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PRINCIPAL MATHEMATICS

Assessment Objective	Construct	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 14. Complex numbers
*AO*2	**GEOMETRY AND MEASURES** Applying geometric concepts and spartial reasoning to interprete	3. Coordinate geometry 1 5. Trigonometry 17. Vectors 24. Coordinate geometry 2
*AO*2	**CALCULUS** Analysing data and modelling of real-life situations involving rates of change, accumulation and optimization of resources.	4. Partial fractions 10. Differential 1 11. Integration 1 18. Differentiation 2 19. Integration 2 26. Differential Equations
*A*04	**DATA ANALYSIS AND PROBABILITY** Analysing data and applying probability models to make informed decisions and predictions in personal, academic, and societal context.	6. Descriptive statistics 7. Correlation and scatter diagrams 9. Probability theory 14. Random variables 15. Probability distribution 16. Error analysis 21. Trapezium rule 22. Sampling distribution 23. Iterative methods 27. Flow charts
*AO*5	**MECHANICS** Analyzing the effects of forces on bodies in motion or at rest, interpreting motion patterns and predict object behaviour and use it to solve real world kinematic problems.	8. Dynamics 1 20. Dynamics 2.

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PAPER 1	**PAPER** 2
1. The paper will have 5 equally weighed items a) One item from Geometry(Section A) b) Two items from Algebra (Section B Part I) c) Two items from Calculus (Section B Part II) 2. The learner will be required to attempt 3 items. 3. The paper will last for $2\frac{1}{2}$ hours.	1. The paper will have 5 equally weighed items from two sections 2. One item from Numerical analysis.(Section A) 2. Two items from Section B Part I from Data analysis 3. Two items in section B Part II on Mechanics. 4. The learner will be required to attempt a total of three items, choosing one from each part of section B.

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1 UACE PURE MATH

1.1 ASSHU Ankole

Uganda Advanced Certificate of Education

ASSHU Ankole Joint Mock Examination

P425/1

2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES:

This examination paper consists of two sections; **A** and **B**. It has **five** examination items.

Section **A** consists of **one compulsory** item.

Section A has one compulsory item.

Section **B** has two parts,**I** and **II** each with two optional items. Respond to only **two** items from Section **B**, choosing **one** item from each of the parts, **I** and **II**

Respond to **three** examination items **in all**.

Any additional item(s) responded to will **not** be scored.

Begin each item on a fresh page

All necessary working **must** be shown clearly

Graph paper is provided.

Silent, non-programmable scientific calculator and mathematical tables with a list of formula may be used.

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SECTION A

The item in this section is compulsory

Item 1

A certain City Council proposes the installation of a rotating Surveillance Camera above an elliptical garden in a Public Park. The garden is modeled by $9x^2 + 25y^2 - 54x - 100y - 44 = 0$. It's required to analyse the geometry and structural feasibility of the design. These poles are positioned at the foci of the ellipse and serve as base supports from which two main support beams extend upward, meeting at a common mounting point above ground level. The first support beam is the line through $(5, 2, 6)$ and $(1, 2, 18)$. The second support beam is given by $\mathbf{r} = (1, 2, 6) + t(4, 0, 12)$. The beams intersect at the mounting point and form an angle that ensures structural stability. A rotating Surveillance Camera is installed at the intersection point. Its vertical displacement during rotation is modeled by $f(\theta) = \sqrt{3}\cos\theta + \sin\theta$, where θ is the angle of rotation. For approval by the City Council, the design must satisfy; the support beams must intersect at a single mounting point. The mounting point must be exactly 12 m above ground. The maximum height of the camera must be less than 20 m and always above ground. The angle between beams must be between 30° and 40°.

Task:

Determine whether the proposed installation is structurally sound and suitable for approval

SECTION B

*Answer only **two** items from this section, choosing **one** item from each of the parts I and II.*

Part I

Item 2.

