آغا خان یونیورسٹی ایگزامینیشن بورڈ
AGA KHAN UNIVERSITY EXAMINATION BOARD

Notes from E-Marking Centre on HSSC-I Physics Annual Examinations 2025

Introduction

This document has been produced for the teachers and candidates of the Higher Secondary School Certificate (HSSC) Part I Physics. It contains comments on candidates' responses to the 2025 HSSC-I Examination, indicating the quality of the responses and highlighting their relative strengths and weaknesses.

E-Marking Notes

This includes overall comments on candidates' performance on every question and *some* specific examples of candidates' responses that support the mentioned comments. Please note that the descriptive comments represent an overall perception of the better and weaker responses as gathered from the e-marking session. However, the candidates' responses shared in this document represent some specific example(s) of the mentioned comments.

Teachers and candidates should be aware that examiners may ask questions that address the Student Learning Outcomes (SLOs) in a manner that requires candidates to respond by integrating knowledge, understanding and application skills they have developed during study. Candidates are advised to read and comprehend each question carefully before writing the response to fulfill the demand of the question.

Candidates need to be aware that the marks allocated to the questions are related to the answer space provided on the examination paper as a guide to the length of the required response. A longer response will not in itself lead to higher marks. Candidates need to be familiar with the command words in the SLOs, which contain terms commonly used in examination questions. However, candidates should also be aware that not all questions will start with or contain one of the command words. Words such as 'how', 'why' or 'what' may also be used. It is imperative to refer to the command word guide available on the AKU-EB website for understanding the expectations of the command word.

General Observations

Overall, the students exhibited a strong conceptual grasp and analytical proficiency in core topics such as power, thermodynamics, simple harmonic motion, and interference of light, with most able to apply these concepts effectively in problem-solving. However, deeper conceptual engagement, particularly in justifying assumptions and articulating derivations, would further elevate the quality of responses.

Certain areas revealed persistent challenges, including Carnot engine, wave motion, escape velocity, equation of continuity and artificial satellites, and weightlessness, where misconceptions occasionally hindered precise solutions. For satellite motion, while students grasped basic principles of orbital mechanics, many struggled to explain the apparent weightlessness in satellites, indicating a need for deeper conceptual clarity rather than mathematical difficulties. A notable observation was the need for students to more systematically extract and interpret given data, alongside recognising the critical role of unit consistency in validating results.

Note: Candidates' responses shown in this report have not been corrected for grammar, spelling, format, or information.

DETAILED COMMENTS

Constructed Response Questions (CRQs)

Question No. 1	
Question Text	Show that $F = G\dfrac{m_1 m_2}{r^2}$ is dimensionally correct.
SLO No.	1.6.2
SLO Text	Show the homogeneity of physical equations by using dimensions and basic units.
Max Marks	03
Cognitive Level	U*
Checking Hints	1 mark for obtaining L.H.S. 1 mark for substituting the value in the R.H.S. 1 mark for obtaining R.H.S with the same dimension
Overall Performance	The overall performance on this question was not satisfactory. A few of the candidates demonstrated a clear understanding of the question's requirements, showcasing their knowledge of homogeneity in dimension analysis.
Description of Better Responses	*Better responses* demonstrated clear, step-by-step dimensional analysis, correctly deriving and equating the dimensions on both sides of the equation. Candidates systematically broke down each component correctly, identifying key dimensions like Force (LHS as $[MLT^{-2}]$) and Universal Gravitational constant (RHS with "G" as $[M^{-1}L^3T^{-2}]$, their solutions featured explicit validation of dimensional consistency $[MLT^{-2}] = [MLT^{-2}]$. These responses reflected deep conceptual understanding, precision in calculations and attention to procedural rigor, key traits of high-quality answers.
Image of Better Response	Solution:- taking L.HS → F $F = ma = [MLT^{-2}]$ The dimension of Force is MLT^{-2} (ii) Taking R.H.S → $G\frac{m_1m_2}{r^2}$ Dimension of G is $M^{-1}L^3T^{-2}$ $m_1m_2 \to M$ & r is L $\Rightarrow G\frac{m_1m_2}{r^2} \Rightarrow$ $\frac{(M^{-1}L^{\cancel{3}}T^{-2})(M^2)}{\cancel{L^2}}$ $M^{-1+2}LT^{-2} \to MLT^{-2}$ Hence $MLT^{-2} = MLT^{-2}$, R.H.S = L.H.S
Description of Weaker Responses	*Weaker responses* treated physical constants as dimensionless [e.g., (G) is constant, so it does not have any dimension] and made errors in dimensional equations, such as equating force (F) with incorrect units (M^2L^{-2}). These responses lacked proper derivation steps and showed confusion between different physical quantities, resulting in invalid dimensional comparison, e.g., $[M]^2[L]^{-2} = [M]^2[L]^{-2}$. The solutions were fragmented, missing logical connections between steps and failing to verify dimensional consistency.

Image of Weaker Response	G is constant so don't have any dimension $\frac{[M][M]}{[L]^2} = [M]^2[L]^{-2}$ $F = M^2L^{-2}$ $[M]^2[L]^2 = [M]^2[L]^{-2}$

Suggestions for improvement (Highlight all that apply)

Maximising SLO Achievement	Preferred Pedagogy** Used for this SLO	Assessment Strategies
• Identify the expectation of command words (use Command Word Guide) • Ensure the content is taught at the relevant cognitive level • Identify necessary content required (skills + concepts) • Review past paper questions on the concept • Utilise the resource guide for additional materials	• Story Board • Cause and Effect • Fish and Bone • Concept Mapping • Audio Visual Resources • Think, Pair, and Share • Knowledge Platform videos • Questioning Technique (Socratic approach) • Practical Demonstration ** For description of each Pedagogy, refer to Annexure A	• Past paper questions • Discussion on E-Marking Notes • AKU-EB Digital Learning Solution powered by Knowledge Platform https://akueb.knowledgeplatform.com/login

Any Additional Suggestions:

- Teachers are encouraged to focus on deriving dimensions step-by-step, especially for constants like G, K, etc., and emphasise checking homogeneity.
- Break derivations into clear steps. Write dimensions, substitute, simplify, and verify.
- Use quick classroom exercises where students identify/ correct dimensional errors in sample solutions.

