A' LEVEL

Principal Mathematics

ASSESSMENT GUIDELINES

With Sample Assessment items and levels of competence

ASSESSMENT GUIDELINES FOR PRINCIPAL MATHEMATICS AT ADVANCED SECONDARY LEVEL

1.1 INTRODUCTION

Principal mathematics in the Advanced Secondary Curriculum (ASC) is assessed at school level and at the End of the Cycle examinations which is administered by the Uganda National Examinations Board (UNEB).

Assessment of Principal mathematics at school level will be formative and summative. Formative assessment will be done through observation (watching learners working), conversation (asking questions and talking to learners) and appraising the learners' work (product). While summative assessment will be done through engaging learners in activities of integration at the end of each topic and an examination at the end of the year.

The end of cycle assessment for Principal mathematics for the Advanced Secondary Curriculum will be guided by assessment objectives based on the constructs. A construct is an abstract representation of a unifying theme that brings coherence to an assessment task. It serves as a generalized concept that combines a cluster of related learning outcomes or competencies, each contributing to a common learning ability. Acquisition of learning outcomes/ competencies in a construct enables the learner to demonstrate mastery in a way that supports real-life functionality and application.

1.2 ASSESSMENT OBJECTIVES

The End of Cycle Assessment for Principal mathematics will be guided by five assessment objectives focusing on the learner's ability to:

AO1: manipulate a wide range of algebraic expressions and equations, evaluate logical proofs and apply these skills to strategically solve real-world problems.

AO2: perform transformations, reason logically, visualize spatial relationships in solving geometrical related challenges in real world.

AO3: apply analytical and numerical skills in mathematical modelling to solve real life challenges involving rates of change, accumulation and optimization for decision making.

AO4: predict future trends by analysing and interpreting statistical data using principles of statistics and probability to make reasonable conclusions

AO5: apply principles of statics and dynamics to analyse and solve real world problems involving state of motion of bodies, and to predict their behaviors.

1.3 LINKAGE BETWEEN ASSESSMENT OBJECTIVES, CONSTRUCTS AND SYLLABUS

The table below shows a linkage between the assessment objectives, the constructs and the topics that contribute to the construct.

Table 1: Table showing relationship between assessment objectives, constructs and the topics in the syllabus

Assessment Objective	**Construct**	**Construct Description**	**Topics in the syllabus**
AO1	Algebra	Applying algebraic principles to model and solve real-life problems and lead to informed decision making.	1. Numerical concepts 2. Equations and inequalities 12. Permutations and combinations 13. Series 25. Complex numbers
AO2	Geometry	Applying geometric concepts and spatial reasoning to interpret relationships in mathematical and real-life contexts for informed problem solving.	3. Coordinate geometry 1 5. Trigonometry 17. Vectors 24. Coordinate geometry 2
AO3	Calculus	Analysing and modelling of real-life situations involving rates of change, accumulation, and optimization of resources.	4. Partial fractions 10. Differentiation 1 11. Integration 1 16. Error analysis 18. Differentiation 2 19. Integration 2 26. Differential equations 21. Trapezium rule 23. Iterative methods 27. Flow charts
AO4	Data analysis and probability	Analysing data and applying probability models to make informed decisions and predictions in personal, academic, and societal contexts	6. Descriptive statistics 7. Correlation and scatter diagrams 9. Probability theory 14. Random variables

			15. Probability distributions 22. Sampling distribution
AO5	Mechanics	Analysing the effect of forces on bodies in motion or at rest, interpreting motion patterns and predict object behavior and use it to solve real world kinematic problems.	8. Dynamics 1 20. Dynamics 2

2.0 TABLE OF CONSTRUCTS

The table below details the constructs for Principal mathematics, i.e the competencies that make up the construct, the expected learner abilities and what assessor should look out for in the learner's work as evidence of achievement of the intended learning outcomes (indicators of mastery).

TABLE OF CONSTRUCTS FOR PRINCIPAL MATHEMATICS				
CONSTRUCTS	**TOPICAL COMPETENCIES The learner**	**ABILITIES**	**INDICATOR OF MASTERY**	**LEVEL OF COMPLEXITY**
ALGEBRA Applying algebraic principles to model and solve real-life problems and lead to informed decision making.	Analyses contextual use of indices, logarithms and surds through mathematical computations for precision, developing analytical skills and making informed decisions to communicate effectively	• Write an index notation • Relate indices to logarithms • Write logarithmic notation • Apply laws of indices and logarithms to simplify expressions • Apply laws of indices and logarithms to solve equations • Solve exponentiation problems involving growth and decay. • Differentiate between rational and irrational numbers • Simplify expressions involving surds • Solve equations involving surds • Rationalize surds • Demonstrate applicability of surds in areas that require high precision and accuracy • Explain solutions using mathematical notation and	• Writes index notation • Converts index notation into logarithmic notation and vice versa • simplifies expressions involving indices and logarithms • solves index and logarithmic equations. • uses laws of indices and logarithms correctly in solving equations involving exponential growth and decay. • Simplifies expressions involving surds • Solves equations involving surds • Demonstrates applicability of surds in areas that require high precision and accuracy • Correctly interprets solutions in surd form	**HIGH**

		language in context of a real-life problem.		
	investigates equations and inequalities to acquire mathematical computational and analytical skills applicable in the real world	• Solve quadratic equations using different methods e.g., graphical, factorization, completing squares, quadratic formula • Relate sum and product of roots to coefficients of a quadratic equation • Formulate quadratic equations given roots • Express roots as sum and products • Solve simultaneous equations where one is linear and the other quadratic • Solve linear simultaneous equations in three variables using various methods • Use graphical methods and algebraic techniques to solve quadratic inequalities • Solve a real-world problem involving optimisation of resources • Solve logarithmic equations that reduce to quadratic	• Solves quadratic equations using different methods • determines sums and products of roots of quadratic equations. • Formulates quadratic equations given roots • applies quadratic equations to model and solve real life situations • Formulates and solve linear simultaneous equations in three unknowns • Uses correct methods in solving linear simultaneous equations in three variables and evaluate their solutions • Draws graphs of quadratic inequalities • Obtains optimal solutions	

		• Solve exponential equations that reduce to quadratic • Solve irrational equations that reduce to quadratic • Determine minimum and maximum values by completing squares and graphical method • Determine the nature of roots and discriminant. • Develop mathematical models for real life situations • Present optimized solutions with justification • Solve polynomial problems, including linear, quadratic, and higher – degree equations • Use division of polynomials to understand properties of polynomials like Remainder and Factor theorems. • Relating polynomial to other math concepts, such as geometry, trigonometry, and calculus to model and solve real word problems	• Solves quadratic inequalities using algebraic techniques. • Expands and factorises polynomial expressions • Solves polynomials (with or without repeated roots) • Computes the remainder when the divisor is linear or quadratic when the polynomial is known or unknown. • Uses mathematics to justify and support decisions	

		• Solve three linear simultaneous equations using substitution, elimination and matrix /row reduction to echelon form methods • Solve real world problems that involve three linear simultaneous equations • Solve linear inequalities • Determine solutions of quadratic inequalities using graphical and algebraic techniques • Formulate a polynomials • determine the degree of a polynomial • use long division to determine the quotients and remainders • apply remainder theorem • use factor theorem to factorise a polynomial • determine roots and factors of a polynomial equation • determine a remainder of a polynomial with repeated roots		
	applies the permutations and combinations concepts to solve mathematical problems and model solutions to real-world situations.	• arrange objects in different ways • write a factorial notation • use factorial notation to determine number of arrangements • write permutation formula	• Applies concept of permutations to count and arrange objects in different orders • Calculates permutations, with and	

		• compute permutations for identical objects with or without repetitions, with restrictions, circular arrangements • Select items from a group • Write the combination formula • Differentiate between combinations and permutations • Evaluate combinations with restriction • Apply combination and permutation in the real-world situations	without repetition, with and without restrictions, using formulas and factorials. • Applies permutations to solve real world problems and identify patterns and relationships • Accurately calculates combination values in a set of various scenarios. • applies combination to solve problems involving selection, grouping, and counting in real world contexts.	
	applies principles and techniques of series and binomial expansions to understand and solve mathematical and scientific problems in the real world	• Identify a series • Identify the relationship between a sequence and a series. • Identify common difference and common ratio. • Generate an Arithmetic progression and Geometrical progression • Determine the nth term of Arithmetic progression and Geometrical progression	• Defines, identifies and solves problems involving arithmetic progressions. • Analyzes and interprets arithmetic progressions in real world contexts, such as finance and science. • Accurately derives and applies formulas for	

		• Determine the sum of an Arithmetic progression and Geometrical progression • Analyse the convergence of a G.P to determine the sum to infinity • Modelling real- world situations using arithmetic progressions, such as calculating interest rates or population growth, radioactivity, cell division. • Modeling real-world situations using geometrical progressions like compound interest, exponential decay • Prove mathematical statements and formulas using inductive reasoning. • Generate Pascal's triangle to expand expressions of the form $(a + b)^n$ • Determine coefficients of terms in expansion $(a + b)^n$ • Deduce the binomial expansion • Expand the terms of binomial theorem in ascending and descending order • Use binomial theorem to; ✓ Compute a particular term and roots of numerical values	geometrical progressions. • Solves problems involving geometrical sequences and series • Applies geometrical progressions to model and solve real-world problems. • Correctly proves mathematical statements and formulas using inductive reasoning. • Accurately expands expressions using the binomial theorem. • Correctly identifies and calculates specific terms or coefficients in a binomial expansion. • Uses binomial theorem to compute roots of numerical values • Determines the range of values within which binomial theorem is valid.	

		✓ State range of validity of binomial expansion		
	applies concepts of complex numbers to solve modelling problems across different mathematical and real-world scenarios.	• identify a complex number • determine the real and imaginary parts of a complex number • simplify expressions involving complex numbers • determine the square roots of a complex number • solve equations with complex roots • relate complex numbers to the cartesian coordinate system • determine the argument and modulus of a complex number • write a complex number in polar form • describe the locus of a complex equation. • represent the locus of a complex equation and inequality on a complex plane. • apply De Moivre's theorem in determining roots and powers of complex numbers, simplification of trigonometrical expressions and solving equations. • Explore and investigate applications of complex	• Performs operations on complex numbers. • Solves equations with complex roots. • Represents complex number on argand diagram • Expresses a complex number in modulus argument form • Describes and represented locus of a complex equation or inequality on graph. • Applies De Moivre's theorem in determining roots and powers of complex numbers, simplification of trigonometrical expressions and solving equations. • Explores and investigates applications of complex numbers in real life situations	

		numbers in real life situations		
GEOMETRY Applying geometric concepts and spatial reasoning to interpret relationships in mathematical and real-life contexts for informed problem solving.	analyses linear relationships to solve geometric problems and interpret spatial relationships in real-life situations.	• Analyse geometry of a line to demonstrate understanding and visualization of geometrical relationships • locate coordinates of any point on a line and sub divide a line • determine the angle between a line and the x-axis • Determine the angle between lines • Relate gradients of parallel lines and perpendicular lines • Determine shortest distance between a line and a point • Solve real life problems involving geometric concepts	• Analyses the geometry of a line to demonstrate understanding of geometrical relationships • Locates coordinates of any point on a line and sub divide a line • interprets the relationship between the angle between lines and their gradients. • Determines the shortest distance between a line and a point. • Uses ICT related aids to demonstrate geometrical concepts and their applications in real life	HIGH
	applies trigonometric functions, identities, and equations to solve problems in mathematics and real-life application in navigation, construction, aviation and other fields	• Relate sides of a right-angled triangle to its angles. • Plot trigonometric graphs of sine, cosine and tangent functions • Determine angles of given functions in a given range	• Relates sides of a right-angled triangle to its angles. • Plots trigonometric graphs of sine, cosine and tangent functions • Determines angles of given functions in a given range	

		• Derive trigonometric ratios of $30^0, 45^0\ and 60^0$ • Derive a variety of identities using trigonometric relationships • Simplify expressions and proves trigonometric relationships • solves different trigonometric equations based on different identities • Solve equations using inverse trigonometric functions • Apply trigonometric concepts to solve real life challenges	• Derives trigonometric ratios of $30^0, 45^0\ and 60^0$ • Derives a variety of identities using trigonometric relationships • simplifies expressions and proves trigonometric relationships • solves different trigonometric equations based on different identities • applies concepts of trigonometry to solve real life challenges	
	applies algebraic and geometric techniques to analyse spatial relationships applicable in real-world contexts.	• Construct and interpret geometric shapes and patterns using loci • Use geometric and differentiation concepts to interpret geometry of a circle, parabola and ellipse. • Solve real-world problems involving ○ loci	• Derives equations of loci for various geometric shapes and conditions. • Interprets geometry of a circle, parabola and ellipse • includes tangents and solved geometrical problems.	

		○ circles and their properties in designing circular structures, calculating distances and areas ○ parabola ○ elliptical shapes		
CALCULUS Analysing and modelling of real-life situations involving rates of change, accumulation, and optimization of resources.	decomposes rational expressions into partial fractions useful in integral calculus and real-world context.	• Simplify the sum or difference of fractions as a single fraction • Express an improper fraction into the sum of the quotient and proper fraction • Decompose the denominator of proper fractions into a product; (a) linear factors (b) Repeated factors (c) Un factorisable Quadratic factor • Express a given fraction in partial form using various techniques • Decomposing rational fractions to solve real world situations e.g signal processing in communication.	• Explains clearly the different types of algebraic fractions • Breaks down fractions into proper and improper fractions into partial fractions • Decomposes rational fractions to solve real world situations e.g signal processing in communication.	HIGH
	applies differentiation techniques to solve problems in calculus and interpret their significance in real-world contexts	• Differentiate functions using first principles and power rule. • Differentiate parametric, implicit and composite functions using the different differentiation	• Differentiates functions using first principles and power rule. • Differentiates parametric, implicit and composite functions using the	

		techniques e.g. chain rule, product rule and quotient rule. • sketch irrational curves • Apply differentiation to determine velocity and acceleration given displacement • Solve real life situations that involve optimization of resources	different differentiation techniques e.g. chain rule, product rule and quotient rule. • sketches irrational curves • Applies differentiation to determine velocity and acceleration • Solves real life situations that involve optimization of resources	
	applies integration techniques to solve problems involving areas under curves, accumulation of quantities, and other real-world applications	• Compute definite and indefinite integrals to determine area under the curve(s) and volume of solids of revolution. • Apply integration concepts to solve real –world problems in various fields like motion	• Computes definite and indefinite integrals to determine area under the curve(s) and volume of solids of revolution. • Applies integration concepts to solve real –world problems in various fields like motion	
	applies differentiation techniques to non-algebraic functions, Maclaurin's series and irrational curves to analyse real-world phenomena in various fields.	• Use various techiniques to differentiate; ○ trigonometric functions ○ inverse trigonometric functions. ○ exponential and logarithmic functions ○ algebraic functions • Relate exponential functions to natural	• Differentiates various functions using various techniques. • Applies Maclaurin's theorem to approximate values. • Correctly sketches curves.	

		logarithms and deduce their derivatives. • Generate and apply Maclaurin's theorem to approximate functions and truncate series to a desired degree • Analyse the behavior of rational curves and sketch them. • Apply differentiation techniques in various fields to address real world problems		
	applies appropriate methods of integration to solve real-world problems	• Integrate functions using different integration techniques. • Use of appropriate integral techniques in solving real life scenarios	• Integrates functions using different integration techniques. • Uses appropriate integral techniques in solving real life scenarios	
	models and solves problems involving rates of change to interpret the solutions for prediction in context for acquisition of analytical skills.	• Model and solve first order differential equations using various techniques. • Create and present solutions to differential problems using various media, such as written reports, graphs or	• Solves first order differential equations using various methods. • Models real-world scenarios using differential equations displaying an understanding of	

		tables • Solve real world scenarios involving prediction of population growth/decline, forensic analysis (time of death estimation), drug absorption, rainfall formation	mathematical concepts.	
	Analyses errors in mathematical operations and functions to understand the role of precision and accuracy in problem-solving	• Compute absolute error, relative error and percentage errors • Determine the limits of accuracy • Derive and compute errors in the sum, difference, product and quotient of expressions • Derive the formulae for error propagation in functions • Apply errors in real world phenomena e.g. in business • Identify the sources and effects of errors in calculations and functions.	• correctly applies formulas and mathematical principles related to error analysis • explains the significance of errors in their results and conclusions • examines the sources of errors in real-world problems • documents error analysis process and results. uses mathematical tools and techniques to minimize errors in various contexts	
	applies the trapezium rule to estimate definite integrals and areas under a curve to solve problems involving numerical integration	• Determine the approximate area under the curve • Compare the approximate area with the exact area	• Compares exact and approximate area and draws conclusions on how the error can be reduced.	

	applies iterative numerical methods to approximate solutions to problems while critically analysing accuracy and limitations of methods used in real life situations	• Predict the non-tabular points or values that are within and outside the table of values. • Estimate the roots of the transcendental functions using linear interpolation and Newton Raphson methods • Analyse accuracy and limitations of using linear interpolation and Newton Raphson methods in real life scenarios.	• Predicts the non-tabular points or values that are within and outside the table of values. • Estimates the roots of the transcendental functions using linear interpolation and Newton Raphson methods	
	develops flowcharts to organise and represent mathematical processes and problem-solving strategies by breaking down complex tasks into simpler, more manageable steps, and applies these skills to tackle emerging challenges.	• Design an algorithm to solve problem • Create a visual representation of mathematical processes to solve problem • Analyze the flowchart to ensure it effectively solves the given mathematical problem	• Creates a visual representation of mathematical processes to solve problem • Analyzes the flowchart to ensure it effectively solves the given mathematical problems	
DATA ANALYSIS AND PROBABILITY Analysing data and applying probability models to make informed decisions and predictions in personal, academic, and societal contexts	analyses data through collection, presentation, and evaluation of population parameters and sample statistics in order to predict and plan for self and community development.	• Organise data and represent it graphically (histogram and O'give) and use it to estimate mode and measures of relative position. • Compute measures of central tendency, measures of spread and relative positions	• Organises and represents data on graph to estimate mode and measures of relative position. • Interprets solutions to predict and make informed decisions	HIGH