At an S.6 Leavers' Party, the Organising Committee prepares a Celebration combining decoration, entertainment, and a sound system to create a memorable experience. The decorations consist of 3 red balloons, 3 green balloons, 3 black balloons, and 3 orange balloons, where balloons of the same colour are identical. To create visually appealing patterns for photographs and stage decoration, the Committee considers different structured arrangements of the balloons under specific design conditions: **Case 1:** the three red balloons are grouped together as a single block, **Case 2:** both the three red balloons and the three green balloons are each grouped together as separate blocks. Need to find out the arrangement that yields the higher number of designs. Inside the Hall, a digital music system controls sound quality during performances. Stability is analysed using two response functions $f(a) = 3^{2a} + 59049$ and $g(a) = 59050(3^a)$, where Engineers find the tuning parameter a by solving $f(a) = g(a)$ to ensure stable audio output is beyond 8. At the same time, budgeting exercise, the Organizing Committee is planning expenditures for decorations, catering, sound systems, and venue arrangements, where x

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represents one unit of budget allocation for a standard service package covering essential party requirements. The total Projected Expenditure is modeled by:

$$2x^4 + 3x^3 - 4200x^2 + 6000x + 900000$$

and the standard service package cost structure is given by $x^2 + 50x + 200$. To determine the any excess in the Planning Process which should be less than one million to avoid misuse of the allocated funds. For sound quality optimization, the audio system also relies on impedance matching in the speaker circuit. Three components of the system are represented by complex numbers: $Z_1 = 5 + 12i$, $Z_2 = 2 - i$, $Z_3 = 1 + 2i$. The overall impedance of the system is obtained by multiplying the first two components and then dividing by the third and evaluate its modulus to ensure it exceeds 9 Ω, confirming clear and stable sound output throughout the Celebration.

Task: Design and analyse an S.6 Leavers' Party System by solving stability, arrangement,

Item 3

A Technology Innovation Hub is preparing a Financial and Operational Assessment for a National Exhibition, and Management is required to make four key approval decisions. The Marketing Department runs a Customer-Acquisition Campaign in which New Subscribers triple each week. In the first week, the sequence of subscribers is **6, 18, 54, ...** Management will approve expansion only if the cumulative number of subscribers exceeds **100,000,000**, with the expectation that this condition should be achieved within a reasonable number of weeks. A Telecommunications System models signal efficiency by $E(x) = \sqrt[3]{1 + 4x}$, where x is a small performance improvement. The expansion is used to approximate $E(x)$ up to the term in x^2, to estimate $E(0.2)$, and to determine system stability when the efficiency increase must not exceed **25%**. The Telecommunications Unit is testing a digital signal represented by a complex number Z. During calibration, Engineers find that the signal and its complex conjugate satisfy the condition; *the product of Z and Z^*, plus eight times the imaginary unit multiplied by Z, is equal to* $9360 + 480i$. The system will only be approved for deployment if a valid complex signal exists and the product of the magnitude of the two signals obtained is less than **10000**. The Hub plans to select at least a Team of 12-Member Male Workers from 15 eligible Members. The Selection Process will only be approved if the number of possible selections does not exceed **800**, ensuring that the administrative workload remains manageable.

Task

Provide a clear final recommendation stating whether the Innovation Hub should approve all four systems or reject any of them, supported by your results.

Part II: (*Attempt ONE Item*)

Item 4:

The Wildlife Authority Officials of a certain Region are assessing a forested area that is at risk of, or has been affected by, a bush-fire. The spatial extent of the affected forest land (**measured in square kilometres**) is modeled by the curve $y = x^2 - 10x$ and the

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straight line $y = -2x + 20$, where all distances are measured in kilometres. The sketch of these boundaries and the corresponding area of the forest are essential for planning fire-fighting Operations, as they guide the strategic positioning of Fire-fighting Teams around the forest to ensure effective containment, suppression of the fire, and prevention of further spread which must be less than 350 $\mathbf{km}^2$.
In addition, a bush-fire is spreading through a dry forest Region with a total area of **288** $\mathbf{km}^2$. The rate at which the dry forest becomes burnt is assumed to be proportional to the product of the area already burnt and the area that remains unburnt. At 9:00 a.m., **2.8** $\mathbf{km}^2$ of the forest had already been burnt, and by 9:30 a.m. this had increased to **18.4** $\mathbf{km}^2$. The fire extinguishing experts arrived at 10:00 a.m. From that time onward, the fire is considered to be under control only if the area already burnt is less than **100** $\mathbf{km}^2$ of the total area of the forest.
Task:
Help the Wildlife Authority Officials to:

(a) generate a sketch to be presented to the Fire Extinguishing Experts.

(b) decide whether the area should be prioritized for emergency response.

(c) determine whether the fire is already under control or still escalating based on the available data.