*K = Knowledge U = Understanding A = Application and other higher-order cognitive skills

Question No. 2	
Question Text	In the head-to-tail rule, can vectors be placed in any order of succession? Justify your answer.
SLO No.	2.2.1
SLO Text	Explain the sum of vectors using the head-to-tail rule.
Max Marks	02
Cognitive Level	U
Checking Hints	1 mark for writing YES only 1 mark for the correct justification
Overall Performance	The overall performance on this question was positive. However, some candidates struggled to understand the question's requirements, resulting in less effective responses.
Description of Better Responses	*Better responses* exemplified an understanding of vector addition's commutative property. The candidates precisely stated the mathematical principle (**A** + **B** = **B** + **A**) and clearly explained that the order of addition does not affect the result.
Image of Better Responses	Yes, because they are commutative A+B=B+A, if we add vectors A+B or B+A the answer would same. in any order of succession.
Description of Weaker Responses	*Weaker responses* incorrectly stated that vectors "cannot be placed in any order", directly contradicting the commutative property of vector addition. These responses typically show fragmented understanding; they mentioned relevant terms but failed to apply them correctly. Many candidates missed key details and instead of mentioning the commutative or associative law of vector addition, they used the definition of the head-to-tail rule.
Image of Weaker Responses	In head to tail rule vectors can not be placed in any order of succession. vectors have a specific order in arrangement and towards the specific point with some magnitude

Suggestions for improvement (Highlight all that apply)

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Any Additional Suggestions:

- Teachers are encouraged to use visual aids like vector plotting software, like GeoGebra, to clarify the concepts of vector addition while explaining the concept of vectors.

- Teachers must teach their students to read the question carefully and identify the demand of the question.

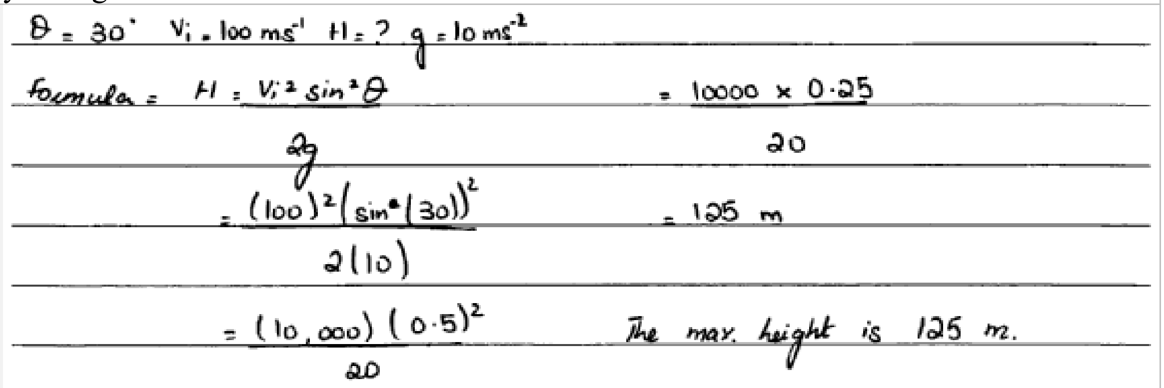
Question No. 3	
Question Text	A projectile is thrown at an angle of 30º with a velocity of 100 m/s. Find its maximum height. (**Note**: Take the value of acceleration due to gravity 'g' as 10 m/s^2.)
SLO No.	3.6.4
SLO Text	Solve word problems related to the above relations (a, b and c).
Max Marks	03
Cognitive Level	U
Checking Hints	1 mark for writing the correct formula 1 mark for substituting the correct values 1 mark for writing the correct answer
Overall Performance	The overall performance on this question was commendable. Candidates communicated the problem-solving process from given data to the final answer, reflecting a solid understanding of projectile motion principles and effective application of their knowledge. Their proficiency in pinpointing key factors in projectile motion highlights their strong analytical skills.
Description of Better Responses	*Better responses* reflected candidates' problem-solving skills using projectile motion principles. The students correctly identified and utilised all essential parameters: initial velocity (100 m/s), launch angle (30°), and gravitational acceleration (10 m/s^2). The solution shows proper use of the maximum height formula ($H = V_i^2 \sin^2 \theta / 2g$), with accurate trigonometric calculation of $\sin^2 30° = 0.25$ and correct final computation yielding 125 m.
Image of Better Response	 $\theta = 30°$ $V_i = 100\ ms^{-1}$ $H = ?$ $g = 10\ ms^{-2}$ formula = $H = \frac{V_i^2 \sin^2\theta}{2g}$ $= \frac{(100)^2(\sin^2(30))^2}{2(10)}$ $= \frac{(10,000)(0.5)^2}{20}$ $= \frac{10000 \times 0.25}{20}$ $= 125\ m$ The max. height is 125 m.
Description of Weaker Responses	*Weaker responses* attempted to solve for maximum height, but incorrectly applied the horizontal range formula $R = vi^2 \sin 2\theta / g$ instead of the maximum height formula $H = vi^2 \sin^2 \theta / 2g$. Such responses also had calculation errors, including incorrect substitution of values and improper handling of trigonometric functions.

Image of Weaker Response	Data: $\theta = 30^{\circ}$ $v = 100\ m.s^{-1}$ $g = 10\ m.s^{-2}$ $h = ?$ Solution: $\frac{\sin(30)(100)}{10} = h$ $h = 5m$ Answer: The maximum height of projectile will be 5meters.