		• Interpret solutions, predict and make informed decisions. • Use ICT tools to analyse data for prediction of real-world situations.	• Uses ICT tools to analyse data for prediction of real-world situations	
	investigates the relationship between two quantitative variables through graphical representation and evaluation of correlation coefficients for decision making and prediction.	• Draw scatter plot and predict the line of best fit. • Compute the rank correlation coefficients of a set of data • Comment on correlation coefficients and scatter graphs using different approaches • Analyses the given data to draw a relationship between two variables • Use ICT tools to draw scatter plots between two variables and predict relationships.	• Draws scatter plot and predicts the line of best fit. • Computes the rank correlation coefficients of a set of data • Comments on correlation coefficients and scatter graphs using different approaches • Analyses the given data to draw a relationship between two variables • Uses ICT tools to draw scatter plots between two variables and predict relationships	
	evaluates probabilities through applying the probability laws and theorems to predict the occurrence of events in real life.	• Determine the chance of occurrences of different events in different situations.	• Analyses a situation, chooses an appropriate approach to determine the probabilities of	

		• Apply probability theory in real life to solve problems	different events in different situations.	
	models and analyses the outcomes of random phenomena through determining probabilities and expected values for prediction of uncertainties in real life	• Differentiate between a discrete and a continuous random variable • Formulate a probability distribution of a discrete random variable • Determine probabilities, measures of central tendency, measures of dispersion and relative positions of discrete and continuous random variable. • Determine the cumulative distribution function of a discrete and continuous random variable and sketch the P.d.f and c.d.f respectively. • Uses a c.d.f to obtain unknowns, probabilities, measures relative positions • investigate the application of discrete and continuous random variable	• Analyses different random variable situations, calculates key statistical measures and make predictions. • Identifies, models, and interprets real-life situations using discrete and continuous random variables, justifies choice of distribution, and evaluates implications of probabilistic outcomes.	
	demonstrates the ability to analyse and apply binomial, rectangular, and normal distributions to solve real-world problems	• Determine probabilities using a binomial formula and mathematical tables. • Determine mean, mode and variance of a binomial distribution. • Determine the probabilities, mean, mode	• interprets a scenario and used an appropriate probability distribution to compute statistical measures. • Models a statistical situation and uses ICT	

		and variance in a rectangular distribution • Determine probabilities of the normal distribution • De standardise the normal variables to determine parameters • Describe conditions for binomial to be approximated by normal distribution • Determine probabilities, expectation and variance under normal approximation to binomial distribution • Model a statistical situation and use ICT tools to analyse a statistical measure, predict and make informed decisions.	tools to analyse a statistical measure, predict and make informed decisions	
	estimates population parameters by using sample distributions to predict and eliminate variability in research and collection of statistical data.	• Standardise the sample mean and use the standardised variable to determine the probabilities • Determine point estimates and interval estimates of population parameters • Compute the confidence interval for population mean when the population variance is known or unknown for large sample ($n \geq 30$). • Interpret the results of confidence intervals and	• Standardises the sample mean and uses the standardised variable to determine the probabilities • Determines point estimates and interval estimates of population parameters • Computes the confidence interval for population mean when the population variance is known or	

		point estimates in the context of real-world problems	unknown for large sample ($n \geq 30$). • Interprets the results of confidence intervals and point estimates in the context of real-world problems	
MECHANICS Analysing the effect of forces on bodies in motion or at rest, interpreting motion patterns and predict object behavior and use it to solve real world kinematic problems	determines the resultant force and analyses the effect of forces on bodies by applying Newton's laws to solve problems in real world phenomena	• Determine resultant force and direction of the resultant of any number of forces and in polygons • Analyse forces in moving and static bodies • Develop mathematical models to describe the behavior of bodies under the influence of friction on various surfaces	• Analyses forces in moving and static bodies • Develops mathematical models to describe the behavior of bodies under the influence of friction on various surfaces	HIGH
	analyses motion patterns of objects as observed from different reference points to predict their behaviour and solving kinematic issues	• Determine the resultant, relative and true velocity of moving bodies and their displacement at any time • Evaluate the distance time and course for closest approach and collision to simplify motion related problems apply equations of motion to solve problems projectiles in the vertical, horizontal, and at an angle in relation to real world scenarios.	• Determines the resultant, relative and true velocity of moving bodies and their displacement at any time • Evaluates the distance time and course for closest approach and collision to simplify motion related problems. • Applies equations of motion to solve problems projectiles in the vertical, horizontal, and at an angle in	

			relation to real world scenarios.	

3.0 STRUCTURE OF THE EXAMINATION

There will be two examination papers for Principal mathematics at ASC.

Paper 1:

This paper assesses mathematical concepts in the constructs of Algebra, Geometry and Calculus. The paper will assess the learner's ability to apply mathematical principles in practical problem-solving and real-world applications.

The items in the paper will be scenario-based. The paper will have 6 equally weighted items (Two on Algebra, one on Geometry and three on Calculus). The learner will be required to attempt one item from Algebra (Section A), one from Geometry (Section B) and two from Calculus (Section C), choosing one item from each part of section C.

The Paper will last 3hours. (Each item will take 40 minutes and 20 minutes for the learner to read through and make a choice out of the optional items).

Paper 2:

This paper assesses mathematical concepts in the constructs of Data Analysis and Probability, and Mechanics. The paper will assess the learner's ability to apply mathematical principles in practical problem-solving and real-world applications.

The items in the paper will be scenario-based. The paper will have 4 equally weighted items from two sections. Two items in Section A will be on Data Analysis and Probability, and the other two items in section B will be on Mechanics. The learner will be required to attempt a total of three items, choosing at least one from each section. The Paper will last $2^{1}/_{4}$ hours. (Each item will take 40 minutes and 15 minutes for the learner to read through and make a choice out of the optional items).

PRINCIPAL MATHEMATICS PAPER 1, SET 1
Time: **3HOURS**

INSTRUCTIONS TO CANDIDATES:

- *This paper consists of* **three** *sections;* **A, B** and **C.** *It has six examinations items.*
- *Section* **A** *has* **two** *items. Answer* ***one*** *item* ***only****.*
- Section **B** has **one compulsory** item.
- *Section* ***C*** *has two parts;* ***part I*** *and* ***part II****. Answer one item from each part.*
- *Answer a total of* **four** *items.*
- *Any additional item(s) answered will* **not** *be scored.*
- **All** *answers* **must** *be written in the answer booklets/sheets provided.*
- *Graph paper is provided.*
- *Silent non-programmable scientific calculators and mathematical tables with a list of formulae may be used.*

FOR OFFICIAL USE ONLY		
SECTION A	**ITEM 1**	
	ITEM 2	
SECTION B	**ITEM 3**	
SECTION C	**ITEM 4**	
	ITEM 5	
	ITEM 6	

	TOTAL	

SECTION A

ITEM 1

A certain Secondary school has Hydro-electric power but is experiencing power fluctuations. This is affecting the computer library in relation with students' research and other important school work. As a result, the school management wants all school buildings to be connected with solar panels. The panels should be able to generate not less than 10,000W if the whole school solar system is to work efficiently.

The research made by school management with the distributor of solar panels in the nearby town shows that a newly installed solar panel produces 500W but its efficiency reduces by 2% every year and should be replaced when its production reaches to 392W. Each solar panel currently costs Shs. 800,000 but the cost increases by Shs. 60,000 each year due to inflation.

Due to limited budget and projections, the management has been advised that the solar can be phased in to operate alongside the hydro-electric power. Management has resolved, it will install panels gradually by installing 5 panels in the first year and increase the number installed by 30% in each subsequent year.

The management would like to know when they will be able to raise the required number of panels for full school system setup, the number of solar panels needed, the life time of the panel and its replacement cost so as to implement the plan for the project.

Task

You have been contacted as a mathematics learner, help the management to prepare an implementation plan of the project.

ITEM 2

A civil engineering firm in Uganda is designing a cable-stayed bridge across River Nile to ease traffic flow. To plan resources, the project manager receives the following information:

The durability (in years) of a new concrete mix that includes a special additive is modeled by:

$D(x) = 28 + 2x - 0.1x^2$ where x is the amount of additive in kg per cubic metre of concrete**.**

The additive costs UGX 45,000 per kg. The concrete budget allows a maximum of UGX 450,000 per cubic metre for additives.

Two bridge cable anchoring points are modelled in the complex plane as: $A = 3 + 4i$,

$B = -2 + 7i$. Coordinates are measured in tens of metres from a reference point on the riverbank. The firm schedules material delivery over five equal weekly instalments.
The amount of additive delivered each week forms a geometric progression**:** $50, 75, 112.5, \ldots (kg)$. The firm has 5 mechanical engineers and 7 civil engineers.
They need to form a team of 4 engineers, but the team must include at least one mechanical and at least one civil engineer.

Tasks:

Help the manager to:

a) Determine the optimal concrete composition that maximizes durability within budget constraints and analyze the delivery schedule adequacy, providing recommendations with justification and judgement on resource allocation efficiency.

b) Plan the site layout and optimal team composition, providing recommendations with justification on how these ensure structural integrity and project success.

SECTION B

ITEM 3

A community is experiencing weak network signal. A telecom company plans to put up a mast to serve three towns, A, B and C whose map coordinates (in hectometers) are (1,1) and (7,1) and (1,9) respectively. The mast must be positioned equidistant from all the three towns. A dish will be mounted on a mast at a height, h (in hectometers) so that the signal to any of the town makes an angle of 60^0 with the horizontal.

The signals transmitted by the dish are modeled by $s(\theta) = 12cos\theta + 5sin\theta$, where θ is the angle of the dish's inclination and $s(\theta)$ is signal strength in the direction θ.

The company wishes to determine the mast location, suitable height, the maximum signal strength and the angle at which it occurs for proper planning.

The community well-wisher also plans to construct a community school along a path that connects all the three towns and keeps a constant distance from the mast to ensure steady network coverage.

Task:

a) Help the company to plan accordingly.
b) Analyse the path that connects the three towns and advise the community well - wisher where to construct the school. Justify your reasoning.

SECTION C

PART 1

ITEM 4

A local charity is running a campaign to raise funds for a new community center. They have a team of volunteers whose number and productivity change over time.

The number of active volunteers after t months is given by N(t) = 50 + 10t. The rate of volunteer hours is a product of the number of active volunteers on the team and the average hours worked per volunteer per month. The average hours worked per volunteer month is modeled by $H(t) = 8e^{-0.2t}$, where t is the number of months since the start of the campaign $(0 \leq t \leq 6)$.

The charity needs to determine the total number of volunteer hours contributed by all volunteers over the first six months. This will help them properly report to their donors and plan for future staffing. To persuade donors and analyse its fundraising performance during an online auction,

the charity modelled the fundraising rate as a separate function of time, measured in hours. Let t_h represent the time in hours from the start of the auction. The rate of funds raised per hour (in thousands of shillings) is modeled by the function $R(t_h) = \frac{500t_h}{{t_h}^2+10}$

Tasks:

(a) As the charity coordinator, you need to conduct a comprehensive analysis of volunteer contributions and resource allocation over the six-month campaign period. Your analysis should integrate the mathematical models to provide insights for donor reporting and future planning.

(b) As the fundraising manager, analyze the auction's financial performance and develop strategic recommendations.

ITEM 5

A district health team is trying to reduce the spread of a water-borne disease at a crowded secondary school. Instead of studying how infection changes over time, the team is studying how infection, W changes with respect to student behaviour.
The school has introduced a Behaviour Improvement Score (denoted by *B*), ranging from 0 to 10: *B* = 0: Students ignore all hygiene measures, *B* = 10: Full compliance (handwashing, no sharing bottles, safe waste disposal).
Scientists determined that the relationship between the infected population and their behaviour level is $\frac{dW}{dB} = -\left(\frac{2\mathrm{B}}{\mathrm{B}^2+9}\right)W$.
W(B) is the percentage of students infected when the school is operating at behaviour level *and the infection level W(B) is* 18% at B =1

The Ministry of Education requires schools to reduce infection to below 6% to allow examinations to proceed in classrooms without spacing restrictions.
The school has realised that it is at behaviour level *B* = 4, and wonders whether they are safe to conduct exams.
A neighbouring school recognises that infection could easily spread to them if they do not plan ahead. They know that they can improve their behaviour by investing in training sessions, posters in dormitories, and monitoring. Each unit increase in behaviour costs UGX 15,000,000. They are currently at level *B* = 2 and would like to know how much money they need to reach the ministry's requirement.
Task
Provide recommendations to the two schools.

PART 2

ITEM 6

A remote community depends on a small wind turbine for electricity, but recently the community has been experiencing frequent power shortages. Engineers traced the issue to poor turbine blade design. Akello, the lead engineer, has been assigned to redesign a high-efficiency turbine blade that will improve power reliability for the community. She is a visual engineer; she insists that the computational steps be organized clearly in a step – by – step sequence and prefers to see processes diagrammatically alongside calculations.

Simulation studies show that the stress experienced by the blade depends on its thickness x (mm) and is modelled by:

$$\sigma(x) = \frac{1200}{x} + 0.8x$$;(Stress in MPa)

To satisfy safety requirements, the stress must equal exactly 62 MPa. Starting with an initial guess of x = 30.0 mm, Akello and her assistant keep changing the value of x until the difference between two successive guesses is less than 0.0005 mm.

Wind tunnel testing shows that the blade width (chord length) varies along its span as follows:

k (m)	0	3	6	9	12	15
c(k) (m)	6.2	5.4	4.9	3.1	1.8	0.6

The blade area (top view) is defined by the definite integral: $A = \int c(k)\,dk$ from k = 0 to 15. Since no explicit function exists, Akello must estimate the area A. To work efficiently, the blade must satisfy the requirement that A ≥ 60 m².

Tasks:

a) Perform a numerical iteration that satisfies safety requirements and provide visual representation of the processes.
b) Determine whether the blade design satisfies the requirement needed. Suggest what design factor could be adjusted if the area is not sufficient.

SCORING RUBRIC ITEM 1: Solar Panel Implementation Plan

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1

1.Interpretation of the scenario and task	Demonstrates **comprehensive** understanding of the scenario and task by identifying **all the six** important variables/concepts: 1. Total power requirement: 10,000W 2. Initial panel capacity: 500W 3. Annual efficiency decay: 2% 4. Replacement threshold: 392W 5. Installation growth: 30% annually 6. Cost inflation: UGX.60,000/year	Demonstrates **good** understanding of the scenario and task by identifying **4-5** important variables/concept	Demonstrates **basic** understanding of the scenario and task by identifying **3** important variables/concepts	Demonstrates **limited** understanding of the scenario and task by Identifying **2** important variables/concepts	Demonstrates **little** understanding of the scenario and task by Identifying only **1** variable or **none.**

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
2.Generating and Presenting ideas a) *Generate Ideas that Address the task*	• Demonstrates **comprehensive understanding** by Stating **all the four** relevant mathematical approaches: 1. Panel requirement calculation: $\frac{10000}{500} = 20$ 2. Geometric progression for installation schedule 3. Exponential decay for efficiency: $500 \times (0.98)^n$ 4. Linear growth for cost projection	• Demonstrates **good understanding** by Stating **most** relevant approaches (3 of above)	• Demonstrates **basic understanding by** • Stating **basic** mathematical approaches needed (any two)	States **few** relevant approaches (any one)	States **no** relevant approaches
b) Makes connections within and between ideas and context	Strong logical connections demonstrated by correctly performing **10-12** of these manipulations: 1. Calculate minimum panels needed: $10000 \div 500 = 20$ 2. Year 1 installation: 5 panels 3. Year 2 installation: $5 \times 1.3 = 6.5 \approx 7$ 4. Year 3 installation: $6 \times 1.3 = 9.1 \approx 9$ 5. Cumulative Year 1: 5 panels 6. Cumulative Year 2: $5 + 7 = 12$ panels 7. Cumulative Year 3: $12 + 9 = 21$ panels 8. Set up exponential decay: $500 \times (0.98)^n = 392$ 9. Solve: $(0.98)^n = 0.784$ 10. Calculate: $n = \ln(0.784) \div \ln(0.98) \approx 12$ years 11. Replacement cost: $800{,}000 + 12 \times 60{,}000 = 1{,}520{,}000$	• Logical connections among most variables and computations **(8-9 manipulations)**	• Some connections among variables **(6-7 manipulations)**	**Few/weak connections** among variables **(4-5 manipulations)**	**No clear connections**; context ignored **(<4 manipulations**)

	12. Total replacement: 20 × 1, 520, 000 = 30, 400, 000				
c)*Presents ideas coherently*	**Clear, logical, fluent** presentation with: – Smooth transitions between calculations – Well-organized implementation plan structure – Complete recommendations with timeline – 10-12 manipulations presented clearly	**Mostly coherent** presentation with: – Logical sequencing of analyses -Clear transitions between planning stages – Minor lapses don't hinder understanding – 8-9 manipulations presented clearly	**Generally understandable** but may lack smooth flow between methods (6-7 manipulations)	**Lacks clear organization**; analyses appear disjointed (4-5 manipulations)	**Incoherent or fragmented**; meaning difficult to follow (<4 manipulations)

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
3. Making informed judgement	Forms **highly informed, insightful** judgement by: – Providing **precise implementation timeline** (3 years) – Offering **comprehensive financial planning** with replacement costs – Giving **specific maintenance strategy** with monitoring recommendations – Integrating **all analyses** into cohesive project plan – Considering **risk management** and budget flexibility	Forms **clear, logical** judgement by: –Connecting calculations to management decisions – Making specific recommendations for timeline and budget –Supporting conclusions with quantitative analysis –Addressing all project components	Forms **generally relevant** judgement by: –Applying mathematics to planning context –Providing basic recommendations –Beginning to link analyses to implementation	Forms **limited** judgement by: –Recognizing project planning context –Attempting basic timeline suggestions – Showing understanding of budget constraints	Forms **unclear, unsupported** g judgement by: - Showing no understanding of project objectives - Providing irrelevant conclusions - No evident use of mathematical analysis

SCORING RUBRIC ITEM 2: Bridge Design and Engineering

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
1.**Interpretation of the scenario and task**	Demonstrates **comprehensive** understanding by identifying **all the eight** important variables/concepts: 1. Durability function: $D(x) = 28 + 2x - 0.1x^2$ 2. Additive cost: UGX 45,000 per kg 3. Budget constraint: UGX 450,000 maximum 4. Complex plane coordinates: $A=3 + 4i$, $B = -2 + 7i$ 5. Geometric progression delivery: 50, 75, 112.5, ... 6. Engineer composition: 5 mechanical, 7 civil 7. Team selection constraints 8. Distance calculation in complex plane	Demonstrates **good** understanding by identifying **6-7** important variables/concept	Demonstrates **basic** understanding by identifying **4-5** important variables/concept	Demonstrates **limited** understanding by identifying **2-3** important variables/concept	Demonstrates **little** understanding by identifying only **1-2** variables or s **none** Showing no understanding of task or context