ITEM 5:
A Humanitarian Water Distribution Project is being implemented in a drought-affected Region to ensure continuous access to clean water. Engineers construct a rectangular tank inside a right circular conical protective shelter with a base radius of 9 m and a height of 21 m to house critical water storage infrastructure. Inside the shelter, a rectangular water tank with a square base is installed such that it fits perfectly within the cone. The tank rests on the circular base of the shelter, and its upper edges are constrained by the curved inner surface of the cone, ensuring maximum possible storage capacity without structural interference. The Engineering Team needs to determine the maximum storage capacity of the tank to establish whether it can meet the water demands of the affected Community.
A water supply pump system is then used to fill the tank. The supply process is modeled by the differential equation:

$$\frac{dV}{dt} = \frac{119622}{1200 - V}$$

where $V(t)$ is the volume of water in the tank measured in m^3, and t is the filling time measured in hours. Initially, the tank is empty. After operating the pump for 4 hours, Engineers need to determine the amount of water delivered. The system will only be accepted if the calculated water volume is slightly greater than the maximum storage capacity of the tank. During the analysis, any mathematically invalid volume must be rejected.
Task:
Assist the Humanitarian Water Distribution Project to decide whether the pump system is suitable for the Project based on the storage capacity and the water supplied.

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1.2 ASSHU BUSHENYI

Uganda Advanced Certificate of Education
ASSHU Bushenyi Joint Mock Examination

P425/1

2 hours 30 minutes

SECTION A

The item in this section is compulsory

Item 1

A zone in one of the districts is facing 3 challenges: traffic congestion, poor mobile network at the two trading centres, and frequent power cuts. The district has approved a zonal upgrade project to solve these problems.

A circular bypass road will be constructed around the congested centre. The path of the bypass is modelled by the equation $x^2 + y^2 - 4x - 8y + 16 = 0$, where all distances are in kilometres. To reduce congestion, a new express road modelled by the equation $y = x + 4$ will intersect the bypass at trading centres A and B.

To improve on network, a telecommunication mast is to be positioned at a point which is equidistant from the midpoint of AB and the centre of the circular bypass. For network clarity, the telecommunication mast points of construction should lie on a linear path whose gradient is less than 1.5. A construction company has been contracted to tarmac both the circular road and the road from A to B, and procurement records show that the cost of tarmacking is UGX 3 billion per kilometre. The amount of money available for tarmacking these two roads is 48 billion.

At the top of a straight pole parallel to the telecommunication mast passing through points $P(2, 2, 5)$ and $Q(4, 2, 7)$, is a fixed solar panel which will be installed to power the mast at night. The panel is to be fitted through 3 support points $C(8, 1, 1)$, $D(0, 2, -14)$ and $E(0, 0, -16)$. For sufficient solar energy to reach the solar panel, the acute angle between the pole and the solar panel should lie between 10° and 20°, and the point $(3, 3, -7)$ should lie on the solar panel. **Using mathematical justifications to help:**
a) Establish whether the network will be clear.
b) Establish whether the available amount of money is enough for tarmacking both roads.
c) Ascertain whether the telecommunication mast, the pole, and the solar panel meet the required specifications.

SECTION B

*Answer only **two** items from this section, choosing **one** item from each of the parts I and II.*

Part I

Item 2.

A manufacturing company produces soap. Management is reviewing production costs,

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meeting customer demand, forming a quality committee, servicing machines, and monitoring product quality. The total cost $C(x)$ in UGX shillings for producing x boxes of soap is modelled by $C(x) = Ex^2 + fx + g$. The company records show that ten boxes of soap cost UGX 320,000, twenty boxes cost UGX 720,000, and thirty boxes cost UGX 1,320,000. The revenue function $R(x)$ is modelled by $\mathbf{40,000x}$ in Uganda shillings. A production run is considered profitable if the profit is greater than Ug. Shs $\mathbf{100,000}$ and the number of boxes produced must be in the range of **12** and **18**.

To meet market demand, soap production was **200** boxes in its first month, 300 boxes in second month, **450** boxes in the third month, and continued increasing following the same pattern. The total production after 30 months must be **at least** $\mathbf{75,000,000}$ boxes to meet market demand.

The company has **12** men and **10** women on its board. A quality assurance committee of **11** members must be formed for effective decision-making, consisting of **at least** 8 men. For effective selection, the committee should have both genders, and the committees formed should **not** exceed $70,000$.