Suggestions for improvement (Highlight all that apply)

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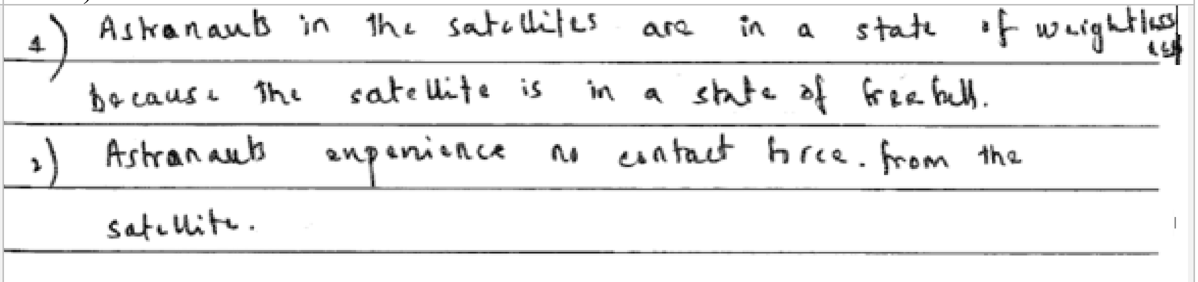
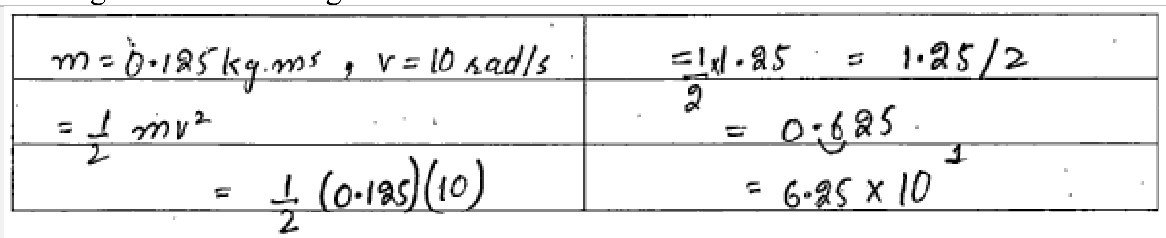
Any Additional Suggestions:

- Teachers suggested that the motion of the projectile can be demonstrated and discussed its horizontal and vertical motion separately, giving clear knowledge about the application of the gravitation force and its role in the motion of a projectile.
- Teachers may connect the concept of projectile motion to practical applications and compare their motion with the motion in the absence of air resistance.
- Teachers may engage their students in activities like launching projectiles at different heights, angles and velocities.
- Teachers are encouraged to continue practicing and applying concepts in different contexts. This will further enhance their mathematical approach towards problem-solving abilities and ensure continued success in similar scenarios.

Question No. 4	
Question Text	Astronauts feel weightlessness in the satellite orbiting the Earth. State TWO reasons for this.
SLO No.	5.6.1
SLO Text	Describe the reasons for weightlessness in artificial satellites.
Max Marks	02
Cognitive Level	U
Checking Hints	1 mark for writing each highlighted statement (2 required)
Overall Performance	The overall performance on this question was unpromising. Many candidates were unable to explain that weightlessness results from free-fall conditions and the absence of normal forces, and failed to use precise terms like “apparent weightlessness”.
Description of Better Responses	*Better responses* concisely captured the physics of orbital weightlessness through two precise observations: (1) the satellite's free-fall condition and (2) the critical absence of contact forces on astronauts. These responses demonstrated a strong conceptual grasp by highlighting both the kinematic state (free-fall) and its dynamical consequence (zero normal force).
Image of Better Response	 4) Astranauts in the satellites are in a state of weightless because the satellite is in a state of free fall. 2) Astranauts experience no contact force. from the satellite.
Description of Weaker Responses	*Weaker responses* incorrectly stated that space lacks gravity, failing to recognise that satellites orbit precisely because of Earth’s gravitational pull. The explanation mistakenly attributes weightlessness to the absence of gravity rather than understanding it as a result of continuous free-fall motion. Additionally, the claim that “satellites do not have gravity” reveals confusion about mass and gravitational fields. These errors demonstrated a significant misunderstanding of Newton’s laws of motion and the basic principles governing orbital mechanics. Some responses revealed persistent misconceptions, particularly the incorrect notion that weightlessness occurs due to a lack of gravity in space, rather than understanding it as a state of continuous acceleration under gravity’s influence. The variation in responses highlights how orbital mechanics remains a challenging concept, with some candidates developing sound Newtonian reasoning while others retain pre-existing misunderstandings.
Image of Weaker Response	 $m = 0.125$ kg.ms , $v = 10$ rad/s $= \frac{1}{2} mv^2$ $= \frac{1}{2}(0.125)(10)$ $= \frac{1}{2} \times 1.25 = 1.25/2$ $= 0.625$ $= 6.25 \times 10^{-1}$

Suggestions for improvement (Highlight all that apply)

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Any Additional Suggestions:

- Teachers are advised to have more targeted demonstrations contrasting free-fall versus zero-gravity scenarios, and clearer visualisations of orbital mechanics so that students can better reconcile this important physics concept with their intuitive expectations.

- Teachers are suggested to focus on the force diagrams comparing Earth's surface vs. orbit to visualise the missing normal force.

- Implement peer teaching where students explain using only key terms: gravity, free-fall, and normal force.

Question No. 5	
Question Text	In a juice factory, juice flows through a horizontal pipe with varying velocities at two ends. At point 1, the velocity of the juice is 3 m/s and the pressure is 120000 Pa. At point 2, the velocity of the juice is 7 m/s, find the pressure at point 2. (**Note**: Assuming the density of the juice is 1050 kg/m^3.)
SLO No.	6.2.3
SLO Text	Solve word problems related to the equation of continuity.
Max Marks	03
Cognitive Level	K
Checking Hints	1 mark for writing the correct formula 1 mark for the correct substitution 1 mark for the correct answer
Overall Performance	The cohort struggled in this question and was unable to demonstrate the problem-solving skills while applying Bernoulli's equation to this fluid dynamics scenario, with some correctly identifying and substituting all relevant parameters, velocity, pressure and density to arrive at valid solutions. Their work consistently showed proper algebraic manipulation and unit consistency, reflecting a solid grasp of the underlying physics principles.