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
2.Generating and Presenting ideas a) *Generate ideas that address the task*	• Demonstrates **comprehensive understanding** by Stating all the four relevant mathematical approaches: 1. Quadratic optimization for durability 2. Budget constraint analysis 3. Geometric progression sum formula 4. Complex number distance calculation	• Demonstrate **good understand ng** by Statin most relevan approaches (3 of above)	• Demonstrate **basic understand ng** by statin basic mathematica approaches needed (any 2)	• Demonstrate **limited understand ng** by statin any one relevant approach	States **no** relevant approaches
b) *Makes connections within and between ideas and context*	**Strong logical connections** demonstrated by correctly performing 12-14 of these manipulations: 1. Differentiate durability: $\frac{dD}{dx} = 2 - 0.2x = 0$ 2. Solve for optimal: $x = 10$ kg/m 3. Calculate maximum durability: $D(10) = 28 + 20 - 10 = 38$ years 4. Check budget: $10 \times 45,000 = 450,000$ UGX 5. Identify GP parameters: $a = 50$, $r = 1.5$ 6. Calculate total delivery S_5 7. Compute: $S_5 = 659.375$ kg 8. Calculate distance between anchors: $\lvert A - B \rvert = \lvert 5 - 3i \rvert$ 9. Compute modulus $\sqrt{(25 + 9)} = \sqrt{34} \approx 5.83$	**Logical connections** among **most** variables and computations (10-11 manipulations)	**Some connection s** among variables (8-9 manipulations)	**Few/weak connections** among variables (6-7 manipulations)	**No clear connections**; context ignored (<6 manipulations)

	10. Convert to meters: $5.83 \times 10 = 58.3$ m 11. Total team combinations $\binom{12}{4} = 495$ 12. Invalid mechanical teams: $\binom{5}{4} = 5$ 13. Invalid $\binom{7}{4} = 35$ civil teams 14. Valid teams: $495 - 5 - 35 = 455$				
c) *Presents ideas coherently*	**Clear, logical, fluent** presentation with: – Smooth transitions between optimization and geometry – Well-organized engineering report structure – Complete recommendations for both parts – 12-14 manipulations presented clearly	**Mostly coherent** presentation with: **–** Logical Sequencies of analyses – Clear transitions between design component -Minor lapses don't hinder under-standing – 10-11 manipulations presented clearly	**Generally understandable** but may lack smooth flow between methods (8-9 manipulations)	**Lacks clear organization**; analyses appear disjointed (6-7 manipulations)	**Incoherent or fragmented**; meaning difficult to follow (<6 manipulations)

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
3. **Making informed judgement**	Forms **highly informed, insightful** judgement by: – Providing **evidence-based concrete composition** with cost-benefit analysis – Offering **comprehensive structural design** with precise anchor placement – Giving **optimal team composition** with diversity considerations – Integrating **all engineering analyses** into cohesive bridge design – Considering **real-world implementation** and safety factors	Forms **clear, logical** judgement by: –Connecting calculations to engineering decisions – Making specific recommendations for materials and teams –Supporting design choices with quantitative analysis –Addressing all project requirements	Forms **generally relevant** judgement by: –Applying mathematics to engineering context –Providing basic de- sign recommendations –Beginning to link analysis to structural integrity	Forms **limited** judgement by: –Recognizing engineering context –Attempting basic design suggestions – Showing understanding of safety requirements	Forms **unclear, unsupported** judgement by: - Showing no understanding of engineering objectives - Providing irrelevant conclusions - No evident use of mathematical analysis

SCORING RUBRIC ITEM 3: Telecom Mast Planning

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
1.**Interpretation of the scenario and task**	Demonstrates **full and precise interpretation** of the scenario; correctly identifies: • Town Coordinates, • Triangle (for location), • Equidistant Position (Circumcenter), • Angle (60^0) for signal, • Trigonometry (for height), • Signal Function $S(\theta)$, and Constant Distance Path (Circle). • R-Formula (for max signal), and • Distance Formula (for the path).	Shows **strong interpretation**; identifies equidistance and height requirement but with minor omissions (e.g., partial explanation of locus or incomplete link to tan 60°). Correctly recognises the need for maximizing signal strength but may not fully articulate dependence on angle.	Shows **basic understanding** of some key elements (e.g., equidistance of mast or angle requirement) but misses one major component such as path locus OR signal maximisation. Interpretation is partially correct but not complete.	Shows **limited understanding**; identifies at least one idea (e.g., mast must be central) but misinterprets others (e.g., wrong angle relation, incorrect locus concept). Key pieces of the scenario remain unclear.	Shows **little or no interpretation**; misunderstands the coordinate setup, fails to recognise equidistance, height requirement, or purpose of the signal model. Provides irrelevant or incorrect representation of the scenario.

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
2.Generating and Presenting ideas *a) Generate Ideas that address the task*	• Demonstrates **comprehensive understanding** by stating all the five relevant mathematical approaches: • The mast must be placed at the **circumcenter** of triangle ABC. • Height must satisfy **tan 60° = h/slant-distance**. • The signal model requires finding its **maximum value** and angle of occurrence. • The school path must be a **locus of points equidistant from mast** (circular arc or Apollonian structure). • Shows complete understanding of towns' coordinates and geometric configuration.	• Demonstrates **good understanding** by stating **most** of the relevant approaches (4 of above)	• Demonstrates **basic understanding** by stating **any 3** mathematical approaches needed	• Demonstrates **basic understanding** by stating **any 2** relevant approaches	• Demonstrates **little understanding** by stating Any 1 or **no** relevant approach
b)Makes connections within and between ideas and context	Performs **all required computations accurately**, including: • Finding circumcenter using perpendicular bisectors or coordinate formulas. • Correctly stating mast center (4, 5), calculating radius r=5. • Computes correct mast	• Performs most processes correctly but may make **minor computational or algebraic errors** OR omit one sub-step. Still obtains mostly valid results for mast location,	• Applies methods with **partial correctness**: correct approach to circumcenter but incorrect height OR correct signal reasoning but wrong maximum. Work is partially correct	• Shows **weak application** attempts some methods (e.g., tries perpendicular bisectors or uses tan 60 wrongly). Large errors and conceptual gaps remain	• Shows **minimal or no relevant mathematical application** Uses incorrect formulas, wrong geometry, incorrect trigonometry

	height from **tan 60°** using slant distance. • Analyses S (θ) to determine **maximum signal strength, S_{max}** = 13 and the **exact angle** $\theta = 22.62°$ where it occurs. • Describes or computes the equation of the **locus** of points at constant distance from the mast.	height, and signal analysis.			
c)*Presents ideas coherently*	• Presents **clear, coherent, sequential** working. • Correct and efficient use of geometry, trigonometry, coordinate methods, and analysis of the signal function.	**Mostly coherent** presentation with logical structure of calculation clear	• **Generally understandable** but lacks completeness c consistency.	Work is fragmented and inconsistent.; analysis appears disjointed.	**Incoherent**; meaning difficult to follow.

3.**Making informed judgement**	Provides **fully justified**, mathematically sound recommendations, including: • Clear statement of the best mast position (circumcenter). • Valid assessment of mast height and coverage adequacy. • Correct identification of maximum signal strength and angle. • Insightful guidance for locating the community school along the **constant-distance path**, with clear justification based on locus geometry. • Demonstrates deep reasoning and strong connection to mathematical results.	Provides **well-reasoned** recommendations with minor gaps. Conclusions are mostly correct and based on computations, though justification may be brief or not fully integrated.	• Provides **adequate but partly supported** recommendations. Some conclusions follow from partial results. Explanation may be shallow or incomplete.	• Provides **weak or poorly justified** recommendations. Conclusions may be vague, partly incorrect, or not clearly linked to the earlier mathematical work.	• Provides **no valid recommendations** or recommendations that contradict mathematical results. • No evidence-based reasoning.

SCORING RUBRIC ITEM 4: Charity Fundraising and Volunteer Analysis

Basis of Assessment	**SCORE 5**	**SCORE 4**	**SCORE 3**	**SCORE 2**	**SCORE 1**
1. **Interpretation of the scenario and task**	• Demonstrate **complete, fluent understanding** by identifying **all the five** important variables/concepts: 1. Correct identification of V***olunteer Hours Function:*** $N(t) = 50 + 10t$ *(linear growth)* 2. explicit statement that $H(t) = 8e^{-0.2t}$ *(exponential decay)* must be interpreted as "average hours worked per volunteer per month, in hours"; 3. clear statement that total volunteer-hours over first six months t*otal hours rate:* $V(t) = N(t) \times H(t)$ 4. ***Fundraising Rate per hour:*** $R(t_h) = \frac{500t_h}{{t_h}^2+10}$ 5. *Units and quantities to compute.*	• Demonstrates **good** understanding by identifying **4** important variables/ concepts	• Demonstrates **basic** understanding by identifying **3** important variables/ concepts	• Demonstrates **limited** understanding by identifying **2** important variables/ concepts	• Demonstrates **little** understanding by Identifying **1** or **no** important variable/ concept

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
2.Generating and Presenting ideas *a) Generate Ideas that address the task*	States all **3** relevant mathematical approaches: • Integration by Parts (Total hours), • Integral Substitution/ln (Total funds), and • Calculus/Differentiation (Analysing rate R(t))	States most relevant approaches (**2** of the above).	States basic mathematical approaches needed (1).	Attempts to write any mathematical approach needed.	States no relevant approaches.
b) *Makes connections within and between ideas and context*	**Strong logical connections** demonstrated by correctly performing **5-6** of these manipulations: • Correctly computes $V(t) = N(t) \times H(t)$ evaluates the integral step by step. • shows the integral values clearly and method of integration • provides accurate final V (hours) with units, • computes time for maximum fundraising at dR/dth • solving the integral for total funds raised $\int R(t)\,dt$, and analyzing the peak fundraising time/rate. • computes maximum rate per hour • provides numerical values with correct units and sensible rounding	• **Logical connections** among **most** variables and computations (4 manipulations)	• **Some connections** among variable (3 manipulations)	• **Few/weak connections** among variables (2 manipulations)	• **No clear connections**; context ignored (<2 manipulations)

b) *Presents ideas coherently*	**Clear, logical, fluent** presentation with: • Smooth transitions between volunteer and financial analysis, • well-organized analysis structure, and • complete recommendations. • 5-6 manipulations presented clearly	**Mostly coherent** presentation with: • Clear transitions between mathematical and practical aspects • 4 manipulations presented clearly	**Generally understand-able** but may lack smooth flow between analysis (3 manipulations)	**Lacks clear organization**; concepts appear disjointed (2 manipulations)	**Incoherent or fragmented**; meaning difficult to follow (<2 manipulations)

Basis of Assessment	**SCORE 5**	**SCORE 4**	**SCORE 3**	**SCORE 2**	**SCORE 1**
3. **Making informed judgement**	Forms **highly Insightful, evidence-based judgement;** • Clarity of donor report (total volunteer hours, staff planning and resource allocation), • Recommendations to improve volunteer efficiency and fundraising strategy (e.g., timing auctions, financial targets), and cost–benefit insights. • Overall Justification to enable evidence-based decision making for both volunteer management and financial planning.	**Clear recommendations** supported by calculations but with minor missing linkages or fewer supporting projections. Good donor reporting and some strategy suggestions.	**Reasonable interpretation** with general recommendations; may lack numerical projections or detailed auction timing strategy	**Weak interpretation**: provides superficial statements (e.g., “hours were many”) without quantitative backing or actionable recommendations	**No valid interpretation or recommendations**; fails to connect calculations to practical decisions

SCORING RUBRIC ITEM 5: Water – borne Disease Reduction Plan

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
1. **Interpretation of the scenario and task**	Demonstrates **comprehensive** under- standing by identifying **all the four** important variables/concepts: • Understanding the differential equation and what W(B) represents (percent infected as function of behaviour level B), units (%) • ministry threshold (W<6%), and • cost per unit behaviour = UGX 15,000,000 • Writes model symbolically (states assumption)	• **Good interpretation** by stating model and interpreting W(4) and W(2) correctly but may be brief in explaining units or inequality solution.	• **Basic interpretation** by recognising need to interpret W(4) and whether (<6%) but shows minor algebraic slip or gives result with small rounding errors	• **Limited interpretation.** • Interprets one value (e.g., W (4) but misapplies inequality or misstates units.	• **Little or no interpretation.** • Does not identify ministry threshold meaningfully or misreads B units; • fails to compute W(4)correctly.

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
2.Generating and Presenting ideas a) *Generate ideas that address the task*	Demonstrates **comprehensive understanding.** States **5-6** relevant mathematical approaches: • Using separation of variables to solve ODEs • Uses given point (W (1) =18%) to find constant of integration. • Correctly computes and interprets W (4) • States neighbour school at (B=2) has W (2) • Correctly identifies target condition: find (B) such that (W(B)<0.06 • Solves inequality to get (B>5).	• Demonstrates **good understanding**. • States **most** relevant approaches (4 of above)	• Demonstrates **basic understanding.** • States **3** mathematical approaches needed	• Demonstrates **limited understanding.** • States **few** relevant approaches	• Demonstrates **little understanding.** • States **minimal** or **no** relevant approaches
b) *Makes connections within and between ideas and context*	**Strong logical connections** demonstrated by correctly performing at least 7-8 of these manipulations: • *Solve the Differential Equation* by separation of variables. • *Correct substitutions* from W(1)= 18% • Analyze First School (B = 4): W(4) = 7.2% versus ministry requirement: below 6% • Analyze neighboring School (B = 2): W(2) = 13.85% versus ministry requirement: below 6% • For neighbouring school at (B=2): to reach (B>5) they need to increase by (>3) units (practical: 4 units	• **Good math with minor arithmetic** performing at least 5 - 6 of these manipulations. • Shows substitution and inequality solution but may not state the difference between continuous and practical integer	• **Partial correct methods** performing 3 -4 of these manipulations: • Computes W(4) but makes small algebraic or arithmetic errors in solving inequality or computing cost; shows steps but with mistakes.	• **Weak method.** Shows 1- 2 correct manipulations or working but misses solving inequality correctly or miscomputes cost or units.	• **Incorrect or no meaningful working.** Wrong inequality manipulations, incorrect numeric values, or missing cost calculation

	to reach (B=6). • *computing money required to raise B from 2→target* • Cost per unit = 15,000,000 UGX ⇒ cost to raise from 2 → 6 • show continuous-minimal cost: to raise from 2 → just above 5 requires increase of (>3.0) units • calculating the total cost.	solutions explicitly.			
c) *Presents ideas coherently*	**Clear, logical, fluent** presentation with: • Smooth of infection-behaviour relationship • 7-8 manipulations presented clearly	**Mostly coherent** presentation with: • Clear transitions of infection-behaviour relationship • 5-6 manipulations presented clearly	**Generally** • **understand - able** but may lack smooth flow of infection-behaviour relationship (3-4 manipulations)	**Lacks clear organization**; time concepts appear disjointed (1-2 manipulations)	**Incoherent 0r fragmented**; meaning difficult to follow.

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
3. **Making informed judgement**	**Insightful, fully justified recommendations.** Must include: • Clear recommendation whether the school at B=4 is safe, recommended actions (delaying exams or implement immediate interventions) • cost implications for neighbour school or phased plan. • alternative measures, monitoring plan; recommend non-monetary or cheaper interventions (intensive hygiene training, poster campaigns, peer-monitoring) that may raise effective behaviour without full unit-cost per B • Present clear monitoring plan: re-measure (W) after each intervention and adjust investment. • justification tied to numerical results.	• **Good recommendations** with correct numbers but fewer alternative strategies or less detailed monitoring plan. Gives cost figures and a practical plan.	• **Adequate recommendations** that identify need to improve but lack precise costings or staged plan; gives general advice.	• **Weak recommendations**: may note that infection is high but give vague or infeasible advice with no cost analysis.	• **Poor or no recommendations**: states conclusions incorrectly (e.g., says B=4 is safe) or gives unrelated advice.

SCORING RUBRIC ITEM 6: Wind Turbine Blade Redesign

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
1. **Interpretation of the scenario and task**	• Demonstrates **comprehensive** understanding by identifying **all the five** important variables/concepts: ***1.*** Stress Function σ(x) ***2.*** Target Stress (62 MPa) ***3.*** Initial Guess (x_0=30.0mm) ***4.*** Stopping Criterion ($\Delta x < 0.0005\ mm$), and ***5.*** Area Table/Requirement: A ≥ 60 m	• Demonstrates **good** understanding by identifying **4** important variables/ concepts	• Demonstrates **basic** understanding by identifying **3** important variables/ concepts	• Demonstrates **limited** understanding by identifying **2** important variables/ concepts	• Demonstrates **little** understanding by identifying only **1** variable or **none** Shows no understanding of business analysis context

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
2.Generating and Presenting ideas a) *Generate Ideas that address the task*	• Demonstrates **com-prehensive understanding** by stating **all the five** relevant mathematical approaches: ***1.*** numerical Iteration Setup σ(x); Use of Newton Raphson method ***2.*** differentiation of σ(x) ***3.*** Flow diagram ***4.*** Area Estimation using Trapezoidal Rule ***5.*** Requirement Analysis: Required: A ≥ 60 m	• Demonstrates **good understanding** by stating 4 relevant approaches	• Demonstrates **basic understanding** by stating 3 mathematical approaches needed	• Demonstrates **limited understanding** by stating 2 relevant approaches	• Demonstrates **little understanding** by stating **1** or **no** relevant approach
b) *Makes connections within and between ideas and context*	**Strong logical connections** demonstrated by correctly performing 8-9 of these manipulations: • Correct iteration method (Newton–Raphson recommended) • Defining f(x) and f'(x); show derivative σ′(x) • Show iterations starting x0=30.0 • performing **accurate iterations** to converge to the solution, • full iteration table until tolerance met. • setting up the Trapezoidal Rule, • calculating the estimated area, A • correct numerical integration for area	**Good method and mostly correct numeric.** • Logical connections among most variables and computations (**6-7)** manipulations). • Student uses Newton correctly and reaches a value close to the model answer but may have one or two minor rounding arithmetic slips; area computed	• **Some connections** among variables (4-5) manipulations)	• **Partial correctness.** • Few/weak connections among variables (**2.3)** manipulations). • Student shows the method and some iterations but stops too early or has arithmetic mistakes; area computed using trapezoid but arithmetic error reduces accuracy.	**Weak method or wrong choice.** Uses some iteration but misapplies Newton (e.g., missing derivative),are a computed poorly or using incorrect h.

	• comparing A to the 60 mm^2 requirement.	correctly.			
c) *Presents ideas coherently*	• **Clear, logical, fluent presentation** with a smooth transition between numerical iteration and numerical integration. **8 -9** manipulations presented clearly, including a visual table/diagram of the iteration process.	Mostly coherent presentation with logical sequencing of analyses; **6-7** manipulations presented clearly.	Generally understandable but may lack smooth flow; **4-5** manipulations.	Lacks clear organization; analyses appear disjointed; **2 -3** manipulations.	**Incoherent or fragmented**; meaning difficult to follow.