Task:

As the company's mathematical consultant, use justification to help management to:
a) Establish whether a single production run is profitable. b) Ascertain whether the company can meet customer demand after 30 months.
c) Determine whether the quality assurance committee will be formed under an effective selection.

Item 3

A production plant processes timber in large volumes. Management needs to schedule machine maintenance and monitor product quality. The factory's monthly production is $10,000$ m^3 in the first month, $15,000$ m^3 in the second month, $20,000$ m^3 in the third month, production increases by a constant amount each month. The levelling machine must be serviced when total cumulative production reaches $450,000$ m^3. The machine operates safely only when its cutting speed V, in revolutions per minute, satisfies the inequality $V^2 - 130V + 4000 \leq 0$, with $40 \leq V \leq 85$.

The timber quality is monitored using the indices x and y.
The indices satisfy $\log_3 x + \log_3 y = 3$ and $x + y = 12$. For good quality production, both x and y must lie between 2 and 12. Use mathematical reasoning to:
a) Establish when the levelling machine will require servicing.
b) Ascertain the safety of the levelling machine based on its cutting speed.
c) Determine whether the timber produced is of good quality.

Part II (CALCULUS)

Attempt one item from this section

Item 4

A livestock farm is managed by a conservation company. The company must ensure continuous water supply for animals, construct efficient housing using limited fencing material, and maintain electrical safety standards.

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Water for animals is stored in a tank and drains through an outlet at the base, and at time t minutes, the depth of the water in the tank is x metres. The rate at which the depth of water remaining in the tank is decreasing is proportional to the square root of the depth at that instant. The manager at the farm one day started monitoring water outflow from the tank at 9:00 am, and the depth of the water was 2 metres. After 10 minutes he noticed that the water depth was 1.5 metres. To maintain continuous supply, the tank must be refilled when the depth reaches 1 metre.

Due to an increase in livestock, the company plans to fence part of the rectangular piece of land using UGX $1,200,000$. The land has already a fence along one side. One side of the rectangular piece of land is to be used as one side. The shorter sides of the land is to be fenced with wire which costs shs 2000 per metre while the longer side is to be fenced with wire which costs shs 3000 per metre.

The area to be fenced will be suitable for the animals if the area is greater than 29000 m^2. The electric current supplied to the farm, measured in Amperes, varies with time and is modelled by $I(t) = \cos^2\left(\frac{t}{2}\right)$, where t is in seconds. For safety compliance, the mean value of the electric current over the interval $0 \leq t \leq \frac{\pi}{2}$ seconds must not exceed 0.9 Amperes. The manager wishes to refill the water tank when the depth is 1 metre but is not sure of the time he would do it. **Task**
Using mathematical justifications help the company to:
a) Establish when the tank should be refilled
b) Determine the suitability of the area to be fenced
c) Establish the safety of the current supplied to the farm

Item 5
A company intends to establish a forest reserve on a minimum of 10 km^2 of land. Part of the land available is bounded above by the curve $y = x(6 - x)$ and below by the line $y = 2x$ in Kilometres squared. For irrigation purposes, a cuboidal tank whose ratio of length to width is 4 : 3 and its total surface area 376 m^2 is to be used. The tank must have a capacity of at least 450 m^3 to be deemed suitable.

During construction, the angle that the longest diagonal of the tank makes with the horizontal was measured as 29° instead of the design value of 30°. If the error was modelled using the sine function, the percentage error must not exceed 4% to satisfy acceptable standards. **Task:**Help the company to establish;
a) Establish whether the area bounded is sufficient for the forest reserve.
b) The suitability of the water tank for its purpose.
c) Ascertain whether the error in measuring the longest diagonal angle is within the acceptable range.

END

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1.3 AITEL Mock

Uganda Advanced Certificate of Education

Aitel Joint Mock Examination

P425/1

2 hours 30 minutes

SECTION A

The item in this section is compulsory

Item 1

An agricultural development board near the Guru industrial zone is planning to establish a secure perimeter and central infrastructure network to connect four regional storage and processing depots. On the district's Cartesian planning grid, the locations of the four depots are mapped as coordinates $A(2,6)$, $B(5,10)$, $C(8,6)$, and $D(5,-2)$ respectively. The project plan requires constructing straight direct boundary roads between adjacent depots to enclose the zone. Additionally, two main internal service pipelines must be laid diagonally across the zone to connect opposite depots (A to C, and B to D). To maximize efficiency, a central security and monitoring tower is to be built at the exact point where these two diagonal pathways intersect.