Description of Better Responses	*Better responses* exhibited strong problem-solving skills in applying Bernoulli's equation to fluid dynamics. The students properly established and solved the equation $P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$ for a horizontal pipe, systematically substituting the given values ($P_1 = 120{,}000$, $v_1 = 3$ m/s, $v_2 = 7$ m/s, $\rho = 1050$ kg/m^3) and presenting clear algebraic steps to determine P_2. Such responses reflected a solid grasp of Bernoulli's principle, attention to unit consistency, and the ability to translate theoretical knowledge into precise numerical solutions.
Image of Better Response	Formula: $P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$ (ρgh is same along horizontal pipe) Data: $v_1 = 3 m/s$ $(\rho)\ d = 1050\ kg/m^3$ $P_1 = 120{,}000\ Pa$ $v_2 = 7 m/s$ $P_2 = ?$ Sol: $120{,}000 + \frac{1}{2}(1050)(3)^2 = P_2 + \frac{1}{2}(1050)(7)^2$ $120{,}000 + 4725 = P_2 + 25725$ $124725 - 25725 = P_2$ The pressure at point 2, $P_2 = 99000\ Pa$ // Ans
Description of Weaker Responses	*Weaker responses* misapplied physics principles by incorrectly using the gas law $P_1V_1 = P_2V_2$ instead of Bernoulli's equation. The solution completely omitted the fluid's density ($\rho = 1050$ kg/m³) and the critical $\frac{1}{2}\rho v^2$ kinetic energy terms, leading to an invalid pressure calculation. The working confused volume (gas laws) with velocity (fluid dynamics), demonstrating a failure to recognise Bernoulli's equation as the proper conservation of energy principle for incompressible flow. These errors reveal a deep misunderstanding of both the problem's requirements and the distinct physics governing fluid motion versus gas behavior. A few responses revealed confusion between fluid flow and gas law equations, incorrectly applying PV relationships.
Image of Weaker Response	Data: At point 1: $V = 3m/s$ $P = 120000 Pa$ At point 2: $V = 7m/s$ $P = ?$ Solution: $P_1V_1 = P_2V_2$ $(120000)(3) = P_2(7)$ $\frac{(120000)(3)}{7} = P_2$ $P_2 = 51429.57 Pa$

Suggestions for improvement (Highlight all that apply)

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Any Additional Suggestions:

- Encourage candidates to make an experimental setup to differentiate between fluid flow and gas systems.
- Teachers can use weaker responses as exercises where students identify/ correct misapplied equations.

Question No. 6	
Question Text	The acceleration of a body vibrating on a smooth surface under an elastic restoring force does not remain constant during its motion. Explain your answer in terms of SHM and write the relevant mathematical expression.
SLO No.	7.1.1
SLO Text	Derive an expression for the acceleration of a body vibrating under an elastic restoring force.
Max Marks	02
Cognitive Level	U
Checking Hints	1 mark for writing each highlighted statement (2 required)
Overall Performance	The candidates' overall performance on this question was generally satisfactory, demonstrating a sound grasp of the key features of simple harmonic motion (SHM). However, some responses lacked clarity in their reasoning, offered weak justifications, and used incorrect mathematical expressions.
Description of Better Responses	*Better responses* effectively demonstrated understanding of SHM principles by correctly applying Hooke's Law ($F = -kx$) and Newton's second law ($F = ma$) to derive the relationship between acceleration and displacement ($a \propto -x$). The students logically connect varying displacement to non-constant acceleration, using proper mathematical notation and clear reasoning.
Image of Better Response	According to hook's law acceleration of body depends upon the displacement from mean position. So as the vibrating body is moving with varying displacement its acceleration is also not constant. $F = -Kx$, $\because F = ma$, $ma = -Kx$, $a = \frac{-kx}{m}$ hence $\boxed{a \propto x}$
Description of Weaker Responses	*Weak responses* revealed a lack of understanding of acceleration under elastic restoring force. Candidates often give vague explanations, mentioning unrelated factors like gravity or environmental conditions, instead of focusing on the key idea that acceleration varies with displacement in simple harmonic motion. These responses also lacked the correct mathematical expression, which is essential to explain why acceleration is not constant. Some candidates included irrelevant formulas, like $T = 2\pi L/g$.
Image of Weaker Response	The acceleration under certain circumstances will not remain constant because of gravity acting on it (and will change according to height) $T = 2\pi\sqrt{\frac{L}{g_a}}$

Suggestions for improvement (Highlight all that apply)

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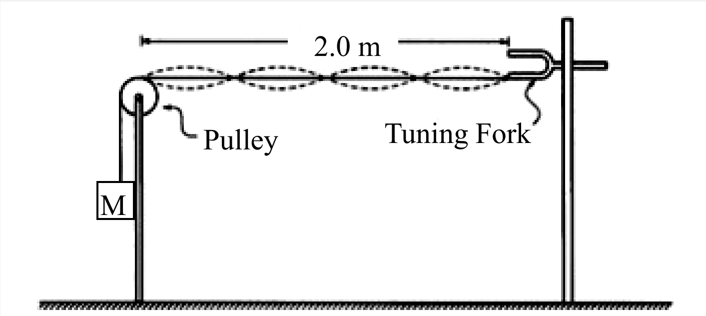
Any Additional Suggestions:

Teachers are suggested to reinforce core concepts and include more practice questions that require linking conceptual understanding with mathematical expressions.

Question No. 7	
Question Text	In the given diagram, one end of a string is attached to a tuning fork with a frequency of 120 Hz, while the other end of the string passes over a frictionless pulley and is connected to a suspended mass M. The value of M is such that the standing wave pattern has four loops. The length of the string from the tuning fork to the point where the string touches the top of the pulley is 2.0 m.  a. Determine the wavelength of the standing wave. b. Determine the speed of transverse waves along the string. c. Explain the effect of increasing the number of loops on the velocity and frequency of the standing waves
SLO No.	8.1.6
SLO Text	Solve word problems using $V = f\lambda$.
Max Marks	03
Cognitive Level	A
Checking Hints	a. 1 mark for finding the correct wavelength b. 1 mark for finding the correct velocity c. 1 mark for writing each highlighted statement