Basis of Assessment	**SCORE 5**	SCORE 4	SCORE 3	SCORE 2	**SCORE 1**
3. **Making informed judgement**	**Insightful, quantitative** recommendations. Must state: • Stress requirement: using model, final thickness required to obtain σ=62MPa; check if this thickness is acceptable for manufacturing and strength specifications. • providing the converged blade thickness, including a visual representation of the process • Area requirement computed and practical design recommendations (how to meet area and/or stress requirements), • cost/feasibility comment and monitoring suggestions	**Good recommendations** with correct identification of both problems (stress and area) and at least one practical adjustment but less detailed discussion.	**Adequate judgement**. Recognises area shortfall and provides e.g., increase chord or reduce thickness slightly, but lacks follow-up plan.	• **Limited judgement**. Notes shortfall but suggests vague or unrealistic fixes without numbers.	• **No useful judgement**. Fails to identify area shortfall or gives incorrect fix; ignores interaction between area and stress.

PRINCIPAL MATHEMATICS PAPER 2, SET 1
Time: **2HOURS AND 15 MINUTES**

INSTRUCTIONS TO CANDIDATES:

- *This paper consists of* **two** *sections;* **A** and **B.** *It has four examinations items.*
- Sections **A** and **B** have two items each. Answer at least one item from each section
- *Answer a total of* **three** *items.*
- *Any additional item(s) answered will* **not** *be scored.*
- **All** *answers* **must** *be written in the answer booklets/sheets provided.*
- *Graph paper is provided.*
- *Silent non-programmable scientific calculators and mathematical tables with a list of formulae may be used.*

FOR OFFICIAL USE ONLY		
SECTION A	**ITEM 1**	
	ITEM 2	
SECTION B	**ITEM 3**	
	ITEM 4	
	TOTAL	

SECTION A

ITEM 1

A non-governmental organisation (NGO), has been running a farmer support program in Masaka district aimed at improving coffee yields. They assume that increased fertilizer application leads to higher coffee production. To evaluate this, a random sample of 20 household farmers who participated in this program were interviewed, each using a different amount of fertilizer. For each farmer, they recorded the total fertilizer applied (in kg/acre) and their average coffee yield in bags per acre for the most recent harvest.

The NGO has set the following criteria for future action:

- **Support Plan**: If the assumption is true, the NGO will support the farmers with more fertilizers.
- **Expansion Condition**: The NGO plans to expand its program to a new group only if the chance of finding at least 4 selected farmers achieving a yield of 30 bags or more per acre is greater than 0.54.
- **Program Success Criterion**: The overall program is considered a success if the range of the middle 60% of the coffee yield data is less than 25 bags.

Farmer ID	Fertilizer Application (kg/acre)	Coffee yield (bags per acre)
1	10	15
2	25	30
3	15	18
4	30	35
5	20	25
6	5	12
7	35	40
8	12	16
9	28	32
10	18	20
11	40	45
12	8	14
13	22	28
14	32	38
15	17	22
16	29	34
17	11	17
18	38	42
19	6	13
20	55	48

You have been selected to take part in the analysis of the data above.

Help the NGO to;

a) Ascertain whether the it will support farmers with more fertilisers.
b) Propose a framework for deciding whether to expand the programme. Based on this framework, what would your recommendation be?

c) Determine whether the programme is a success and propose strategic recommendations for program enhancement. (hint use groups of 10 from the smallest coffee yield).

ITEM 2

The Ugandan Ministry of Health (MoH) is simultaneously managing two urgent public health issues that strain the national budget and healthcare resources: a community malaria outbreak and a high rate of Road Traffic Injuries (RTIs) on the Kampala northern by pass.
During a malaria outbreak, the MoH needs to treat children. Due to a financial constraint, the Ministry can only afford to purchase one of the two World Health Organization (WHO) recommended treatments. The recommended drugs are Chloroquine (C) and Doxycycline (D) however Chloroquine represents a lower-cost treatment option.

The two drugs can be used independently. Preliminary data on a child's survival indicates that the chances of survival when both drugs C and D are used is 1/6 and the chance of either C or D is 2/3.

The MoH in partnership with the Traffic Police, is studying the high rate of Road Traffic Injuries (RTIs) on the major roads in the country. These injuries place a major burden on the national health system. The MoH assumes that controlling excessive speed is the most effective preventative measure.

Data collected on a random a sample of 50 major roads indicate that the speeds of motorists are normally distributed with a mean of 80 km/h and a standard deviation of 15 km/h.

The (MoH) and Traffic Police need statistical insights to finalize their enforcement and safety policies.

- Identify Reckless Speed by only the top 5% of drivers exceed. This speed will define the most reckless group causing severe accidents.
- Determine Safe speed Interval required to contain at least 85% of all motorists, which will establish the bounds for safe driving speeds.
- Estimate True Mean Speed interval for all roads basing on 99.5% confidence to better inform future highway design and safety standards.

As a mathematician, ~~a~~dvise;

a) the Ministry of health to choose the single drug to be used, and justify the choice of the drug.
b) the Ministry of health and the police address the three policy challenges under Road Traffic Injuries (RTIs) and make justifications.

SECTION B

ITEM 3

A local art gallery is preparing for a new exhibition and needs to move a marble sculpture on to a display platform. The sculpture is too heavy to lift manually, so the gallery staff has decided to use a pulley system with a counter weight.
The sculpture is of mass 450kg and is attached to one end of a strong cable that passes over a smooth fixed pulley mounted on the ceiling beam.
One end of the cable is tied to a crate filled with construction materials that acts as a counterweight. The crate rests on a rough plane inclined at an angle of 60^0 to horizontal concrete floor.
The gallery crew would like know the crates weight sufficient to overcome the friction between the crate and the incline.

given:

- Coefficient of friction between crate and incline: 0.2
- Acceleration due to gravity: 9.8 m/s²

(a) Analyze the lifting system to determine if the minimum crate mass required to initiate the sculpture's movement is also sufficient to sustain its motion at a constant speed. In your response, provide the calculated minimum mass and a reasoned explanation based on the relevant mechanics principles.

(b) As a safety measure, the crate's acceleration must be limited to a maximum of 0.874 m/s². Propose a suitable mass for the crate that adheres to this safety constraint. In your response, justify how this specific mass value ensures a controlled acceleration and discuss one potential risk that is mitigated by imposing this acceleration limit.

ITEM 4

The Israel Ministry of Défense (IMOD) is tracking a cargo aircraft involved in a sensitive operation.

A cargo aircraft, flying horizontally at a constant velocity of $100ms^{-1}$ and at a constant altitude of 200 meters above the horizontal ground, releases a package of emergency supplies

At this exact instant IMOD radar spots the aircraft and communicates to their drone in space positioned 150 km away from the aircraft's current position on a bearing 150^0 relative to the cargo aircraft's position. The drone remains stationary at the altitude of the aircraft. The cargo aircraft maintains its velocity but changes the course to $N30^0E$ after the supplies are released.

If a missile is immediately fired from the drone at a maximum constant speed of $190ms^{-1}$.

The IMOD is struggling to determine the emergency supplies' landing point a critical data point for the operation and the course the missile should take to intercept the cargo aircraft in the shortest time and range possible, thereby minimizing the extent of damage.

Task

Analyse the motion patterns in the context above and provide justified solutions to challenge the IMOD is facing.

SCORING RUBRIC ITEM 1: NGO Farmer Support Program

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
1. **Interpretation of the scenario and task**	Demonstrates **comprehensive** understanding by identifying **all the eight** important variables/ concepts: • Fertilizer application and coffee yield data pairs • Spearman's rank correlation requirement • Support plan criterion for fertilizer dis- tribution • Expansion condition using binomial prob- ability • Program success criterion (middle 60% range) • Data ranking methodology • Probability calculation for high- yield farmers • Percentile analysis for range calculation	Demonstrates **good** understanding by identifying **6-7** of the important variables/ concepts.	Demonstrates **basic** understanding by identifying **4-5** of the important variables/ concepts.	Demonstrates **Limited** understanding by identifying **2-3** of the important variables/ concepts.	Demonstrates **Little** (identifying only **1** variable) or **no** understanding of the task and context.

Basis of Assessment	**SCORE 5**	**SCORE 4**	**SCORE 3**	**SCORE 2**	**SCORE 1**
2.**Generating and Presenting ideas** a) *Generate ideas that address the task*	Demonstrates **comprehensive understanding** by stating **all** relevant statistical methods for all three parts • Spearman's rank correlation: $r_s = 1 - \frac{6\sum d^2}{n(n^2-1)}$ • Data ranking and difference calculation • Correlation interpretation criteria • Decision framework for fertilizer support	Demonstrates **good understanding** by Stating **most** relevant statistical methods (3 of the above)	Demonstrates **basic understandin g** by Stating **any 2** statistical approaches needed	Demonstrates **limited understanding** by Stating **any 1** statistical approach needed	Demonstrates **No understanding** by stating **no** relevant mathematical approach

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
b) *Makes connections within and between ideas and context*	**Strong and logical connections** demonstrated by correctly performing 14-16 of these manipulations: 1. Rank fertilizer application data correctly 2. Rank coffee yield data correctly 3. Calculate rank differences $d = R_x - R_y$ 4. Square the differences d^2 5. Sum of squared differences $\sum d^2 = 4$ 6. Apply Spearman's formula: $r_s = 1 - \frac{6\times4}{20\times399}$ 7. Calculate $r_s = 0.997$ 8. Interpret correlation strength 9. Count farmers with yield ≥ 30: 9 out of 20 10. Calculate probability $p = 9/20 = 0.45$ 11. Set up binomial: $X \sim \text{Binomial}(20, 0.45)$ 12. Calculate $P(X = 0), P(X = 1), P(X = 2), P(X = 3)$ 13. Compute $P(X \leq 3) = 0.083017$ 14. Calculate $P(X \geq 4) = 0.916983$ 15. Sort yield data for percentile analysis 16. Calculate middle 60% range = 22 bags	**Logical connections** among **most** variables and computations (11-13 manipulations)	**Some connections** among variables (8-10 manipulations)	**Few/weak connections** among variables (5-7 manipulations)	**No clear connections**; context ignored (<5 manipulations)

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
c) *Presents ideas coherently*	**Clear, logical, fluent** presentation with: • Smooth transitions between correlation, probability, and range analysis • Well-organized statistical report structure • Complete recommendations for all three parts • 14-16 manipulations presented clearly	**Mostly coherent** presentation with: • Logical sequencing of statistical analyses • Clear transitions between decision criteria • Minor lapses don't hinder understanding • 11-13 manipulations presented clearly	**Generally understandable** but may lack smooth flow between statistical methods (8-10 manipulations)	**Lacks clear organisation**; statistical analyses appear disjointed (5-7 manipulations)	**Incoherent Or fragmented**; meaning difficult to follow (<5 manipulations)
3. **Making informed judgement**	Forms **highly informed, insightful** judgement by: • Providing **clear fertilizer support recommendation** based on strong correlation • Offering **comprehensive expansion framework** with probability justification • Determining **program success** with proper range analysis • Giving **specific strategic recommendations** for program enhancement • Integrating **all three analyses** into cohesive decision framework	Forms **clear, logical** judgement by: • Connecting statistical results to NGO criteria • Making data-driven recommendations for each part • Supporting conclusions with calculations • Addressing all three task components	Forms **generally relevant** judgement by: • Applying statistics • to decision context • Providing basic recommend-dations • Beginning to link analyses to program decisions	Forms **limited** judgement by: • Recognizing agricultural context • Attempting basic program assessment • Showing understanding of decision needs	Forms **unclear, unsupported** judgement by: • Showing No understanding of program objectives • Providing irrelevant conclusions • No evident use of statistical analysis

SCORING RUBRIC ITEM 2: Ministry of Health Policy Analysis

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
1. **Interpretation of the scenario and task**	Demonstrates **comprehensive** understanding by identifying **all nine** important variables/concepts: • Drug survival probabilities: $P(C \cap D) = {}^{1/6}$ $P(C \cup D) = {}^{2/3}$ • Independence assumption for drugs • Cost comparison between treatments • Normal distribution for speeds: $X \sim N(80, 15^2)$ • Reckless speed threshold (top 5%) • Safe speed interval (85% containment) • True mean speed interval (99.5% confidence) • Sample size $n = 50$ for speed data • Policy implications for health and safety	Demonstrates **good** understanding by identifying **7-8** of the important variables/ concepts.	Demonstrates **basic** under-standing by identifying **5-6** of the important variables/ concepts.	Demonstrates **Limited** understanding by identifying **3-4** of the important variables/concepts.	Demonstrates **little** (identifying only **1-2** variables) or **no** under-standing of the task or context.

Basis of Assessment	**SCORE 5**	**SCORE 4**	**SCORE 3**	**SCORE 2**	**SCORE 1**
2.**Generating and Presenting ideas** a) *Generate ideas that address the task*	Demonstrates **comprehensive understanding** by stating **all four** relevant mathematical approaches: • Probability addition rule: $P(C \cup D) = P(C)+P(D)-P(C \cap D)$ • Independence: $P(C \cap D)= P(C)\times P(D)$ • Quadratic equation solution for individual probabilities • Cost-effectiveness analysis framework	Demonstrates **good understanding** by stating **most** relevant mathematical approaches (3 of the above)	Demonstrates **basic understanding** by stating **basic** mathematical approaches needed (2)	Demonstrates **limited understanding** by stating **few** relevant mathematical approaches (1)	Demonstrates **little understanding** by stating **none of the** relevant mathematical approaches

Basis of Assessment	**SCORE 5**	**SCORE 4**	**SCORE 3**	**SCORE 2**	**SCORE 1**
b) *Makes connections within and between ideas and context*	Making **strong logical connections** demonstrated by correctly performing 12-14 of these manipulations: 1. Set up probability equations: $pq = \frac{1}{6}$, $p + q - \frac{1}{6} = \frac{2}{3}$ 2. Solve for $p + q = \frac{5}{6}$ 3. Form quadratic equation: $x^2 - \frac{5}{6}x + \frac{1}{6} = 0$ 4. Solve quadratic: $x = \frac{5 \pm 1}{12}$ 5. Determine probabilities: $P(C) = \frac{1}{2}$, $P(D) = \frac{1}{3}$ 6. Compare cost-effectiveness 7. Find z-value for top 5%: $z = 1.6449$ 8. Calculate reckless speed: $80 + 1.6449 \times 15 = 104.67$ km/h 9. Find z-value for 85% interval: $z = 1.4395$ 10. Calculate safe speed bounds: $80 \pm 1.4395 \times 15$ 11. Determine 99.5% confidence z-value: $z = 2.807$ 12. Calculate standard error: $\frac{15}{\sqrt{50}} = 2.121$ 13. Compute margin of error: $2.807 \times 2.121 = 5.95$ 14. Determine confidence interval: 80 ± 5.95	Making **logical connections** among **most** variables and computations (9-11 manipulations)	Making **some connections** among variables (6-8 manipulations)	Making **few/weak connections** among variables (3-5 manipulations)	Making **no clear connections**; Context ignored (<3 manipulations)

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
c) *Presents ideas coherently*	Presenting work in a **clear, logical, fluent** presentation with: • Smooth transitions between drug analysis and speed policy • Well-organized policy recommendation structure • Complete justifications for all recommendations • 12-14 manipulations presented clearly	Presenting work in **mostly coherent** presentation with: • Logical sequencing of analyses • Clear transitions between health and safety components • Minor lapses don't hinder understanding • 9-11 manipulations presented clearly	Presenting work in **generally understandable way** but may lack smooth flow between analysis types (6-8 manipulation)	Presenting work that **lacks clear organisation**; analysis appear disjointed (3-5 manipulations)	Presenting work in **Incoherent Or fragmented way**; meaning is difficult to follow (<3 manipulations)
3. **Making informed judgement**	Forms **highly informed, insightful** judgement by: • Providing **evidence-based drug selection** with cost-benefit analysis • Offering **comprehensive speed policy framework** with three specific thresholds • Giving **practical enforcement recommendations** for traffic police • Integrating **health and safety considerations** into cohesive policy • Considering **real-world implementation** factors	Forms **clear, logical** judgement by: • Connecting calculations to policy decisions • Making specific recommendations for both parts • Supporting policy choices with quantitative analysis • Addressing all policy challenges	Forms **generally relevant** judgement by: • Applying mathematics to policy context • Providing basic recommendations • Beginning to link analysis to real-world impact	Forms **limited** judgement by: • Recognizing public health context • Attempting basic policy suggestions • Showing understanding of decision criteria	Forms **un clear, un supported** judgement by: • Showing No understanding Of policy objectives • Providing irrelevant conclusions • No evident use of mathematical analysis

SCORING RUBRIC ITEM 3: Art Gallery Pulley System

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
1. **Interpretation of the scenario and task**	Demonstrates **comprehensive** understanding by identifying **all eight** important variables/concepts: • Sculpture mass: m_s = 450 kg • Incline angle: $\theta = 60^\circ$ • Coefficient of friction: $\mu = 0.2$ • Gravity: $g = 9.8$ m/s^2 • Maximum acceleration constraint: a_{max}= 0.874 m/s^2 • Force resolution on inclined plane • Newton's second law application • Safety risk mitigation requirements	Demonstrates **good** understanding by identifying **6-7** of the important variables/ concepts.	Demonstrates **basic** understanding by identifying **4-5** of the important variables/ concepts.	Demonstrates **Limited** understanding by identifying **2-3** of the important variables/ concepts.	Demonstrates **Little understanding** (identifying at most **1** variable)
2.**Generating and Presenting ideas**	• Stating **all** relevant physics principles and equations • Making **strong logical connections** between static and dynamic analysis • Presenting work in **clear, logical, fluent** manner with 13-15 correct manipulations	Demonstrates **good understanding** by: • Stating • **most** relevant physics equations • Making **logical connections** between most concepts • Presenting work with 10-12 • correct manipulations in clear • manner	Demonstrates **basic understanding** by: • Stating **basic** physics principles • Making **some connections** between concepts • Presenting work with 7-9 correct manipulations	Demonstrates **limited understanding** by: • Stating **few** rel- evant equations • Making **weak connections** between concepts • Presenting work with 4-6 correct manipulations	Demonstrates **little understanding** by: • Stating only **one** equation or **none** • Making **no clear connections** • Presenting work with **less than 4** correct manipulations