The structural engineering firm handling the project must mathematically verify the exact geometric shape of the enclosed area to qualify for specific regional infrastructure funding and determine the optimal coordinates for the monitoring tower.

Task:

a) Verify whether the boundary roads connecting the four depots enclose a region that forms a regular shape, and determine the precise coordinate location where the central monitoring tower should be built.

b) Calculate the total length of the internal service pipelines required to connect the opposite depots, and determine the equations of the lines representing these two diagonal pathways.

SECTION B

*Answer only **two** items from this section, choosing **one** item from each of the parts **I** and **II**.*

PART I

Item 2

A large-scale grain milling and processing factory near the Mbale industrial zone is conducting a comprehensive operational audit to maximize its financial efficiency and reduce overhead expenses. The plant manager needs to evaluate three critical sectors of the business: raw grain procurement optimization, automated hydration control systems, and wholesale product inventory market readiness.

The factory's recent supply ledger shows three separate bulk batch purchases of Maize Flour, Millet Flour, and Sorghum Grain (measured in units of 100 kg bags) as detailed below:

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SECTION B

*Answer only **two** items from this section, choosing **one** item from each of the parts I and II.*

Part I

Item 2.

A large-scale grain milling and processing factory near the Mbale industrial zone is conducting a comprehensive operational audit to maximize its financial efficiency and reduce overhead expenses. The plant manager needs to evaluate three critical sectors of the business: raw grain procurement optimization, automated hydration control systems, and wholesale product inventory market readiness.

The factory's recent supply ledger shows three separate bulk batch purchases of Maize Flour, Millet Flour, and Sorghum Grain (measured in units of 100 kg bags) as detailed below:

Purchase Batch	Maize Flour (Bags)	Millet Flour (Bags)	Sorghum Grain (Bags)
Batch A	2	1	2
Batch B	1	3	1
Batch C	3	1	1

The total financial expenditure for batches A, B, and C was 750,000/=, 1,000,000/=, and 800,000/= respectively. The management will classify future raw material acquisitions as cost-friendly if a prospective order of 5 bags of Maize Flour, 4 bags of Millet Flour, and 2 bags of Sorghum Grain stays below a total budget of 2,100,000/=.

To maintain precise product moisture levels, the factory uses an automated processing bay where a liquid conditioning compound is introduced. Sensor telemetry records indicate that the volume of conditioning fluid consumed during the daytime production shift is represented by $\sqrt{11x+75}$ thousand litres, while the volume consumed during the night-time shift is $\sqrt{x+25}$ thousand litres. The automated logs show that the total volume of fluid consumed over a full 24-hour cycle is exactly 20 thousand litres. The automated hydration system successfully protects the grains from spoilage without risking structural degradation only if the chemical variable x does not exceed 15 units.

Furthermore, the facility currently holds an inventory of 25 tons of processed flour sitting in its main storage reservoir. Due to regional market price volatility, the facility's inventory software implements a strict regulatory rule to automatically determine whether a stock batch is cleared for immediate external distribution or must be held back. A batch is cleared for export only if 90 times the number of tons in storage is strictly greater than the square of the tonnage plus 1400. The plant manager needs to verify if the current stock level satisfies this safety margin to be cleared for the market.

Task:

a) Formulate and solve the mathematical models representing the raw material procurement costs and the automated hydration system variables.

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b) Evaluate the factory's inventory status against the regulatory rule and provide definitive recommendations to help the plant manager optimize operational decisions.

Item 3

A commercial fruit processing factory near the Natete industrial zone specializes in manufacturing concentrated juices. The factory relies on automated extraction chambers that operate under controlled conditions. The technical team observed that as the internal chamber pressure factor (x) increases, the efficiency percentage (E) of the extraction juice output decreases according to the polynomial model:

$E = ax^3 + bx^2 + cx + 40$

Where a, b, and c are constant operation parameters determined by the fruit density. The quality control log shows the following efficiency levels recorded at different pressure factors using the same batch configuration:

Pressure Factor (x)	Extraction Efficiency (E)
1	37
2	32
3	19

An external production consultant recommends that the factory should aim to run the extraction process at a pressure factor of $x = 4$ to conserve power, claiming it will still maintain a viable efficiency.