Overall Performance	The overall performance of the cohort on this question was not up to the mark. Some candidates demonstrated a solid understanding of standing waves, with most using the correct formula to calculate the wavelength and speed of standing waves in a string and applying that relation to explain the relationship between frequency, wavelength, and speed.
Description of Better Responses	*Better responses* reflected a strong understanding of both conceptual and mathematical aspects of physics. Students applied relevant formulas, such as λ = 2L / n and v = f λ and carried out accurate calculations with proper units and logical steps. Their explanations are well-reasoned and directly addressed the question, demonstrating an ability to connect physical changes, such as increasing the number of loops, to their effects on wavelength, frequency and velocity. These responses were also neatly presented and showed clarity in both thought and expression.
Image of Better Response	a. Determine the wavelength of the standing wave. (1 Mark Formula: $\lambda = \frac{2L}{n}$, $\lambda = \frac{2(2.0)}{4} = 1m$ Given: $L = 2.0$ $n = 4$ (4 loops) b. Determine the speed of transverse waves along the string. (1 Mark $v = \lambda f$ $v = (1)(120) = 120 m/s$ Given: $\lambda = 1m$ Formula ↑ $f = 120Hz$ c. Explain the effect of increasing the number of loops on velocity and frequency of the standing waves. (1 Mark The frequency of standing waves increase with the increasing number of loops. The velocity stays constant as ∴ $v = \lambda f$ (the wavelenght decreases and frequency increases)
Description of Weaker Responses	*Weaker responses* showed three key issues: (1) incorrect wavelength derivation (e.g., using √λ = 2 instead of L = n λ / 2), (2) mathematical errors in wave speed calculations using V = f λ), and (3) misunderstanding loop-frequency relationships (claiming more loops decrease frequency when they increase harmonic frequencies at fixed length). These errors revealed fundamental gaps in applying wave equations and interpreting standing wave behaviour.
Image of Weaker Response	a. Determine the wavelength of the standing wave. (1 Marl $\frac{\lambda}{2} + \frac{\lambda}{2} + \frac{\lambda}{2} + \frac{\lambda}{2} \Rightarrow \boxed{\lambda = 2}$ b. Determine the speed of transverse waves along the string. (1 Marl $= V = f\lambda$ $\boxed{V = 240 m/s}$ $= V = 120(2)$ c. Explain the effect of increasing the number of loops on velocity and frequency of the standing waves. (1 Marl Increasing the number of loops will increase velocity and decrease frequency of the standing waves

Suggestions for improvement (Highlight all that apply)

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Any Additional Suggestions:

- Teachers are encouraged to incorporate visual diagrams and animations of the production of stationary waves in a string and pipe that is open from both ends and closed from one end during their classroom teaching.

- Encourage students to make an experimental setup to demonstrate the formation of standing waves in their physics laboratory.

- Teachers are suggested to practice with their students to pay attention to the wording of the question can help avoid misunderstandings and enhance accuracy in future assessments.

- Teachers should enhance their students' understanding of standing waves in both organ pipes and strings by showing them animations and pictorial diagrams to better differentiate the formation of standing waves in various scenarios.

Question No. 8	
Question Text	In Young's double slit experiment, the distance between two consecutive fringes (y) is affected by the separation between the slits (d). Explain the given statement with the help of a mathematical formula.
SLO No.	9.2.5
SLO Text	Derive a relation for fringe spacing and use the relation in solving word problems.
Max Marks	03
Cognitive Level	U
Checking Hints	1 mark for writing the mathematical formula 1 mark for stating the relation between fringe distance and separation between slits 1 mark for explaining the above statement
Overall Performance	The overall performance on this question was encouraging, demonstrating a strong ability to identify the relation between slits separation (d) and fringe spacing (Y) in Young's double-slit experiment. Their adept recognition of the context, along with mathematical expression, showcased a commendable understanding of the topic. Such well-attained responses indicate a solid grasp of relevant concepts and principles.

Description of Better Responses	*Better responses* correctly applied Young's double-slit interference fringe spacing formula ($y = \lambda L / d$) and accurately explained the inverse relationship between slit separation (d) and fringe spacing (y). The students demonstrated a clear understanding of how changing the slit separation affects the interference pattern, correctly stating that increasing (d) decreases (y).
Image of Better Responses	The mathematical formula for distance between two consecutive fringes is $Y = \frac{\lambda L}{d}$, from this formula we can clearly see that separation between the slits (d) is inversely proportional to the distance between fringes $Y \propto \frac{1}{d}$. So if we increase distance between slits, distance between fringes will decrease and vice vessa.
Description of Weaker Responses	*Weaker responses* misunderstood the double-slit experiment by incorrectly stating slit separation (d) is directly proportional to fringe spacing (y), when the correct relationship is inverse ($y \propto 1 / d$). The candidates appeared confused between two key formulas, incorrectly applying the angular maxima condition ($d \sin \theta = n \lambda$) instead of the fringe spacing formula ($y = \lambda L / d$). This leads to the wrong conclusion that increasing slit separation increases fringe spacing.
Image of Weaker Response	$d \sin\theta = y\lambda$ In young's double slit experiment, the ~~diff~~ distance between slits affect the distance between fringes. Acc to the formula (d) distance b/w slits is directly proportional to the (y) distance b/w fringes. As the distance b/w slits increase the distance between fringes also ~~the~~ increases.

Suggestions for improvement (Highlight all that apply)

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Any Additional Suggestions:

- Teachers are encouraged to use simulation or animation to visually show interference patterns forming from two coherent light sources. Some of the websites are also given in the subject-specific resource guide to help students grasp the wave nature of light.

- Students are encouraged to thoroughly understand the question and identify the correct formulas for interference of light and fringe spacing.

- Students should be guided by their teachers to provide appropriate application of relevant formulas, which can support their development in this topic, resulting in more accurate responses in future assessments.

Extended Response Questions (ERQs)

Extended response questions offered a choice between parts 'a' and 'b'

Question No. 9a	
Question Text	A marathon runner weighing 60 kg runs up the stairs to the top of a 440 m tall building. If he lifts himself to the top in 15 minutes, then what will be his average output power?
SLO No.	4.3.3
SLO Text	Derive the formula of power in terms of force and velocity and use it in solving word problems.
Max Marks	07
Cognitive Level	A
Checking Hints	1 mark for each highlighted step (7 required)
Overall Performance	Most of the candidates attempted this part of the question and the overall performance indicates a strong conceptual grasp. Most candidates generally demonstrated a good understanding of power calculations in this question, with most correctly identifying and applying the fundamental relationship between work, time and power. These candidates showed proficiency in connecting theoretical concepts to practical calculations while maintaining appropriate unit consistency throughout their work.
Description of Better Responses	*Better responses* accurately demonstrated strong problem-solving skills in calculating power, showcasing clear methodology and accurate calculations. The candidates correctly identified and substituted all given values (mass = 60 kg, height = 440 m, gravity = 10 m/s^2, time = 900 s) into the power formula $P = m\,g\,h / t$. The solution was well-structured, with logical steps from data listing to final computation, including proper unit conversion (minutes to seconds).