Basis of Assessment	**SCORE 5**	**SCORE 4**	**SCORE 3**	**SCORE 2**	**SCORE 1**
a) *Generate ideas that address the task*	Demonstrates **comprehensive understanding** by stating **all five** relevant physics approaches: • Force resolution: $mg \sin\theta$, $mg \cos\theta$ • Friction force: $f = \mu N = \mu mg \cos\theta$ • Equilibrium equations for impending motion • Newton's second law for dynamic case • Tension relationship in pulley system	States **most** relevant physics approaches (4 of the above)	States **basic** physics approaches needed	States **few** relevant physics approaches	States **minimal** or **no** relevant physics approaches

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
b) *Makes connections within and between ideas and context*	Making **strong logical connections** demonstrated by correctly performing 13-15 of these manipulations: 1. Resolve weight into components: $mg\sin\theta$, $mg\cos\theta$ 2. Calculate normal force: $N = m_c g\cos\theta$ 3. Calculate maximum friction: $f_{max} = \mu m_c g\cos\theta$ 4. Set up equilibrium equations for im-pending motion 5. Solve for minimum crate mass: $m_c = \frac{m_s}{\sin\theta - \mu\cos\theta}$ 6. Compute $\sin 60° = 0.8660, \cos 60° = 0.5$ 7. Calculate $\sin\theta - \mu\cos\theta = 0.7660$ 8. Compute $m_c = 450/0.7660 = 587.47$ kg 9. Analyze static vs kinetic friction implications 10. Set up dynamic equations with acceleration 11. Apply Newton's second law to both masses 12. Derive tension: $T = m_s(g + a)$ 13. Substitute into crate equation 14. Solve for safe mass: $m_c = \frac{m_s(g+a)}{g(\sin\theta - \mu\cos\theta) - a}$ 15. Compute safe mass: $m_c = 724.18$kg	Making **logical connections** among **most** variables and computations (10-12 manipulations)	Making **some connections** among variables (7-9 manipulations)	Making **few/weak connections** among variables (4-6 manipulations)	Making **no clear connections**; context ignored (<4 manipulations)

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
c)*Presents ideas coherently*	**Clear, logical, fluent** presentation with: • Smooth transitions between static and dynamic analysis • Well-organized safety assessment structure • Complete risk mitigation discussion • 13-15 manipulations presented clearly	**Mostly coherent** presentation with: • Logical sequencing of physics analysis • Clear transitions between calculation stages • Minor lapses don't hinder understanding • 10-12 manipulations presented clearly	**Generally understandable** but may lack smooth flow between analysis types (7-9 manipulations)	**Lacks clear organization**; physics concepts appear dis-jointed (4-6 manipulations)	**Incoherent Or fragmented**; meaning difficult to follow (<4 manipulations)
3.**Making informed judgement**	Forms **highly informed, insightful** judgement by: • Providing **precise mass calculations** for both scenarios • Offering **comprehensive safety analysis** with risk mitigation • Explaining **static vs kinetic friction implications** • Giving **specific** • **Safety recommendations** with justification • Considering **practical implementation** factors	Forms**clear, logical** judgement by: • Connecting physics calculations to safety requirements • Making specific mass recommendations • Supporting safety choices with quantitative analysis • Addressing both parts completely	Forms **generally relevant** judgement by: • Applying physics to engineering context • Providing basic safety recommendations • Beginning to link calculations to risk assessment	Forms **limited** judgement by: • Recognizing safety context • Attempting basic mass calculations • Showing understanding Of acceleration concerns	Forms **un clear, un supported** judgement by: • Showing No understanding Of safety objectives • Providing irrelevant conclusions • No evident use of physics analysis

SCORING RUBRIC ITEM 4: Israel Ministry of Defense Interception

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
1. **Interpretation of the scenario and task**	Demonstrates **comprehensive** understanding by identifying **all nine** important variables/concepts: • Aircraft velocity: 100 m/s horizontal • Altitude: 200 m • Package projectile motion analysis • Drone position: 150 km at bearing 150° • Coordinate system setup • Aircraft course change to N30°E • Missile speed: 190 m/s • Relative motion principles • Interception time minimization	Demonstrates **good** understanding by identifying **7-8** of the important variables/ concepts.	Demonstrates **basic** understanding by identifying **5-6** of the important variables/ concepts.	Demonstrates **Limited** understanding by identifying **3-4** of the important variables/ concepts.	Demonstrates **little** understanding (identifying only **1-2** variables) or **no** under-standing of the task or context.

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
2.**Generating and Presenting ideas** a) *Generate ideas that address the task*	Demonstrates **comprehensive understanding** by stating **all the four** relevant mathematical approaches: • Projectile motion equations: $y = y_0 - \frac{1}{2}gt^2$ • Coordinate transformation for bearings • Relative velocity vectors • Interception time optimization	Demonstrates **good understanding** by stating **most** relevant mathematical approaches (3 of the above)	Demonstrates **basic understanding** by stating **basic** mathematical approaches needed (2)	Demonstrates **limited understanding** by stating 1 relevant mathematical approach	Demonstrates **little understanding** by stating **no** relevant mathematical approach

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
b) *Makes connections within and between ideas and context*	**Strong logical connections** demonstrated by correctly performing 12-14 of these manipulations: 1. Calculate package fall time: $200 = \frac{1}{2} \times 9.8 \times t^2$ 2. Solve for $t = 6.388$ s 3. Calculate Calculate landing distance: $100 \times 6.388 = 638.8$ m 4. Convert drone position from polar to Cartesian coordi- nates 5. Calculate x_d = 150 × sin 150° =75 km 6. Calculate $y_d = 150 \times \cos 150° = -129.9$ km 7. Convert km to meters 8. Resolve aircraft velocity after turn 9. Calculate v_{ax} = 100 × sin 30° = 50 m/s 10. Calculate v_{ay} = 100×cos 30° = 86.60 m/s 11. Set up interception equations 12. Express missile velocity components in terms of time 13. Apply missile speed constraint: $v_{mx}^2 + v_{my}^2 = 190^2$ 14. Solve numerically for optimal interception time	**Logical connections** among **most** variables and computations (9-11 manip-ulations)	**Some connections** among variables (6-8 manipulations)	**Few/weak connections** among variables (3-5 manipulations)	**No clear connections**; context ignored (<3 manipulations)

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
c)*Presents ideas coherently*	**Clear, logical, fluent** presentation with: • Smooth transitions between projectile and interception analysis • Well-organized military operation structure • Complete mission recommendations • 12-14 manipulations presented clearly	**Mostly coherent** presentation with: • Logical sequencing of kinematic analyses • Clear transitions between calculation stages • Minor lapses don't hinder understanding • 9-11 manipulations presented clearly	**Generally understand-able** but may lack smooth flow between analysis types (6-8 manipulations)	**Lacks clear organisation**; kinematics concepts appear disjointed (3-5 manipulations)	**Incoherent Or fragmented**; meaning difficult to follow (<3 manipulations)

3.**Making informed judgement**	Forms **highly informed, insightful** judgement by: • Providing **precise landing point calculation** for emergency supplies • Offering **optimal interception strategy** with time minimisation • Giving **comprehensive mission recommendations** • Considering **real-time operational factors** • Integrating **all motion analysis** into cohesive plan	Forms **clear, logical** judgement by: • Connecting kinematics calculations to mission objectives • Making specific interception recommendations • Supporting operational choices with quantitative analysis • Addressing both landing and interception challenges	Forms **generally relevant** judgement by: • Applying mathematics to military context • Providing basic operational recommendations • Beginning to link analysis to mission success	Forms **limited** judgement by: • Recognizing military operation context • Attempting basic trajectory calculations • Showing understanding Of interception concept	Forms **unclear, unsupported** judgement by: • Showing No understanding of mission objectives • Providing irrelevant conclusions • No evident use of kinematic analysis

PRINCIPAL MATHEMATICS PAPER 1, SET 2
Time: **3HOURS**

INSTRUCTIONS TO CANDIDATES:

- *This paper consists of* **three** *sections;* **A, B** and **C.** *It has six examinations items.*
- *Section* **A** *has* **two** *items. Answer* ***one*** *item* ***only****.*
- Section **B** has **one compulsory** item.
- *Section* ***C*** *has two parts;* ***part I*** *and* ***part II****. Answer one item from each part.*
- *Answer a total of* **four** *items.*
- *Any additional item(s) answered will* **not** *be scored.*
- **All** *answers* **must** *be written in the answer booklets/sheets provided.*
- *Graph paper is provided.*
- *Silent non-programmable scientific calculators and mathematical tables with a list of formulae may be used.*

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SECTION A	**ITEM 1**	
	ITEM 2	
SECTION B	**ITEM 3**	
SECTION C	**ITEM 4**	
	ITEM 5	
	ITEM 6	
	TOTAL	

SECTION A

ITEM 1

Mr. Katende, a local farmer, is planning to expand his operations by investing in a new sustainable farming project. He is evaluating two financial options over a five- year planning period; to either invest first and use the proceeds later or borrow from a microfinance institution to expand immediately.

Option A: He can delay expansion and earn interest first by investing 20 million in a fixed deposit account that offers an annual interest rate of 8%, compounded semi-annually. He plans to withdraw the accumulated amount after 5 years to fund the farm expansion.

Option B: He could combine his own 20 million with a loan of UGX 15,000,000 taken from a microfinance institution to expand immediately. The microfinance uses a digital loan system that applies interest at continuous compounding rate. For agricultural loans, there is one -year grace period - during which no interest accrues, before loan repayment begins. He has been informed that a loan of similar amount with no grace period grew to UGX.17,624,000 in two years. Mr. Katende wishes to know how much he would owe if he gets the loan of UGX. 15,000,000 for five years.

To optimize production, he aims to ensure his production methods remain profitable while conserving soil fertility and minimizing financial risk. The agricultural consultant provides the following information: the crop yield Y(in kg) responds to fertilizer, x in kg per acre according to the function $Y(x) = 500 + 40x - 2x^2$; The crops sell at UGX. 3500 per kg, the cost of the fertilizer is UGX. 1500 per kg, other costs are UGX. 200,000 per acre. The initial expansion will cover the newly acquired three acres of land. Mr. Katende assumes that if he proceeds with option B, the total annual net profit from these three acres calculated using the optimal fertilizer rate, will be applied directly towards repaying the loan.

To diversify, he plans to select 3 varieties from 10 unique types of drought-resistant seeds for an initial trial and plant one variety per acre on his recently acquired three acres land to test their performance and suitability under local conditions.

Tasks:

a) Compare the two financial options to help Mr. Katende make an informed decision.
b) Based on your findings, prepare a short report advising Mr. Katende on better financial option for his five-year plan, whether the annual profit is sufficient to pay off the total loan obligation and how seed selection might influence his financial decision assuming each new variety has a different yield potential.

ITEM 2

Faced with persistent dry seasons that disrupt water access, a secondary school faces water shortage during the dry season and wants to install rainwater harvesting cuboid tank. The engineer explains that the possible side lengths (in meters) of the tank satisfy:

$$f(x) = x^3 - 10x^2 + 31x - 30 = 0.$$

Records from the past rainy season show that the school collected: $1200, 1800, 2700, \ldots litres$ each month, increasing by 50% from month to month. The rainy season lasts for four months. The school has 800 learners, each needing 40 litres of water per day for drinking, cooking and cleaning.

To build the tank, exactly two lead technicians must be selected from **n** available technicians while the remaining offer supportive roles during the construction. The engineer mentions that there are 66

different possible 2-person teams that could accomplish the work and that this number is equal the coefficient of y^2 in the expansion of $(1 + y)^n$.

The headteacher must arrange payment for the construction period. The two lead technicians are paid UGX 60,000 per day, and the remaining supportive technicians are each paid UGX 30,000 per day. The construction is expected to take 10 days.

Tasks:

a) Based on your results and the school's water needs, write a brief advisory note recommending whether the engineer should keep the current tank dimensions or propose new ones.
b) Advise the headteacher on the total number of available technicians and explain how this information could affect payment decisions during the construction period.

SECTION B

ITEM 3

A real estate developer plans to convert a trapezoidal plot into a customer parking area. The plot was surveyed using a coordinate system (in meters) from a reference point on the public road. The corner coordinates of the plot are A (0,0), B (26,0), C (20,17), D (4,17). Side AB lies along the public road and serves as the main access road. The other sides AD, DC, and CB border neighboring plots and cannot be crossed or encroached upon.
The developer intends to construct two rows of vehicle parking spaces (double-loaded), separated by an aisle (drive through area). The dimensions of each parking space for one vehicle are 2.5 m × 5 m. The developer wants to compare 90° and 60° angled parking where the angle measured from AB toward the interior of the plot.

Aisle width standards depending on the intended traffic flow:

Type of aisle	**Minimum width(m)**
Two – way Aisle	7.0
One – way Aisle (90^0 bays)	6.0
One – way Aisle (60^0 bays)	5.5

To enhance safety, the engineer must install pole CCTV surveillance cameras to provide full coverage of the entire parking area (including aisles). Each camera produces a sector-shaped coverage region defined by radius 25m, field-of-view 70° from its position. All cameras must be positioned inside the plot boundary and every point of the parking area must lie inside the field of view of at least one camera.

Tasks

Advise the engineer on the:

a) Parking layout design.
b) Safety and surveillance measures around this parking space.

SECTION C

PART 1

ITEM 4

A new parish irrigation scheme draws water from a central reservoir to feed crop field sprinklers. If the flow rate to the field is too low, the irrigation is ineffective; if it is too high, the field becomes waterlogged. Agricultural engineers have determined that irrigation is ineffective below 100 m³/h and waterlogging occur above 600 m³/h.
At 6:00 p.m. (t = 0), the reservoir holds 200 m³ of water. The reservoir interacts with two water movements: Inflow, I(t), from a nearby river, which varies naturally due to temperature and rainfall, and outflow, Q(t), to the irrigation sprinklers, controlled by a pumping system.

The inflow rate is modelled$by\ I(Q) = 150 + 80\sin(30t)$ and the controlled outflow rate is modelled by$Q(t) = 3t^2 - 36t + 60$ where I(Q) and Q(t) are in m³/h, t is measured in hours for 0 ≤ t ≤ 24.

The irrigation management wants to keep irrigation within the safe flow range, prevent the reservoir from running dry or overflowing and use mathematical modelling to plan effective pumping times.

Tasks:

Help the management to:

a) Conduct a comprehensive analysis of the pumping schedule and provide a justification.
b) If a farm attendant notices that the water from the sprinklers is 95m³/h at 8:00A.M., what would be your advice?

ITEM 5

Every school day, your siblings drink tea before leaving home at 7:30 A.M. so that they can report to school on time.
Your mother usually wakes up at 6:00A.M. and takes 30 minutes to prepare the tea. The moment the tea is ready and poured into the cup, its temperature is 90°C. The surrounding (room) temperature is constant at 25°C and it begins to cool naturally.

Ten minutes later, its temperature has drops to 70°C. Assume that surrounding temperature remains constant, no reheating, no stirring, no isolation or other heat loss processes occur except cooling to the room air.

Your siblings find it comfortable to start drinking the tea only when its temperature is 30°C, and they take exactly 15 minutes to finish drinking before leaving home.
However, they sometimes fail to take the tea or arrive late due to delayed breakfast, your siblings wish to advise their mother on the correct time she should wake up so that the tea is ready on time, it cools naturally and they finish drinking exactly at 7:30 A.M.

Task:

a) Advise the mother on the optimal waking time to meet all requirements.
b) Compare your recommended time with the mothers' current 6:00am routine.

PART 2
ITEM 6

Innovatech solutions Ltd; a technology and consulting firm, is preparing its annual report for 2025. The company's total capital is UGX. 500 million. The company's operations are divided into two main sections; section A is for software development and section B is for IT consulting and support.

For the fiscal year 2024, the accounting department initially reported profit figures as: UGX. 25.8 million profit for section A and UGX.14.56 million profit for section B.

However, the internal audit team has discovered potential discrepancies in the figures reported. After reviewing the financial records, they have estimated possible error profit margins of $\mp$ 5% and $\mp$ 8% for section A and B respectively.

The management would wish know the range of the total profits for the two sections combined and the percentage that these total profits represent of the company's total capital. This will help the management make informed decisions about future investments for the company's sustainability

After analysing the possible profit ranges, the management proposed a simple linear model that assumes the percentage changes in profit for both sections are directly proportional. The proportionality constant for this model is defined by the ratio of section B's maximum allowable error margin to section A's maximum allowable error margin.

The company intends to use this model to forecast profitability targets. To apply the model, management revised Section A's profit target downward to UGX. 25million from the initially reported UGX. 25.8 million. They now wish to know the target for section B.

Task:

As a learner of mathematics, help the management at Innovatech solutions to:

a) Provide management with clear insights into the range within which the total profit for both sections lie, the range as percentage of the company's total capital and their significance for strategic decision-making about the company's sustainability and future investments.

b) Develop and validate the proportional forecasting model, applying it to the specific scenario where Section A's target is revised. Your work should provide management with a justification for using this approach.

END

SCORING RUBRIC ITEM 1: Farmer Financial Planning

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
1.**Interpretation of the scenario and task**	• Demonstrates **comprehensive** understanding by dentifying **all the eight** important variables/concepts: 1. Option A: Compound interest with semi-annual compounding 2. Option B: Continuous compounding with grace period 3. Loan growth com- parison for rate determination 4. Profit function optimization for fertilizer application 5. Revenue and cost functions derivation 6. Seed selection combinatorics 7. Risk assessment and diversification benefits 8. Five-year financial planning horizon.	• Demonstrates **good** understanding. • Identifies **6-7** important variables/concepts	• Demonstrates **basic** understanding. • Identifies **4-5** important variables/concepts.	• Demonstrates **limited** understanding. • Identifies **2-3** important variables/concepts.	• Demonstrates **little** understanding. • Identifies only **1** variable or **none.** • Shows no under-standing of financial planning contexts.

