^2}{r}$.
2. Tangential acceleration $a_t = \frac{dv}{dt}$.
3. Power $P = F_t \cdot v = (ma_t) \cdot v$.

Step 3: Detailed Explanation

1. Find velocity (v): Given $a_c = k^2 r t^2$. Since $a_c = \frac{v^2}{r}$:

$$\frac{v^2}{r} = k^2 r t^2 \implies v^2 = k^2 r^2 t^2 \implies v = k r t$$

2. Find tangential acceleration (a_t): Differentiate velocity with respect to time:

$$a_t = \frac{dv}{dt} = \frac{d}{dt}(k r t) = k r$$

3. Calculate Power (P):

$$P = F_t \times v = (m \times a_t) \times v$$

$$P = (m \times k r) \times (k r t) = m k^2 r^2 t$$

Step 4: Final Answer

The power delivered to the particle is mk^2r^2t .

Quick Tip: Remember that centripetal force does zero work because it is always perpendicular to the displacement. Only the tangential component of force contributes to a change in speed and thus to the power delivered.

5. A source of frequency f gives 5 beats/sec when sounded with a source of frequency 200 Hz. The second harmonic of f gives 10 beats/sec when sounded with a source of frequency 420 Hz. The value of f is:

- (a) 195 Hz
- (b) 205 Hz
- (c) 190 Hz
- (d) 210 Hz

Correct Answer: (b) 205 Hz

Solution:

Step 1: Understanding the Concept

Beat frequency is the absolute difference between the frequencies of two sounding sources:

$f_{beat} = |f_1 - f_2|$. Harmonic frequencies are integer multiples of the fundamental frequency (2^{nd} harmonic = $2f$).

Step 2: Key Formula or Approach

1. $|f - 200| = 5$.
2. $|2f - 420| = 10$.

Step 3: Detailed Explanation

1. From the first condition, f can be either: - $f = 200 + 5 = 205$ Hz - $f = 200 - 5 = 195$ Hz
2. Now, test both possibilities with the second condition (2^{nd} harmonic produces 10 beats with 420 Hz): - If $f = 205$ Hz: $2f = 2 \times 205 = 410$ Hz. Beat frequency with 420 Hz = $|420 - 410| = 10$ Hz. (Matches given condition) - If $f = 195$ Hz: $2f = 2 \times 195 = 390$ Hz. Beat

frequency with 420 Hz = $|420 - 390| = 30$ Hz. (Does not match)

Step 4: Final Answer

The value of f is 205 Hz.

Quick Tip: When you have multiple choices for the frequency from the first set of beats, always calculate the harmonic for each and see which one produces the required beat frequency with the second source. It acts as an automatic verification.