Image of Better Responses	<u>Option (a):</u> <u>Data:</u> Mass of runner = $m = 60\ kg$ Height of building = $h = 440\ m$ Acceleration due to gravity = $g = 10 m/s^2$ Time taken = $t = 15\ min$ $= 15 \times 60 = 900\ sec$ Average output power = $P = ?$ <u>Solution:</u> Power = $\frac{\text{Work done}}{\text{Time}}$ $\therefore W = mgh$ $P = \frac{mgh}{t}$ $= \frac{(60)(10)(440)}{900}$ $= \frac{264000}{900}$ $\boxed{P = 293.33\ W}$ <u>Result:</u> The average output power of runner would be 293 W.
Description of Weaker Responses	*Weaker responses* revealed several fundamental errors in calculating power. Candidates incorrectly used the momentum formula ($P = m\ v$) instead of the correct power equation ($P = m\ g\ h\ /\ t$), demonstrating a critical misunderstanding of the required physical concept. Such responses typically showed: (1) confusion between different physics formulas (momentum vs. power), (2) arbitrary mathematical operations without a physical basis and (3) failure to utilise given data appropriately (height, time). Some candidates faced difficulties, particularly in distinguishing between different physical formulas and their applications. A notable portion also neglected proper unit handling or failed to fully contextualise their final answers. These patterns suggest that while most candidates have grasped the core principles, some require additional support in formula selection and dimensional analysis.

Image of Weaker Response	a. $P = mv$ $\qquad \frac{440}{900} = 0.48$ $P = (60)(0.48)$ $P = \cancel{It} \cancel{=} 28.8\ W$ It will be 28.8 W. average output power,

Suggestions for improvement (Highlight all that apply)

Maximising SLO Achievement	**Preferred Pedagogy Used for this SLO**	**Assessment Strategies**
• Identify the expectation of command words (use Command Word Guide) • Ensure the content is taught at the relevant cognitive level • Identify necessary content required (skills + concepts) • Review past paper questions on the concept • Utilise the resource guide for additional materials	• Story Board • Cause and Effect • Fish and Bone • Concept Mapping • Audio Visual Resources • Think, Pair, and Share • Knowledge Platform videos • Questioning Technique (Socratic approach) • Practical Demonstration	• Past paper questions • Discussion on E-Marking Notes • AKU-EB Digital Learning Solution powered by Knowledge Platform https://akueb.knowledgeplatform.com/login
Any Additional Suggestions: Teachers should encourage their students to predict and justify their choice of formula before solving problems will deepen conceptual understanding and improve problem-solving accuracy.		

Question No. 9b	
Question Text	The escape velocity from the Earth is about 11.2 km/s. Calculate the escape velocity from Saturn, whose mass is about 100 times the Earth's mass and radius is about 10 times the Earth's radius.
SLO No.	4.7.3
SLO Text	Calculate escape velocity for the Moon and the Earth when the mass and radius of the bodies are given and use this formula for solving word problems.
Max Marks	07
Cognitive Level	A

Checking Hints	1 mark for each highlighted step (7 required)
Overall Performance	The overall performance of candidates on this question was not good. Only few of the candidates demonstrated proper understanding of gravitational concepts and maintained unit consistency throughout their calculations. Their solutions showed logical problem-solving by systematically substituting planetary parameters and simplifying the equations accurately.
Description of Better Responses	*Better responses* exemplified a thorough and accurate solution for calculating Saturn's escape velocity, demonstrating strong problem-solving skills and attention to detail. The candidates correctly applied the escape velocity formula V_{esc} = (square root) 2 G M / R, substituting Saturn's given mass (100 times Earth's mass) and radius (10 times Earth's radius) with precise values ($M = 6 \times 10^{26}$ kg, $R = 6.4 \times 10^{7}$ m). The calculations were meticulously executed, showing clear steps from dimensional analysis to the final conversion of units (m/s to km/s).
Image of Better Responses	Data: $V_{esc} = 11.2$ km/s Mass of saturn = 100 (mass of Earth) Radius of saturn = 10 (radius of Earth) We know, G (gravitational constant for Earth) = 6.67×10^{-11} Nm^2 kg^{-2} R (radius of Earth) = 6.4×10^{6} m M (mass of Earth) = 6.0×10^{24} kg Formula for escape velocity (Vesc) = $\sqrt{\frac{2GM}{R}}$ Vesc for saturn = $\sqrt{\frac{2(6.67 \times 10^{-11})(6 \times 10^{26})}{6.4 \times 10^{7}}}$ Vesc = $\sqrt{\frac{8.004 \times 10^{16}}{6.4 \times 10^{7}}} = \sqrt{1.25 \times 10^{9}}$ = 35355.34 m/s $\boxed{= 35.36 \text{ km/s}}$ Ans Now, $M_s = 100 \times 6.0 \times 10^{24}$ $= 6 \times 10^{26}$ kg $R_s = 10 \times 6.4 \times 10^{6}$ $= 6.4 \times 10^{7}$ m G = stays same The escape velocity for Saturn is 35.36 km/s or 35355.34 m/s.
Description of Weaker Responses	*Weaker responses* typically showed an attempt to use the correct formula for escape velocity but lacked clarity, structure, and proper reasoning. These responses often include mathematical steps without clear justification or explanation. Common issues include incorrect or inconsistent use of units, poor handling of comparative values (like mass and radius given in terms of the Earth), and skipping important steps in simplification. candidates might also have failed to relate their work to known values, such as Earth's escape velocity, which could have made the process more efficient. These responses reflected a surface-level understanding and lacked the logical flow and accuracy needed for a strong scientific answer.

Image of Weaker Response	m = 100 times Radius ÷ 10 time G = 10 m/s Using formula $V_{esc} = \sqrt{\frac{2GM}{R}}$ $V_{es} = \sqrt{\frac{2(10ms)(100)}{10}}$ $V_{esc} = \sqrt{\frac{20 \times 200}{10}}$ $V_{esc} = \sqrt{\frac{4000}{10}}$ $V_{esc} = 6.324$ km/s.