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
2.**Generating and Presenting ideas** a) *Generate ideas that address the task*	• Demonstrates **comprehensive understanding.** • States **all five** relevant mathematical approaches: 1. Compound interest: $A = P(1 + \frac{r}{n})^{nt}$ 2. Continuous compounding: $A = Pe^{rt}$ 3. Profit optimization using derivatives 4. Combinatorics for seed selection 5. Cost-benefit analysis framework	• Demonstrates **good understanding.** • States **most (4)** relevant approaches.	• Demonstrates **basic understanding.** • States **basic (3)** mathematical approaches needed	• Demonstrates **limited under-standing.** • States **few (2)** relevant approaches	• Demonstrates **little understanding.** • States **minimal (1)** or **no** relevant approaches
b)Makes connections within and between ideas and context	• **Strong logical connections** demonstrated by correctly performing 14-16 of these manipulations: 1. Calculate Option A future value: $20M \times (1.04)^{10}$ 2. Compute $(1.04)^{10} = 1.48024428$ 3. Final Option A: 29, 604, 886 UGX 4. Determine continuous rate from given loan: $17.624M = 15M \times e^{2r}$ 5. Solve for $r = 0.0806$ 6. Calculate	• **Logical connections** among **most** variables and computations (11-13 manipulations)	• **Some connections** among variables (8-10 manipulations)	• **Few/weak connections** among variables (5-7 manipulations)	• **No clear connections**; context ignored (<5 manipulations)

	Option B obligation: $15M \times e^{0.0806 \times 4}$ 7. Compute $e^{0.3224} = 1.3804$ 8. Final Option B: 20, 706, 000 UGX 9. Develop revenue function: $R(x) = 3500 \times (500 + 40x - 2x^2)$ 10. Develop cost function: $C(x) = 1500x + 200,000$ 11. Form profit function: $P(x) = R(x) - C(x)$ 12. Differentiate profit: $P'(x) = 138,500 - 14,000x$ 13. Solve for optimal $x = 9.89$ kg/acre 14. Calculate max profit per acre: 2, 235, 110 UGX 15. Total profit for 3 acres: 6, 705, 330 UGX 16. Seed combinations: $\binom{10}{3} = 120$				

c) Presents ideas coherently	**SCORE 5**	**SCORE 4**	**SCORE 3**	**SCORE 2**	**SCORE 1**
	Clear, logical, fluent presentation with: • Smooth transitions between financial options analysis. • Well-organized advisory report structure. • Complete recommendations for both parts. • 14-16 manipulations presented clearly	**Mostly coherent** presentation with: • Logical sequencing of financial analyses. • Clear transitions between decision criteria. • Minor lapses don't hinder under-standing. • 11-13 manipulations presented clearly	**Generally understandable** but may lack smooth flow between financial methods (8-10 manipulations)	**Lacks clear organization**; financial analyses appear disjointed (5-7manipulations)	**Incoherent or fragmented;** meaning difficult to follow (<5 manipulations)

3. **Making informed judgement**	Forms **highly informed, insightful** judgement by: • Providing **comprehensive financial comparison** with quantitative justification. • Offering **evidence-based Option B recommendation** with risk assessment. • Giving **specific implementation strategy** with re-payment timeline. • Integrating **seed diversification benefits** into financial planning. • Considering **real-world agricultural constraints** and market factors	Forms **clear, logical** judgement by: • Connecting calculations to financial decision. • Making specific option recommendations. • Supporting conclusions with quantitative analysis. • Addressing both financial and agricultural aspects	Forms **generally relevant** judgement by: • Applying mathematics to farming context. • Providing basic financial recommendation. • Beginning to link analysis to practical implementation	Forms **limited** judgement by: • Recognizing farming financial context. • Attempting basic option comparison. • showing under-standing of decision criteria	Forms **un-clear, un-supported** judgement by: • Showing no understanding of financial objectives. • Providing irrelevant conclusion • No evident use of mathematical analysis

SCORING RUBRIC ITEM 2: Water Harvesting Tank Project

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
1.**Interpretation of the scenario and task**	Demonstrates **comprehensive** understanding Identifies **all seven** important variables/concepts: 1. Cubic equation for tank dimensions: $x^3 - 10x^2 + 31x - 31 = 0$ 2. Geometric sequence for water collection: $1200, 1800, 2700, \ldots$ 3. School water requirements: 800 learners x 40 litres/day. 4. Combinatorics for technician teams: $nC2 = 66$ 5. Payment structure: lead vs support technicians 6. Capacity vs requirement analysis 7. Construction cost budgeting	Demonstrates **good** understanding Identifies **5-6** important variables/ concept	Demonstrates **basic** understanding Identifies **3-4** important variables/ concept	Demonstrates **limited** understanding Identifies **2** important variables/ concept	Demonstrates **little** understanding Identifies only **1** variable or **none** Shows no understanding of engineering context

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
2.**Generating and Presenting ideas** a) *Generate ideas that address the task*	• Demonstrates **comprehensive understanding.** • States **all four** relevant mathematical approaches: 1. Polynomial root finding for tank dimensions 2. Geometric series sum for water col-lection 3. Combinatorial equation solving 4. Cost calculation and budgeting	• Demonstrates **good understanding.** • States **most** relevant approaches (3 of above)	• Demonstrates **basic understanding.** • States **basic** mathematical approaches needed	• Demonstrates **limited under-standing.** • States **few** relevant approaches	• Demonstrates **little understanding.** • States **minimal** or **no** relevant approaches
b) Makes connections within and between ideas and context	• Strong logical connections demonstrated by correctly performing 12-14 of these manipulations: 1. Solve cubic equation: f (2) = 0 identified 2. Polynomial division: $\frac{(x^3 - 10x^2 + 31x - 30}{x - 2} = x^2 - 8x + 15$ 3. Factor quadratic: (x – 3) (x − 5) = 0 4. Determine dimensions: 2m, 3m, 5m 5. Calculate volume: 2 × 3 × 5 = 30 m = 30,000 litres. 6. Identify GP parameters: a = 1200, r = 1.5 7. Calculate total collection: $S = 1200 \times \frac{1.5^4 - 1}{0.5}$	• Logical connections among most variables and computation (9-11 manipulations)	• Some connections among variables (6-8 manipulations)	• Few/weak connections among variables (3-5 manipulations)	• No clear connections; context ignored (<3 manipulations)

	8. Compute $1.5^4 = 5.0625$ 9. Final collection: 9, 750 litres 10. Calculate daily requirement: 800 × 40 = 32, 000 litres 11. Calculate dry season requirement: 32, 000 × 90 = 2, 880, 000 litres. 12. Solve combinatorial equation: $\frac{n(n-1)}{2}$ = 66. 13. Find n = 12 technicians 14. Calculate labor cost: 2 × 60, 000 + 10 × 30, 000 = 420, 000/day. 15. Total cost: 420, 000 × 10= 4, 200, 000 UGX				
c) *Presents ideas coherently*	**Clear, logical, fluent** presentation with: • Smooth transitions between engineering analyses • Well-structured advisory notes for both parts • Complete dimensional and financial recommendations • 12-14 manipulations presented clearly	**Mostly coherent** presentation with: • Logical sequencing of calculations • Clear transitions between technical and financial aspects • 9-11 manipulati	**Generally understandable** but may lack smooth flow between methods (6-8 manipulations)	**Lacks clear organization**; analyses appear disjointed (3-5 manipulations)	**Incoherent or fragmented**; meaning difficult to follow (<3 manipulations)

		ons presented clearly			
3.**Making informed judgement**	Forms **highly informed, insightful** judgement by: • Providing **critical tank adequacy assessment** with quantitative evidence • Offering **compelling recommendation for new dimensions** with justification. • Giving **comprehensive payment advice** with budget planning. • Integrating **all technical analyses** into practical implementation plan. • Considering **school's actual water needs** versus current capacity.	Forms **clear, logical** judgement by: • Connecting calculations to engineering decisions • Making specific dimensional and financial recommendations • Supporting conclusions with quantitative analysis • Addressing both technical and budgetary aspects	Forms **generally relevant** judgement by: • Applying mathematics to engineering context. • Providing basic design recommendations. • Beginning to link analysis to practical implementation.	Forms **limited** judgement by: • Recognizing engineering context. • Attempting basic design suggestions. • Showing understanding of water requirements.	Forms **unclear, unsupported** judgement by: • Showing no understanding of project objectives. • Providing irrelevant conclusion. • No evident use of mathematical analysis.

SCORING RUBRIC ITEM 3: Parking Lot Design and Surveillance

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
1. **Interpretation of the scenario and task**	Demonstrates **comprehensive** understanding by identifying **all the eight** important variables/concepts: 1. Trapezoidal plot coordinates: A (0,0), B (26,0), C (20,17), D (4,17) 2. Parking space dimensions: 2.5m 5m 3. Aisle width standards for different parking angles 4. Camera coverage: 25m radius, 70 field-of-view 5. Area calculation using trapezoid formula 6. Spatial optimization for parking layout 7. Surveillance coverage geometry 8. Safety requirements and standards	Demonstrates **good** understanding. • Identifies **6-7** important variables/concepts	Demonstrates **basic** understanding • Identifies **4-5** important variables/concepts	Demonstrates **limited** under-standing. • Identifies **2-3** important variables/concepts	Demonstrates **little** understanding. • Identifies only **1-2** variables or **none**. • Shows no understanding of spatial design context

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
a) *Generate ideas that address the task*	• Demonstrates **comprehensive understanding.** • States **all four** relevant mathematical approaches: 1. Coordinate geometry and area calculation 2. Spatial optimization for parking layouts 3. Sector area calculation for camera coverage 4. Comparative analysis of parking configurations	• Demonstrates **good understanding.** • States **most** relevant approaches (3 of above)	• Demonstrates **basic understanding.** • States **basic** mathematical approaches needed	• Demonstrates **basic understanding.** • States **few** relevant approaches	• Demonstrates **little understanding.** • States **minimal** or **no** relevant approaches
b) *Makes connections within and between ideas and context*	**Strong logical connections** demonstrated by correctly performing 10-12 of these manipulations: 1. Calculate trapezoid area: $0.5\ (26 + 16) \times 17 = 357\ m$ 4. Determine base lengths: AB = 26m, DC = 16m 5. Calculate 90 parking capacity: $26 \div 2.5 = 10.4 \rightarrow 10$ spaces 6. Calculate 60 parking capacity estimation 7. Compare aisle requirements: 6.0m vs 5.5m 8. Analyze trapezoid shape utilization for different lay-	**Logical connections** among **most** variables and computations (8-9 manipulations)	**Some connections** among variables (6-7 manipulations)	**Few/weak connections** among variables (4-5 manipulations)	**No clear connections**; context ignored (<4 manipulations)

	outs 9. Calculate camera sector area: 10. $\frac{70}{360} x\ \pi\ x\ 25^2\ \approx 382\ m$ 11. Compare camera coverage area vs plot area 12. Determine optimal camera positions 13. Estimate parking capacities: 16-20 spaces 14. Analyze maneuverability factors 15. Develop safety measure recommendations				
c) *Presents ideas coherently*	**Clear, logical, fluent** presentation with: • Smooth transitions between layout design and surveillance planning. • Well-organized engineering advisory structure. • Complete recommendations for both parking and safety aspects. • 10-12 manipulations presented clearly,	**Mostly coherent** presentation with: • Logical sequencing of design analyses • Clear transitions between spatial and technical considerations • Minor lapses don't hinder understanding • 8-9 manipulations	**Generally understandable** but may lack smooth flow between design methods (6-7 manipulations)	**Lacks clear Organization**: design concepts appear disjointed (4-5 manipulations)	**Incoherent or fragmented**; meaning difficult to follow (<4 manipulations)

		presented clearly			

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
3.**Making informed judgement**	Forms **highly informed, insightful** judgement by: • Providing **optimized parking layout recommendation** with capacity analysis. • Offering **comprehensive surveillance strategy** with camera placement. • Giving **detailed safety implementation plan** with multiple measures. • Integrating **all spatial analyses** into cohesive design framework • Considering **practical implementation factors** and user experience	Forms **clear, logical** judgement by: • Connecting calculations to design decisions. • Making specific layout and surveil-lance recommendations. • Supporting design choices with quantitative analysis. • Addressing both parking efficiency and safety requirements.	Forms **generally relevant** judgement by: • Applying mathematics to design context • Providing basic layout recommendations • Beginning to link analysis to practical implementation.	Forms **limited** judgement by: • Recognizing design context. • Attempting basic layout suggestions. • Showing under-standing of safety requirements.	Forms **unclear, unsupported** judgement by: • Showing no understanding of design objectives • Providing irrelevant conclusion. • No evident use of mathematical analysis.

SCORING RUBRIC ITEM 4: Irrigation System Management

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
1. **Interpretation of the scenario and task**	Demonstrates **comprehensive** understanding Identifies **all seven** important variables/concepts: 1. Inflow function: $I(t) = 150 + 80\sin(30t)$ 2. Outflow function: $Q(t) = 3t^2 - 36t + 60$ 3. Safe flow range: 100-600 m^3 /h 4. Reservoir initial volume: 200 m 5. Time conversion: t=0 at 6:00 PM 6. Net rate analysis: $dV/dt = I(t) - Q(t)$ 7. System troubleshooting for observed discrepancies	Demonstrates **good** understanding Identifies **5-6** important variables/concept	Demonstrates **basic** understanding Identifies **3-4** important variables/concept	Demonstrates **limited** understanding Identifies **2** important variables/concept	Demonstrates **little** understanding Identifies only **1** variable or s **none** Shows n o understanding of irrigation management context

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
a) *Generate ideas that address the task*	• Demonstrates **com-prehensive under-standing.** • States **all four** relevant mathematical approaches: 1. Quadratic equation solving for safe flow boundaries 2. Trigonometric function analysis 3. Time conversion and scheduling 4. System performance verification	• Demonstrates **good understanding**. • States **most** relevant approaches (3 of above)	• Demonstrates **basic understanding.** • States **basi** mathematical approaches needed	• Demonstrates **limited understanding.** • States **few** relevant approaches	• Demonstrate s **little understandi ng.** • States **minimal** or **no** relevant approaches
b) *Makes connections within and between ideas and context*	• **Strong logical connections** demonstrated by correctly performing 11-13 of these manipulations: 1. Solve $Q(t) = 100$: $3t^2 - 36t + 60 = 100$ 2. Solve quadratic: $t = 13.02$ hours 3. Solve $Q(t) = 600$: $3t^2 - 36t + 60 = 600$ 4. Solve quadratic: $t = 20.70$ hours 5. Convert to clock time: 13.02h = 7:01 AM 6. Convert to clock time: 20.70h = 2:42 PM 7. Determine safe pumping window: 7:01 AM to 2:42PM 8. Calculate net rate: $dV/dt = I(t) - Q(t)$	• **Logical connections** among **most** variables and computations (9-10 manipulations)	• **Some connections** among variable (7-8 manipulations)	• **Few/weak connections** among variables (5-6 manipulations)	• **No clear connections**; context ignored (<5 manipulations)

	9. Compute Q (14) For 8:00AM: $3(14)^2 - 36(14) + 60 = 144$ m^3/h 10. Compare observed vs calculated flow: 95 vs 144 m^3/h 11. Identify system issues from discrepancy 12. Develop troubleshooting recommendations 13. Formulate emergency response plan				
c) *Presents ideas coherently*	**Clear, logical, fluent** presentation with: • Smooth transitions between scheduling and troubleshooting • Well-organized management advisory structure • Complete pumping schedule and emergency response plan • 11-13 manipulations presented clearly	**Mostly coherent** presentation with: • Logical sequencing of time analyses • Clear transitions between mathematical and practical aspects • Minor lapses don't hinder under-standing. • 9-10 manipulations presented clearly	**Generally understand-able** but may lack smooth flow between analysis types (7-8 manipulations)	**Lacks clear organization**; irrigation concepts appear disjointed (5-6 manipulations)	**Incoherent or fragmented**; meaning difficult to follow (<5 manipulations)

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
3. **Making informed judgement**	Forms **highly informed, insightful** judgement by: • Providing **precise pumping schedule** with time conversion. • Offering **comprehensive system diagnosis** for observed discrepancy. • Giving **immediate emergency response plan** with specific actions Integrating **all mathematical analyses** into operational management. • Considering **real-world irrigation constraints** and crop requirements.	Forms **clear, logical** judgement by: • Connecting calculation to operational decision. • Making specific scheduling and troubleshooting recommendations. • Supporting management choices with quantitative analysis • Addressing both normal operations and emergency situations	Forms **generally relevant** judgement by: • Applying mathematics to irrigation context. • Providing basic scheduling recommendations. • Beginning to link analysis to practical implementation.	Forms **limited** judgement by: • Recognizing irrigation management context. • Attempting basic scheduling suggestions. • Showing under-standing of flow requirements.	Forms **un-clear, un-supported** judgement by: • Showing no understanding of irrigation objectives • Providing irrelevant conclusions • No evident use of mathematical analysis

SCORING RUBRIC ITEM 5: Tea Cooling Optimization

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
1. **Interpretation of the scenario and task**	Demonstrates **comprehensive** understanding Identifies **all seven** important variables/concepts: 1. Newton's Law of Cooling: $dT/dt = -k(T - T_s)$ 2. Initial temperature: 90^0C at t=0 3. Room temperature: 25^0C constant 4. Temperature data point: 70^0 C at t=10 minutes 5. Target drinking temperature: 30^0 C 6. Drinking duration: 15 minutes 7. Departure time: 7:30 AM constraint	Demonstrates **good** understanding. • Identifies **5-6** important variables/concept	Demonstrates **basic** understanding • Identifies **3-4** important variables/concept	Demonstrates **limited** understanding • Identifies **2** important variables/concept	Demonstrates **little** understanding. • Identifies only **1** Variable or **none** • Shows no understanding of thermal dynamics context.