Suggestions for improvement (Highlight all that apply)

Maximising SLO Achievement	**Preferred Pedagogy Used for this SLO**	**Assessment Strategies**
• Identify the expectation of command words (use Command Word Guide) • Ensure the content is taught at the relevant cognitive level • Identify necessary content required (skills + concepts) • Review past paper questions on the concept • Utilise the resource guide for additional materials	• Story Board • Cause and Effect • Fish and Bone • Concept Mapping • Audio Visual Resources • Think, Pair and Share • Knowledge Platform videos • Questioning Technique (Socratic approach) • Practical Demonstration	• Past paper questions • Discussion on E-Marking Notes • AKU-EB Digital Learning Solution powered by Knowledge Platform https://akueb.knowledgeplatform.com/login
Any Additional Suggestions: Teachers should focus on more targeted practice in distinguishing fundamental constants from variables and reinforcing unit awareness in astrophysical calculations for improved performance of students.		

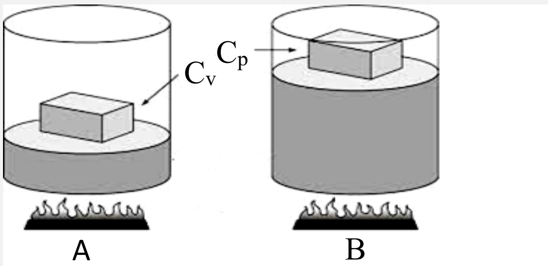
Question No. 10a	
Question Text	Two containers (A) and (B) are placed in a high-temperature reservoir. Container (A) is at constant volume (Cv) and container (B) is at constant pressure (Cp).  Show that the heat capacity at constant pressure (Cp) is greater than that of heat capacity at constant volume (Cv).
SLO No.	10.6.3
SLO Text	Show that Cp - Cv = R by using 1st law of thermodynamics.
Max Marks	07
Cognitive Level	A
Checking Hints	1 mark for writing the formula of internal energy 1 mark for writing the mathematical form of the first law of thermodynamics 1 mark for comparing equations 1 mark substituting the values 1 mark for writing PV = RT 1 mark for obtaining the relation 1 mark explaining the relation (OR) writing
Overall Performance	Overall, most of the candidates attempted this part of the question. Most of the candidates demonstrated that Cp > Cv by properly accounting for the work done during expansion at constant pressure, showing a clear understanding of thermodynamic principles. Their solutions featured accurate derivations linking heat transfer, internal energy change, and work done.
Description of Better Responses	*Better responses* demonstrated a clear understanding of thermodynamic principles and logical derivation. They correctly applied the first law of thermodynamics at both constant volume and constant pressure, clearly distinguishing between conditions. These answers showed proper algebraic substitution (using $\Delta U = C\ v\ \Delta T$), applied the ideal gas law effectively and arrived accurately at the relationship Cp − Cv = R. Additionally, they explained the physical meaning that at constant pressure, heat is used not only to increase internal energy but also to do work, making Cp > Cv. The steps were well-organised, equations were clearly labeled, and the conclusion was both mathematically and conceptually justified.

Image of Better Responses	a) $Cp > Cv$ $Cv = \frac{Q}{\Delta T}$ $n=1$ ~~At constant~~ volume: $\Delta Q = \Delta U + p\Delta V$ (1^{st} law) $Cv\ \Delta T = \Delta U + p(0)$ $\boxed{\Delta U = C_v\ \Delta T} \rightarrow$ (i) At constant pressure: $\Delta Q = \Delta U + p\Delta V$ $\boxed{Cp\Delta T = \Delta U + p\Delta V} \rightarrow$ (ii) Put the value of ΔU in eq (ii) $Cp\Delta T = Cv\Delta T + p\Delta V$ ideal gas equation: $p\Delta V = nRT$ $n=1$ $p\Delta V = R\Delta T$ $Cp\Delta T = Cv\Delta T + R\Delta T$ Dividing both sides by ΔT $\frac{Cp\cancel{\Delta T}}{\cancel{\Delta T}} = \frac{Cv\cancel{\Delta T}}{\cancel{\Delta T}} + \frac{R\cancel{\Delta T}}{\cancel{\Delta T}}$ $Cp = Cv + R$ $\boxed{Cp - Cv = R}$ So, molar specific heat capacity is greater at constant pressure then at constant volume because at constant pressure, heat is utilized to increase internal energy as well as to do external work done. $Cp > Cv$.
Description of Weaker Responses	*Weaker responses* revealed significant conceptual misunderstandings in thermodynamics, particularly regarding heat capacities at constant volume (Cv) and constant pressure (Cp). The candidates incorrectly manipulated equations, combining unrelated terms without physical justification, and failed to derive the correct relationship (Cp > Cv). Such responses indicated a lack of grasp of basic thermodynamic definitions and relationships. Weaker responses revealed fundamental errors, including incorrect equation manipulation and failure to distinguish between constant-pressure and constant-volume processes.
Image of Weaker Response	Cv= heat capacity at Constant volume Cp= heat capacity at Constant pressure $\therefore \Delta = \frac{Q_1 - Q_2}{n\Delta T}$ For Cv (volume) For Cp (pressure) $\rightarrow Q = \Delta U + W$ $\rightarrow Q = \Delta U + W$ $\rightarrow Q = \Delta U + CvT$ $\rightarrow Q = \Delta U + \frac{P\Delta t}{n\Delta T}$ $\rightarrow$ So $Q = CP - CU = CP + CU = \boxed{Cp > Cv}$

Suggestions for improvement (Highlight all that apply)

Maximising SLO Achievement	Preferred Pedagogy Used for this SLO	Assessment Strategies
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Any Additional Suggestions: Teachers are advised to use visual aids like P-V diagrams to illustrate the work difference between these processes could help bridge the gap between theory and application.		

Question No. 10b	
Question Text	An inventor looking for financial support approaches you with an idea of an engine that runs on a unique type of thermodynamic cycle. His design is made entirely of copper and is air-cooled. He claims that the engine will be 88% efficient. Whereas the melting point of copper is 1083°C and the exhaust temperature is 27°C. Should you invest in this new engine? Why or why not? Justify your answer using calculations.
SLO No.	10.9.3
SLO Text	Derive the formula for the efficiency of the Carnot engine and use it in solving word problems.
Max Marks	07
Cognitive Level	A
Checking Hints	1 mark for each highlighted step (7 required)
Overall Performance	The overall performance on this question was not strong, with few candidates answering it correctly. demonstrated a clear understanding of the Carnot efficiency concept and applied the formula accurately. responses included appropriate calculations, correct temperature conversions, and well-justified conclusions.
Description of Better Responses	*Better responses* accurately applied the Carnot efficiency formula with correct temperature conversions and clear steps to either calculate the required high temperature or the maximum possible efficiency using copper. They logically concluded that the claimed 88% efficiency is unrealistic, either because it exceeds the limits of copper's melting point or is mathematically unachievable. These responses combined correct calculations with sound reasoning and often suggest practical alternatives, such as using a higher melting point material. Overall, they showed both scientific understanding and practical evaluation.