Basis of Assessment	**SCORE 5**	**SCORE 4**	**SCORE 3**	**SCORE 2**	**SCORE 1**
a) *Generate ideas that address the task*	Demonstrates **comprehensive understanding.** • States **all four** relevant mathematical approaches: 1. Newton's Law of Cooling differential equation 2. Exponential de-cay modeling 3. Logarithmic solving for time parameters 4. Backward time calculation from constraints	Demonstrates **good understanding** . • States **most** relevant approache s (3 of above)	Demonstrates **basic understandin** **.** • States **basic** mathemati al approache needed (2)	Demonstrates **limited understandin** **.** • States 1 relevant approach	Demonstrates **little understandin** **.** • States **no** relevant approach

b) *Makes connections within and between ideas and context*	**Strong logical connections** demonstrated by correctly performing 10-12 of these manipulations: 1. Set up Newton's Law: $T(t) = T_s + (T_0 - T_s)\, e^{-kt}$ 2. Usedata point: $70 = 25 + (90 - 25)e^{-10k}$ 3. Solve for k: $45 = 65e^{-10k}$ 4. Calculate: $e^{-10k} = 9/13 \approx 0.6923$ 5. Find k: $k \approx 0.03677$ per minute 6. Set up target equation: $30 = 25 + 65e^{-0.03677t}$ 7. Solve for drinking time: $5 = 65e^{-0.03677t}$ 8. Calculate: $e^{-0.03677t} = 1/13 \approx 0.07692$ 9. Find cooling time: $t \approx 69.75$ minutes 10. Work backward from 7:30AM departure 11. Determine start drinking: 7:15AM 12. Calculate tea ready time: 6:04 AM 13. Determine wake up time: 5:34 AM 14. Compare with current routine analysis	• **Logical connections** among **most** variables and computations (8-9 manipulations)	• **Some connections** among variables (6-7 manipulations)	• **Few/weak connections** among variables (4-5 manipulations)	• **No clear connections**; context ignored (<4 manipulations)

c) *Presents ideas coherently*	**Clear, logical, fluent** presentation with: • Smooth transitions between cooling analysis and scheduling • Well-organized family advisory structure • Complete time optimization with com- parison analysis • 10-12 manipulations presented clearly	**Mostly coherent** presentation with: • Logical sequencing of thermal calculations • Clear transitions between mathematical and practical scheduling • Minor lapses don't hinder under-standing • 8-9 manipulations presented clearly	**Generally understand-able** but may lack smooth flow between analysis types (6-7 manipulations)	**Lacks clear organization**; time concepts appear disjointed (4-5 manipulations)	**Incoherent 0r fragmented**; meaning difficult to follow (<4 manipulations)

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
3. **Making informed judgement**	Forms **highly informed, insightful** judgement by: • Providing **precise optimal waking time** with mathematical justification • Offering **comprehensive routine comparison** with temperature analysis • Giving **specific implementation plan** with time breakdown • Integrating **all thermal analyses** into practical family scheduling • Considering **comfort factors** and real-world constraints	Forms **clear, logical** judgement by: • Connecting calculations to scheduling decisions • Making specific time recommendations with comparison • Supporting routine choices with quantitative analysis. • Addressing both optimal and current scenarios	Forms **generally relevant** judgement by: • Applying mathematics to daily routine context • Providing basic scheduling recommendations • Beginning to link analysis to practical implementation	Forms **limited** judgement by: • Recognizing family routine context • Attempting basic time suggestions • Showing understanding of comfort requirements	Forms **unclear, unsupported** judgement by: • Showing no understanding of routine objectives • Providing irrelevant conclusions • No evident use of mathematical analysis

SCORING RUBRIC ITEM 6: Company Profit Analysis and Forecasting

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
1. **Interpretation of the scenario and task**	Demonstrates **comprehensive** understanding by identifying **all the eight** important variables/concepts: 1. Section A profit: 25.8M 2. Section B profit: 14.56M 3. Total company capital: 500M UGX 4. Profit range calculation and percentage con- version 5. Proportionality model based on error margins 6. Section A revised target: 25.0M UGX 7. Linear relation- ship between per- centage changes 8. Forecasting and target setting methodology	Demonstrates **good** understanding • Identifies **6-7** important variables/concept	Demonstrates **basic** understanding • Identifies **4-5** important variables/concept	Demonstrates **limited** under- standing • Identifies **2-3** important variables/concept	Demonstrates **little** understanding • Identifies only **1-2** variables or **none** Shows no understanding of business analysis context

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
a) *Generate Ideas that address the task*	• Demonstrates **comprehensive understanding** • States **all four** relevant mathematical approaches: 1. Error margin calculation for profit ranges 2. Percentage of capital computation 3. Proportionality constant derivation 4. Linear forecasting model application	• Demonstrates **good understanding** • States **most** relevant approaches (3 of above)	• Demonstrates **basic understanding** • States **basic** mathematical approaches needed	• Demonstrates **limited under-standing** • States **few** relevant approaches	• Demonstrates **little understanding.** • States **minimal** or **no** relevant approaches
b) *Makes connections within and between ideas and context*	**Strong logical connections** demonstrated by correctly performing 11-13 of these manipulations: 1. Calculate Section A range: 25.8 ×0.95= 24.51M, 25.8 × 1.05= 27.09M 2. Calculate Section B range: 14.56×0.92= 13.395M, 14.56×1.08 = 15.725M 3. Calculate total profit range: 24.51 + 13.395 =37.905M, 27.09 + 15.725 = 42.815M 4. Compute percent-age of capital: 37.905⁄500=	**Logical connections** among **most** variables and computations (9-10 manipulations)	**Some connections** among variables (7-8 manipulations)	**Few/weak connections** among variables (5-6 manipulations)	**No clear connections**; context ignored (<5 manipulations)

	7.581%, 42.815/500 = 8.563% 5. Determine proportionality constant: k = 8%/5% = 1.6 6. Calculate Section A percentage change: (25.0 − 25.8)/25.8 × 100% = −3.10% 7. Apply proportionality: Section change =1.6 × −3.10% = −4.96% 8. Calculate Section B target: 14.56 × (1 − 0.0496) = 13.838M 9. Verify target within error range 10. Develop mathematical justification 11. Provide business validation 12. Consider risk factor				

c) *Presents ideas coherently*	**Clear, logical, fluent** presentation with: • Smooth transitions between range analysis and forecasting • Well-organized business advisory structure • Complete profit analysis with target recommendations • 11-13 manipulations presented clearly	**Mostly coherent** presentation with: • Logical sequencing of financial calculations • Clear transitions between analytical stages • Minor lapses don't hinder under-standing • 9-10 manipulations presented clearly	**Generally understand-able** but may lack smooth flow between analysis types (7-8 manipulations)	**Lacks clear organization**; financial concepts appear disjointed (5-6 manipulations)	**Incoherent or fragmented**; meaning difficult to follow (<5 manipulations)

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
3. **Making informed judgement**	Forms **highly informed, insightful** judgement by: • Providing **comprehensive profit range analysis** with capital percentage • Offering **mathematically sound forecasting** with proportionality model • Giving **specific tar- get recommendations** with business validation • Integrating **all financial analyses** into cohesive management strategy • Considering **risk assessment** and practical implementation factors	Forms **clear, logical** judgement by: • Connecting calculations to business decisions • Making specific profit target recommendations • Supporting forecasting choices with quantitative analysis • Addressing both range analysis and target setting	Forms **generally relevant** judgement by: • Applying mathematics to business context • Providing basic financial recommendations • Beginning to link analysis to corporate planning	Forms **limited** judgement by: • Recognizing business analysis context. • Attempting basic profit calculations • Showing under-standing of forecasting needs	Forms **unclear, unsupported** judgement by: • Showing No understanding of business objectives • Providing irrelevant conclusions • No evident use of mathematical analysis

PRINCIPAL MATHEMATICS PAPER 2, SET 2
Time: **2HOURS AND 15 MINUTES**

INSTRUCTIONS TO CANDIDATES:

- *This paper consists of* **two** *sections;* **A** and **B.** *It has four examinations items.*
- Sections **A** and **B** have two items each. Answer at least one item from each section
- *Answer a total of* **three** *items.*
- *Any additional item(s) answered will* **not** *be scored.*
- **All** *answers* **must** *be written in the answer booklets/sheets provided.*
- *Graph paper is provided.*
- *Silent non-programmable scientific calculators and mathematical tables with a list of formulae may be used.*

FOR OFFICIAL USE ONLY		
SECTION A	**ITEM 1**	
	ITEM 2	
SECTION B	**ITEM 3**	
	ITEM 4	
	TOTAL	

SECTION A

ITEM 1

The **Kituza Coffee Research Institute** near Kampala is urgently preparing a large batch of the new **'Kafé Ganda'** Arabica variety for distribution to local farmers. The success of the distribution depends entirely on providing farmers with a reliable, guaranteed window for seedling delivery.

The institute has limited, expensive nursery space and personnel. If seeds are kept in the nursery for too long, resources are wasted. If they release the seeds too early, they risk providing farmers with seeds that have not germinated, leading to farmer frustration and crop failure. They need precise statistical data to set the most efficient delivery schedule.

From a test batch under standard conditions, the germination time (T, in days) is assumed to be normally distributed. The researchers have these two data points:

- 20% of the seeds take more than 6 days to germinate.
- 10% of the seeds take less than 4 days to germinate.

The institute also prepares custom seed mixes for different agricultural regions. Their "**Standard Mix**" is composed of three popular varieties, Variety A, Variety B, and Variety C, packaged according to a fixed volumetric ratio of **2:4:1**.
The germination success rates for these seeds, determined through previous lab testing, are:

- Variety A: 60%
- Variety B: 50%
- Variety C: 80%

The client makes an order of the varieties but requires a guarantee that the overall germination rate of the mix is **at least 65%.**
A quality control manager at **Kituza Coffee Research Institute** wants to assess the overall average quality of the Standard Mix before approving a large batch for delivery. They plan to take a single, random seed from the mix for germination testing.
Task.

a) Analyse the statistical data provide a precise and most efficient delivery schedule for the seedlings basing this on a 95 % assurance in order to solve the institute's logistical challenge, make recommendations.
b) Will the quality control manager approve the batch for delivery? Justify your answer briefly.

ITEM 2

You are a junior data analyst at “Axiom Tech,” a company that manufactures high end smartphones. The production line for the main circuit board involves the precise installation of a critical micro-component. A single board is rejected if this component is faulty. The production manager provides you with the following information and a small, recent dataset.
Historically, the long-term probability that any individually installed micro-component is faulty is 5%. However, the manager is concerned about the performance of a specific robotic arm, “Unit-7,” which was recently serviced. To investigate, you take a random sample of 20 circuit boards assembled by Unit-7 and measure the precise installation time (in seconds) for the micro-component on each board.

You hypothesize that if Unit-7 is misaligned, it might not only affect the defect rate but also the speed and consistency of its operation.

Your dataset of installation times (in seconds) from the sample is:

18.2	19.5	20.1	22.8	17.9	25.1	18.9	23.0	19.8	21.2
24.5	20.5	22.1	18.7	23.7	19.1	21.9	20.3	22.5	23.9

The engineering department specifies that for optimal performance, the installation time should follow a normal distribution with a mean of 21 seconds and a standard deviation of 2 seconds. Any significant deviation from these parameters could indicate a calibration issue with Unit-7.

TASK:

Perform an integrated analysis to assess the performance of Unit-7. Your report should use the provided information and dataset to:

Predict and analyse the likelihood of defects from Unit-7.

(a) Analyse the characteristics of the installation times and compare them to the engineering specifications interpret your findings in the context of the real-world problem.

SECTION B

ITEM 3

A mountain rescue team is conducting an emergency operation to deliver medical supplies to an injured climber. The rescue package of mass 40 kg must be lowered down a rocky slope inclined at 25° to the horizontal. The package is connected by a strong, lightweight rope to an anchor point at the top of the slope.

Due to the steepness and rough terrain, the rescue team cannot simply let the package slide down freely. They need to control the descent carefully. The coefficient of kinetic friction between the package and the rocky surface is 0.15.

The rescue team applies a tension force through the rope to control the package's motion. They want the package to move down the slope with a constant acceleration of 0.5 m/s^2.

During the descent, the rope suddenly snaps when the package is halfway down the 80-meter slope. The package continues sliding down the remainder of the slope, and then moves horizontally across a rough plateau before coming to rest.

Task:

As the rescue team's consultant, analyze this emergency situation and provide comprehensive guidance for the operation. Your analysis should determine all necessary forces, predict the package's motion throughout the entire journey, and assess the safety implications for the rescue operation.

Note: Assume $g = 9.8\ m/s^2$ throughout your calculations.

ITEM 4

An emergency situation is developing at Entebbe airport during poor visibility conditions. Three vehicles are moving toward the same runway intersection point:

Aircraft A: A large passenger aircraft landing on the main runway, currently 600 meters from the intersection, decelerating at $2\ m/s^2$ with initial speed 25 m/s.

Aircraft B: A taxiing aircraft approaching from the taxiway, currently 200 meters from the intersection, moving at constant 8 m/s.

Service Vehicle: A maintenance vehicle on the runway, currently 200 meters from the intersection, moving at constant 5 m/s toward the intersection.

The air traffic control tower has lost direct visual contact due to fog and must rely on mathematical prediction to determine if a collision is imminent and coordinate emergency avoidance maneuvers.

Task:

As the air traffic control analyst, conduct a comprehensive kinematic analysis of this critical situation. Your analysis should predict the motion of all vehicles from different reference frames, determine potential collision points and times, and provide emergency avoidance protocols.

Present your complete mathematical working and interpret your results in the context of this real-world safety emergency.

Coordinate System: Origin at intersection, x-axis eastward (runway direction), y-axis northward (taxiway direction).

END

SCORING RUBRIC ITEM 1: Kituza Coffee Research Institute

Basis of Assessment	**SCORE 5**	**SCORE 4**	**SCORE 3**	**SCORE 2**	**SCORE 1**
1. **Interpretation of the scenario and task**	Demonstrates **comprehensive** understanding by identifying **all six** important variables/concepts: • Normal distribution assumption: $T \sim N(\mu, \sigma^2)$ • Given probabilities: • Given probabilities: $\mathbb{P}(T > 6) = 0.20$, $\mathbb{P}(T < 4) = 0.10$ • Z-score transformations needed • Ratio interpretation: 2: 4: 1 for varieties A, B, C • Individual germination rates: 0.60, 0.50, 0.80 • Required overall germination rate: ≥65%	Demonstrates **good** understanding by identifying **4-5** of the important variables/concepts.	Demonstrates **basic** understanding by identifying **3** of the important variables/concepts.	Demonstrates **limited** understanding by identifying **2** of the important variables/concepts.	Demonstrates **little** (identifying only **1** variable) or **no** understanding of the task or context.

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
2. **Generating and Presenting ideas** a) *Generate ideas that address the task*	Demonstrates **comprehensive understanding** by: states **all three** relevant mathematical approaches: • Normal distribution equations: $\frac{6-\mu}{\sigma} = z_{0.20}$, $\frac{4-\mu}{\sigma} = z_{0.10}$ • Z-score calculations: $z_{0.20} = 0.8416$, $z_{0.10} = -1.2816$ • Total probability theorem: $\mathbb{P}(G) = \sum \mathbb{P}(V_i)\mathbb{P}(G\|V_i)$ • Ratio to probability conversion	Demonstrates **good understanding** by: stating **most** relevant mathematical approaches (2-3 of the above)	Demonstrates **basic understanding** by: stating **basic** mathematical approaches needed	Demonstrates **limited understanding** by: • Stating **few** relevant mathematical approaches	Demonstrates little **understanding** by: • Stating **minimal** or **no** relevant mathematical approaches

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
b) *Makes connections within and between ideas and context*	**Strong logical connections** demonstrated by correctly performing 11-13 of these manipulations: 1. Identify normal distribution assumption 2. Set up $P(T > 6) = 0.20$ equation 3. Set up $P(T < 4) = 0.10$ equation 4. Correct z-value for $P(T > 6)$: $z = 0.8416$ 5. Correct z-value for $P(T<4)$: $z = -1.2816$ 6. Solve the system of equations 7. Compute σ correctly: 0.942 8. Compute μ correctly: 5.207 9. Identify correct z-value for 95%: 1.6449 10. Compute delivery time: 6.756 days 11. Convert ratio to probabilities: $\frac{2}{7}, \frac{4}{7}, \frac{1}{7}$ 12. Apply total probability theorem correctly 13. Compute final germination rate: 57.14% 14. Make correct quality control decision	**Logical connections** among **most** variables and computations (8-10 manipulations)	**Some connections** among variables (5-7 manipulations)	**Few/weak connections** among variables (2-4 manipulations)	**No clear connections**; context ignored (<2 manipulations)

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
c) *Presents ideas coherently*	**Clear, logical, fluent** presentation with: • Smooth transitions between steps • Well-organized solution structure • Complete explanations • 11-13 manipulations presented clearly	**Mostly coherent** presentation with: • Logical sequencing • Clear transitions • Minor lapses don't hinder understanding • 8-10 manipulations presented clearly	**Generally understand-able** but may lack smooth flow or have occasional lapses in logic (5-7 manipulations)	**Lacks clear organization**; ideas appear disjointed (2-4 manipulations)	**Incoherent Or fragmented**; meaning difficult to follow (<2 manipulations)
3. **Making informed judgement**	Forms **highly informed, insightful** judgement by: • Providing **precise delivery schedule**: • 6.76 days (6 days 18 hours) • Making **clear quality decision**: rejection at 57.14% • Offering **practical recommendations** for both logistical and quality aspects • **Justifying** decision with comprehensive data analysis • Considering **alternative scenarios or implications**	Forms **clear, logical** judgement by: • Providing delivery schedule based on calculations • Making quality control decision • Offering relevant recommendations • Supporting with data	Forms **generally relevant** judgement by: • Applying mathematics to both tasks • Providing interpretation for each result • Beginning to justify conclusions	Forms **limited** judgement by: • Recognizing scenario re-lates to real-life • Attempting to link one task to context • Showing basic understanding of goal	Forms **unclear, unsupported** judgement by: • Showing no understanding of goals • Providing irrelevant conclusions • No evident use of acquired knowledge

SCORING RUBRIC ITEM 2: Axiom Tech Quality Control

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
1. **Interpretation of the scenario and task**	Demonstrates **comprehensive** under-standing by identifying **all seven** important variables/concepts: • Binomial distribution for defects: $X \sim \text{Binomial}\ (n = 20, p = 0.05)$ • Defect probability: $p = 0.05$, $q = 0.95$ • Installation time normal distribution: $T \sim N(21, 2^2)$ • Sample statistics calculation needed • Comparison with specifications • Probability analysis for both parts • Real-world implications for Unit-7	Demonstrates **good** under-standing by identifying **5-6** of the important variables/concepts.	Demonstrates **basic** under-standing by identifying **3-4** of the important variables/concepts.	Demonstrates **limited** understanding by identifying **2** of the important variables/concepts.	Demonstrates **little** (identifying only **1** variable) or **no** understanding of the task or context.