Image of Better Responses	A/cc to the information provided Exhaust temp = low temp. reservoir = T_2 = 27°C + 273 = 300K Input temp. = high temp reservoir = T_1 = ? Efficiency % = 88% $\eta\% = \left(1 - \frac{T_2}{T_1}\right) \times 100$ $88 = \left(1 - \frac{300}{T_1}\right) \times 100$ T_1 = 2500K − 273 or T_1 = 2227 °C Since the melting point of copper is 1083°C, which is much lesser than than the input high temp. reservoir, so the engine would be ineffective. I will not invest in it.
Description of Weaker Responses	*Weaker responses* generally lacked proper application of the Carnot efficiency formula and failed to approach the question systematically. The responses showed vague reasoning, with no clear use of the efficiency equation or relevant calculations. The candidates neither converted temperatures correctly nor attempted to evaluate the claim quantitatively. Conclusions were often based on guesswork or incomplete logic, without considering physical constraints like copper's melting point.
Image of Weaker Response	b. Yes, I think investing in this engine would be profitable. This is for a few reasons: 1/ The engine is claimed to be having a really good efficiency of 88% indicating that it would perform alot of work. In real life cases where carnot engine is not possible, this is efficient. 2/ furthermore, the melting point of copper (the material used) is also very high as it a metal. This can make sure more heat is trapped for greater work done 3/ from the formula, $e = \frac{T_H - T_c}{T_H} \times 100\%$. $\frac{88\%}{100\%} = \frac{300 - T_c}{300}$ $T_c = 36°C$ Both of the tempretures 27°C and 36°C said to lead to efficiency of 88% for the engine.

Suggestions for improvement (Highlight all that apply)

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Any Additional Suggestions:

- Teachers are encouraged to create similar practice questions to help students improve their problem-solving skills and provide complete and accurate answers.

- Encouraging students to continue honing their problem-solving skills and ensuring precise application of formulas and units will further enhance their performance in similar scenarios by providing them with more practice questions from the past papers.

- Regular practice of problems related to the efficiency of heat engines will enhance students' problem-solving skills, leading to more accurate responses in similar situations.

Annexure A: Pedagogies Used for Teaching the SLOs

Pedagogy: Storyboard
Description: A visual pedagogy that uses a series of illustrated panels to present a narrative, encouraging creativity and critical thinking. It helps learners organise ideas, sequence events, and comprehend complex concepts through storytelling.
Example: In a Literature class, students are tasked with creating storyboards to visually retell a novel. They draw key scenes, write captions, and present their stories to the class, enhancing their reading comprehension and fostering their imagination.

Pedagogy: Cause and Effect
Description: This pedagogy explores the relationships between actions and consequences. By analysing cause-and-effect relationships, learners develop a deeper understanding of how events are interconnected and how one action can lead to various outcomes.
Example: In a History class, students study the causes and effects of the Industrial Revolution. They research and discuss how technological advancements in manufacturing led to significant societal changes, such as urbanisation and labour reform movements.

Pedagogy: Fish and Bone
Description: A method that breaks down complex topics into main ideas (the fish) and supporting details (the bones). This visual approach enhances comprehension by highlighting essential concepts and their relevant explanations.
Example: During a Biology class on human anatomy, the teacher uses fish and bone techniques to teach about the human skeletal system. The teacher presents the main components of the human skeleton (fish) and elaborates on each bone's structure and function (bones).

Pedagogy: Concept Mapping
Description: An effective way to visually represent relationships between ideas. Learners create diagrams connecting key concepts, aiding in understanding the overall structure of a subject and fostering retention.
Example: In a Psychology assignment, students use concept mapping to explore the various theories of personality. They interlink different theories, such as Freud's psychoanalysis, Jung's analytical psychology, and Bandura's social-cognitive theory, to see how they relate to each other.

Pedagogy: Audio Visual Resources
Description: Incorporating multimedia elements like videos, images, and audio into lessons. This approach caters to different learning styles, making educational content more engaging and memorable.
Example: In a General Science class, the teacher uses a documentary-style video to teach about the solar system. The video includes stunning visual animations of the planets, interviews with astronomers, and background music, enhancing students' interest and understanding of space.

Pedagogy: Think, Pair, and Share
Description: A collaborative learning technique where students ponder a question or problem individually, then discuss their thoughts in pairs or small groups before sharing with the entire class. It fosters active participation, communication skills, and diverse perspectives.
Example: In a Literature in English class, the teacher poses a thought-provoking question about a novel's moral dilemma. Students first reflect individually, then pair up to exchange their opinions, and finally participate in a lively class discussion to explore different viewpoints.

Pedagogy: Questioning Technique (Socratic Approach)
Description: Based on Socratic dialogue, this method stimulates critical thinking by posing thought-provoking questions. It encourages learners to explore ideas, justify their reasoning, and discover knowledge through a process of inquiry.
Example: In an Ethics class, the instructor uses the Socratic approach to lead a discussion on the meaning of justice. By asking a series of probing questions, the students engage in a deeper exploration of ethical principles and societal values.

Pedagogy: Practical Demonstration
Description: A hands-on approach where learners observe real-life applications of theories or skills. Practical demonstrations enhance comprehension, skill acquisition, and problem-solving abilities by bridging theoretical concepts with real-world scenarios.
Example: In a Food and Nutrition class, the instructor demonstrates the proper technique for filleting a fish. Students observe and then practice the skill themselves, learning the practical application of knife skills and culinary precision.

(**Note:** The examples provided in this annexure serve as illustrations of various pedagogies. It is important to understand that these pedagogies are versatile and can be applied across subjects in numerous ways. Feel free to adapt and explore these techniques creatively to enhance learning outcomes in your specific context.)

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