2. **Generating and Presenting ideas**	Demonstrates **comprehensive understanding** by: • Stating **all** relevant formulae for both binomial and normal analysis • Making **strong logical connections** between statistical concepts and quality control • Presenting work in **clear, logical, fluent** manner with 12- 14 correct manipulations	Demonstrates **good understanding** by: • Stating **most** relevant formulae for both parts • Making **logical connections** between most concepts • Presenting work with 9-11 correct manipulations in clear manner	Demonstrates **basic understanding** by: • Stating **basic** formulae for both parts • Making **some connections** between concepts • Presenting work with 6-8 correct manipulations	Demonstrates **limited understanding** by: • Stating **few** relevant formulae • Making **weak connections** between concepts • Presenting work with 3-5 correct manipulations	Demonstrates **little understanding** by: • Stating only **one** formula or **none** • Making **no clear connections** • Presenting work with **less than 3** correct manipulations

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
a) *Generate ideas that address the task*	States **all four** relevant mathematical approaches: • Binomial PMF: $P(X = k) = \binom{20}{k}(0.05)^k(0.95)^{20-k}$ Binomial variance: Var(*X*) = *npq* = 0.95 • Binomial expectation: $E[X] = np = 1$ • Binomial variance: $\mathrm{Var}(X) = npq = 0.95$ • Key probability calculations for quality control	States **most** relevant mathematical approaches (3 of the above)	States **basic** mathematical approaches needed	States **few** relevant mathematical approaches	States **minimal** or **no** relevant mathematical approaches

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
b) *Makes connections within and between ideas and context*	**Strong logical connections** demonstrated by correctly performing 12-14 of these manipulations: 1. Identify binomial distribution for defects 2. Calculate $P(X=0) = (0.95)^{20}$ 3. Calculate $P(X \geq 1) = 1 - P(X = 0)$ 4. Calculate $P(X = 1) = 20 \times 0.05 \times (0.95)^{19}$ 5. Calculate $P(X = 2)$ and $P(X > 2)$ 6. Compute $E[X] = 1$, $\text{Var}(X) = 0.95$ 7. Calculate sample mean: $\bar{x} = 21.06$ 8. Calculate sample variance: $s^2 = 4.770$ 9. Calculate sample standard deviation: $s = 2.184$ 10. Compare with specifications 11. Calculate $P(19<T < 23)$ using normal distribution 12. Calculate $P(T>25)$ 13. Empirical validation with sample data 14. Make integrated recommendations	**Logical connections** among **most** variables and computations (9-11 manipulations)	**Some connections** among variables (6-8 manipulations)	**Few/weak connections** among variables (3-5 manipulations)	**No clear connections**; context ignored (<3 manipulations)

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
c) *Presents ideas coherently*	**Clear, logical, fluent** presentation with: • Smooth transitions between binomial and normal analysis • Well-organized statistical report structure • Complete explanations of quality implications • 12-14 manipulations presented clearly	**Mostly coherent** presentation with: • Logical sequencing of statistical analysis • Clear transitions be- tween parts • Minor lapses don't hinder under-standing • 9-11 manipulations presented clearly	**Generally understandable** but may lack smooth flow between statistical methods (6-8 manipulations)	**Lacks clear organization**; statistical analyses appear disjointed (3-5 manipulations)	**Incoherent or fragmented**; meaning difficult to follow (<3 manipulations)
3. **Making informed judgement**	Forms **highly informed, insightful** judgement by: • Integrating binomial defect analysis with installation time statistics • Providing **comprehensive risk assessment** for Unit-7 • Offering **specific monitoring recommendations** • **Quantifying** both performance and variability issues • Considering **calibration implications** and economic impact	Forms **clear, logical** judgement by: • Connecting statistical results to Unit-7 performance • Making data driven recommendations • Addressing both defect likelihood and timing issues • Supporting conclusions with calculations	Forms **generally relevant** judgement by: • Applying statistics to both assessment criteria • Providing basic interpretation of results • Beginning to link findings to operational decisions	Forms **limited** judgement by: • Recognizing manufacturing context • Attempting basic quality assessment • Showing understanding of monitoring need	Forms **unclear, unsupported** judgement by: • Showing no understanding of quality control goals • Providing irrelevant conclusions • No evident use of statistical analysis

SCORING RUBRIC ITEM 3: Mountain Rescue Operation

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
1. **Interpretation of the scenario and task**	Demonstrates **comprehensive** under-standing by identifying **all eight** important variables/concepts: • Mass: m = 40 kg, gravity: g = 9.8 m/s^2 • Incline angle: θ = 25° • Coefficient of kinetic friction: μ_k = 0.15 • Desired acceleration: a = 0.5 m/s^2 • Slope length: 80 m total, 40 m per segment • Force resolution on inclined plane • Motion in multiple segments • Safety implications and emergency protocols	Demonstrates **good** understanding by identifying **6-7** of the important variables/concepts.	Demonstrates **basic** understanding by identifying **4-5** of the important variables/concepts.	Demonstrates **limited** understanding by identifying **2-3** of the important variables/concepts.	Demonstrates **little** (identifying only **1** variable) or **no** under-standing of the task or context.
2. **Generating and Presenting ideas**	Demonstrates **comprehensive understanding** by: • Stating **all** relevant physics principles and equations • Making **strong logical connections** be- tween force analysis and motion prediction • Presenting work in **clear, logical, fluent** manner with 13- 15 correct manipulations	Demonstrates **good understanding** by: • Stating **most** relevant physics equations • Making **logical connections** between most concepts • Presenting work with 10-12 • correct	Demonstrates **basic understanding** by: • Stating **basic** physics principles • Making **some connections** between concepts • Presenting work with 7-9 correct manipulations	Demonstrates **limited understanding** by: • Stating **few** relevant equations • Making **weak connections** between concepts • Presenting workwith 4-6 correct manipulations	Demonstrates **little understanding** by: • Stating only **one** equation or **none** • Making **no clear connections** • Presenting work with **less than 4** correct manipulations

		manipulations in clear manner			

Basis of Assessment	**SCORE 5**	**SCORE 4**	**SCORE 3**	**SCORE 2**	**SCORE 1**
a) *Generate ideas that address the task*	States **all five** relevant physics approaches: • Newton's second law: $F = ma$ • Force resolution: $mg\sin\theta$, $mg\cos\theta$ • Friction force: $f_k = \mu_k N$ • Kinematic equations: $v^2 = u^2 + 2as$, $v = u + at$ • Energy considerations and safety analysis	States **most** relevant physics approaches (4 of the above)	States **basic** physics approaches needed	States **few** relevant physics approaches	States **no** relevant physics approaches

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
b) *Makes connections within and between ideas and context*	**Strong logical connections** demonstrated by correctly performing 13-15 of these manipulations: 1. Resolve weight into components 2. Calculate normal force: $N = mg\cos\theta = 355.3$ N 3. Calculate friction force: $f_k = \mu_k N = 53.3$ N 4. Apply Newton's law parallel to slope 5. Calculate required tension: $T = 92.4$ N 6. Compute velocity after 40 m: $v_1 = 6.325$ m/s 7. Compute time for first segment: $t_1 =$ 12.65 s 8. Calculate acceleration after rope snaps 9. Compute final slope velocity: $v_2 = 16.27$ m/s 10. Compute time for second segment: $t_2 = 3.54$ s 11. Resolve velocity at slope bottom 12. Calculate deceleration on plateau 13. Compute stopping distance: 74.0 m 14. Compute stopping time: 10.03 s 15. Analyze safety implications	**Logical connections** among **most** variables and computations (10-12 manipulations)	**Some connections** among variables (7-9 manipulations)	**Few/weak connections** among variables (4-6 manipulations)	**No clear connections**; context ignored (<4 manipulations)

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
c) *Presents ideas coherently*	**Clear, logical, fluent** presentation with: • Smooth transitions between force analysis and kinematics • Well-organized multistage solution structure • Complete safety analysis and recommendations • 13-15 manipulations presented clearly	**Mostly coherent** presentation with: • Logical sequencing of physics analysis • Clear transitions between motion segments • Minor lapses don't hinder understanding • 10-12 manipulations presented clearly	**Generally understandable** but may lack smooth flow between analysis stages (7-9 manipulations)	**Lacks clear organization**; physics concepts appear disjointed (4-6 manipulations)	**Incoherent Or fragmented**; meaning difficult to follow (<4 manipulations)
3. **Making informed judgement**	Forms **highly informed, insightful** judgement by: • Providing **comprehensive safety assessment** with quantitative risk analysis • Offering **specific emergency protocols** with clear justification • **Quantifying dangerous conditions** (58.6 km/h impact speed) • Considering **multiple safety factors** and backup systems • Providing **practical operational guidelines** for rescue teams	Forms **clear, logical** judgement by: • Connecting physics calculations to safety implications • Making specific equipment recommendations • Addressing rope failure scenarios • Supporting emergency procedures with data	Forms **generally relevant** judgement by: • Applying physics to rescue context • Providing basic safety recommendations • Beginning to link calculations to operational decisions	Forms **limited** judgement by: • Recognizing emergency context • Attempting basic safety assessment • Showing understanding of danger	Forms **unclear, unsupported** judgement by: • Showing no understanding of safety implications • Providing irrelevant conclusions • No evident use of physics analysis

SCORING RUBRIC ITEM 4: Airport Traffic Control Emergency

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
1. **Interpretation of the scenario and task**	Demonstrates **comprehensive** understanding by identifying **all nine** important variables/concepts: • Coordinate system setup with intersection as origin • Aircraft A: $x_{A0} = -600$ m, $v_{A0} = 25$ m/s, $a_A = -2$ m/s^2 • Aircraft B: $y_{B0} = -200$ m, $v_B = 8$ m/s constant • Service Vehicle: $x_{V0} = 200$ m, $v_V = -5$ m/s constant • Position functions for all vehicles • Intersection time calculations • Collision detection methodology • Relative motion analysis • Emergency protocol development	Demonstrates **good** understanding by identifying **7-8** of the important variables /concepts.	Demonstrates **basic** understanding by identifying **5-6** of the important variables /concepts.	Demonstrates **limited** understanding by identifying **3-4** of the important variables /concepts.	Demonstrates **little** (identifying only **1-2** variables) or **no** understanding of the task or context.

Basis of Assessment	**SCORE 5**	**SCORE 4**	**SCORE 3**	**SCORE 2**	**SCORE 1**
2. **Generating and Presenting ideas**	Demonstrates **comprehensive understanding** by: • Stating **all** relevant kinematic equations and vector methods • Making **strong logical connections** between motion analysis and safety protocols • Presenting work in **clear, logical, fluent** manner with 14- 16 correct manipulations	Demonstrates **good understanding** by: • Stating **most** relevant kinematic equations • Making **logical connections** between most concepts • Presenting work with 11-13 • correct manipulations in clear manner	Demonstrates **basic understanding** by: • Stating **basic** motion equations • Making **some connections** between concepts • Presenting work • with 8-10 correct manipulations	Demonstrates **limited understanding** by: • Stating **few** relevant equations • Making **weak connections** between concepts • Presenting workwith 5-7 correct manipulations	Demonstrates **little understanding** by: • Stating only **one** equation or **none** • Making **no clear connections** • Presenting work with **less than** • **5** correct manipulations
a) *Generate ideas that address the task*	States **all six** relevant mathematical approaches: • Position functions: $x(t) = x_0 + v_0 t + \frac{1}{2}at^2$ • Velocity functions: • $v(t) = v_0 + at$ • Intersection time calculations • Distance minimization using calculus • Relative velocity vectors • Emergency strategy • optimization	States **most** relevant mathematical approaches (5 of the above)	States **basic** mathematical approaches needed	States **few** relevant mathematical approaches	States **minimal** or **no** relevant mathematical approaches

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1

b) *Makes connections within and between ideas and context*	**Strong logical connections** demonstrated by correctly performing 14-16 of these manipulations: 1. Set up coordinate system correctly 2. Write Aircraft A position: $x_A(t) = -600 + 25t - t^2$ 3. Write Aircraft position: $y_B(t) = -200 + 8t$ 4. Write Vehicle position: $x_V(t) = 200 - 5t$ 5. Solve Aircraft A intersection time (find no solution) 6. Calculate Aircraft A stopping time: t =12.5 s 7. Calculate Aircraft A stopping position: x = −443.75 m 8. Calculate Aircraft B intersection time: t = 25 s 9. Calculate Vehicle intersection time: t = 40 s 10. Analyze Aircraft A-Vehicle collision possibility 11. Analyze Aircraft B-Vehicle collision possibility 12. Calculate minimum Aircraft A-Vehicle distance 13. Calculate minimum Aircraft B-Vehicle distance (63.65 m critical) 14. Calculate minimum Aircraft A-B distance 15. Develop emergency strategies with calculations 16. Verify safety margins for recommended strategies	**Logical connections** among **most** variables and computations (11-13 manipulations)	**Some connections** among variables (8-10 manipulations)	**Few/weak connections** among variables (5-7 manipulations)	**No clear connections**; context ignored (<5 manipulations)

Basis of Assessment	SCORE 5	SCORE 4	SCORE 3	SCORE 2	SCORE 1
c) *Presents Ideas coherently*	**Clear, logical, fluent** presentation with: • Smooth transitions between kinematic analysis and emergency planning • Well organized multi-vehicle coordination structure • Complete emergency protocol development • 14-16 manipulations presented clearly	**Mostly coherent** presentation with: • Logical sequencing of traffic analysis • Clear transitions between analysis stages • Minor lapses don't hinder understanding • 11-13 manipulations presented clearly	**Generally understandable** but may lack smooth flow between analysis types (8-10 manipulations)	**Lacks clear organization**; traffic concepts appear disjointed (5-7 manipulations)	**Incoherent Or fragmented**; meaning difficult to follow (<5 manipulations)

3. **Making informed judgement**	Forms **highly informed, insightful** judgement by: • Providing **comprehensive emergency protocol** with multiple verified strategies • Offering **quantified safety margins** for all recommendations • **Prioritizing actions** based on critical analysis (63.65 m minimum distance) • Considering **multiple reference frames** and relative motions • Providing **implementable ATC instructions** with success probability assessment	Forms **clear, logical** judgement by: • Connecting kinematic analysis to collision avoidance • Making specific speed adjustment recommendations • Addressing the critical Aircraft • B-Vehicle near miss • Supporting emergency procedures with calculations	Forms **generally relevant** judgement by: • Applying kinematics to air traffic context • Providing basic safety recommendations • Beginning to link calculations to operational decisions	Forms **limited** judgement by: Recognizing air traffic emergency context • Attempting basic collision assessment • Showing understanding of coordination need	Forms **unclear, unsupported** judgement by: • Showing no understanding of collision risks • Providing irrelevant conclusions • No evident use of kinematic analysis

GRADES FOR THE LEVELS OF PERFORMANCE

MATHEMATICS PAPER 1

Algebra Construct

ITEM 1 OR 2

Grade	Range of scores	Description of the grade
E	5 – 8	The learner shows no evidence of meaningful algebraic reasoning.
D	9 – 12	The learner shows fragmented or incorrect algebraic reasoning; struggles to apply methods or justify results.
C	13 – 17	The learner uses basic algebraic procedures with partial accuracy; shows limited justification and requires guidance.
B	18 – 21	The learner uses correct algebraic methods with minor errors; identifies most variables and justifies conclusions reasonably.
A	22 – 25	The learner models real-life situations using correct algebraic expressions and methods; identifies all variables and justifies conclusions independently.

Geometry Construct

ITEM 3

Grade	Range of scores	Description of the grade
E	5 – 8	The learner is unable to apply geometric concepts or represent the situation.
D	9 – 12	The learner misinterprets geometric ideas; diagrams inaccurate; justification missing.
C	13 – 17	The learner shows partial application of geometric concepts; limited connections and weak justification.
B	18 – 21	The learner shows correct use of geometric methods with minor lapses; diagrams mostly accurate.
A	22 – 25	The learner applies geometric reasoning accurately, uses correct diagrams/representations, and justifies solutions.

Calculus Construct

ITEM 4 OR 5 AND 6

Grade	Range of scores	Description of the grade
E	10 – 17	The learner shows no evidence of calculus understanding or application.
D	18 – 25	The learner applies calculus mechanically without understanding; inaccurate results.
C	26 – 35	The learner performs basic procedures correctly but struggles to interpret meaning.
B	36 – 43	The learner uses correct differentiation/integration with minor interpretation errors.
A	44 – 50	The learner uses calculus to model change and solve contextual problems; justifies decisions with correct interpretation.

MATHEMATICS PAPER 2

DATA ANALYSIS AND PROBABILITY (ITEM 1)

GRADE	RANGE OF SCORES	GRADE DESCRIPTOR
E	$\mathbf{5-8}$	Minimal or no conceptual understanding. Fails to select appropriate models, and analysis is fundamentally flawed. Unable to make informed decisions.
D	$\mathbf{9-12}$	Struggles to select correct approaches, relies on simple methods, and frequently makes calculation errors. Decisions are vague or weakly supported.
C	$\mathbf{13-17}$	Generally, selects appropriate tools and correctly executes basic analysis. Decisions are plausible and partially supported but may lack depth in justification or complexity.
B	$\mathbf{18-21}$	Accurately selects and executes appropriate tools. Provides clear, data-supported decisions,

		effectively linking evidence to outcomes with high reliability.
A	$22 - 25$	Flawlessly selects optimal models, executes complex analysis, and translates results into precise, well-justified decisions with profound contextual awareness.

DATA ANALYSIS AND PROBABILITY (ITEM 2)

GRADE	RANGE OF SCORES	GRADE DESCRIPTOR
E	$7 - 12$	Minimal or no conceptual understanding. Fails to select appropriate models, and analysis is fundamentally flawed. Unable to make informed decisions.
D	$13 - 18$	Struggles to select correct approaches, relies on simple methods, and frequently makes calculation errors. Decisions are vague or weakly supported.
C	$19 - 24$	Generally, selects appropriate tools and correctly executes basic analysis. Decisions are plausible and partially supported but may lack depth in justification or complexity.
B	$25 - 30$	Accurately selects and executes appropriate tools. Provides clear, data-supported decisions, effectively linking evidence to outcomes with high reliability.
A	$31 - 35$	Flawlessly selects optimal models, executes complex analysis, and translates results into precise, well-justified decisions with profound contextual awareness.

MECHANICS (ITEM 3)

GRADE	RANGE OF SCORES	GRADE DESCRIPTOR
E	$\mathbf{6-10}$	Minimal or no understanding. Fails to analyse basic forces or motion. Unable to set up or solve even simple problems. Work is disorganized and fundamentally flawed.
D	$\mathbf{11-15}$	Struggles with analysis, misinterprets fundamental concepts, and makes significant errors when attempting to predict and solve problems. Solutions are confusing or incomplete.
C	$\mathbf{16-20}$	Mostly accurate analysis of standard forces/patterns, generally successful prediction and solving of standard problems. Solutions are understandable but may lack detail.
B	$\mathbf{21-25}$	Accurate analysis of intricate forces and patterns, reliable prediction, and successful application to challenging problems with minimal errors. Well-communicated.
A	$\mathbf{26-30}$	Flawless analysis of complex forces and motion, accurate prediction, and construction of original, highly effective solutions. Perfectly logical and clearly communicated.

MECHANICS (ITEM 4)

GRADE	RANGE OF SCORES	GRADE DESCRIPTOR
E	$7 - 12$	Minimal or no understanding. Fails to analyse basic forces or motion. Unable to set up or solve even simple problems. Work is disorganized and fundamentally flawed.
D	$13 - 18$	Struggles with analysis, misinterprets fundamental concepts, and makes significant errors when attempting to predict and solve problems. Solutions are confusing or incomplete.
C	$19 - 24$	Mostly accurate analysis of standard forces/patterns, generally successful prediction and solving of standard problems. Solutions are understandable but may lack detail.
B	$25 - 30$	Accurate analysis of intricate forces and patterns, reliable prediction, and successful application to challenging problems with minimal errors. Well-communicated.
A	$31 - 35$	Flawless analysis of complex forces and motion, accurate prediction, and construction of original, highly effective solutions. Perfectly logical and clearly communicated.