To streamline the workflow before the pasteurization phase, the factory employs two heavy-duty extraction pumps, Pump P and Pump Q. The operational workloads of these pumps depend on the running time, t minutes, according to the mathematical models:

$$\text{Pump P: } 32^{t-1}$$

$$\text{Pump Q: } 28(3^t) - 9$$

To prevent fluid congestion in the pipeline, both pumps must achieve a perfect equilibrium of workloads, and the operational time t required to reach this balance should not exceed 3 minutes.

Additionally, the factory stores its finished product in a multi-level automated warehouse consisting of 9 distinct storage zones. The total capacity of these zones is represented by the terms of the binomial expansion:

$$N = (x + 3)^8 \text{ hundred crates}$$

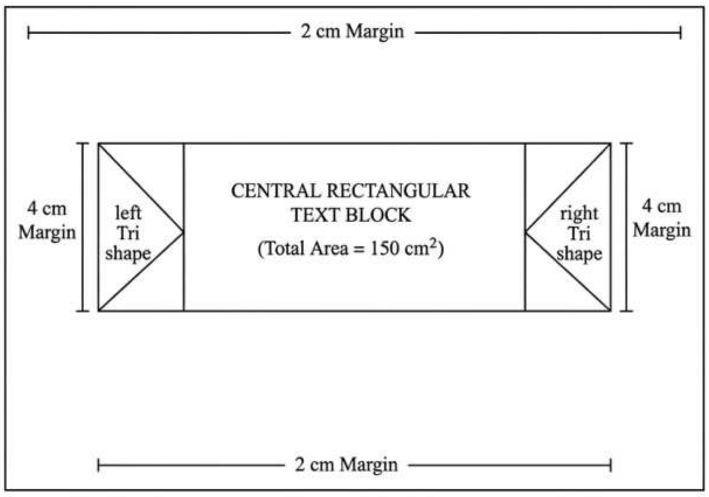
Where x represents the baseline clearance height (in meters) allocated for stackable shipping crates. The factory management plans to expand their current distribution orders. This expansion will be approved only if the storage capacity calculated using the first four terms of the expansion with crates set at a clearance height of $x = 0.2$ m shows that the facility can accommodate at least $550,000$ crates.

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Task:
a) Help the factory officials to get the system of equations from the efficiency log to determine the constants a, b, and c, and analyse whether the consultant's recommended operating pressure yields a viable efficiency.
b) Determine the operational time required for the two pumps to achieve equilibrium, and evaluate whether the warehouse capacity meets the criteria needed to approve the factory's distribution expansion plans.

PART 1

Item 4
An agro-environmental cooperative based in Mbarara City designs specialized concrete water basins to harvest clean rainwater for livestock during drought seasons. The internal chamber of a newly proposed basin model is engineered by rotating a two-dimensional region bounded by the horizontal line $y = 6$ and the curve $y = x^2 + 2$ about the line $y = 6$.
To secure a localized green energy grant, the cooperative must print a standard technical brief document. The layout specifications dictate that the central text area dedicated to the engineering metrics must be shaped as a composite block: it consists of a central rectangle flanked by two identical right-angled triangles on its left and right sides to highlight the structural cross-sections. This entire combined central text block must cover an exact area of 150 cm^2.
To guarantee clear binding and readable presentation margins, the document layout requires a fixed margin of 4 cm on both the left and right sides of the paper, and a fixed margin of 2 cm at both the top and bottom.



Mbarara District print-office guidelines state that for the document to fit standard evaluation folders, its total combined horizontal width (including both the inner text blocks and the side margins) must be kept within a strict limit between 18 cm and 35 cm. The cooperative wants to optimize the layout by finding the precise external dimensions that minimize the total combined surface area of the paper sheet to keep paper costs low,

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while preserving the mandatory central text block space.
Additionally, before submission, the team must compute and explicitly print the exact volume capacity of the water basin on the document sheet.
Task:
a) Determine the optimal external dimensions of the paper sheet that minimize its total area while meeting the print-office layout limits.
b) Calculate the exact volume capacity of the water basin to complete the technical brief.

Item 5
An organic juice refinery situated near Soroti City is upgrading its packaging line to handle increased production volumes. The plant manager plans to channel the refined fruit concentrate into specialized cylindrical canisters designed such that the height of each canister is exactly four times its radius. The canister fabrication plant has a known manufacturing tolerance error in the radius of 0.5%. The refinery manager will reject the batch of canisters if the corresponding percentage error in the total volume exceeds 1.6%.
The automated induction nozzle intended for the filling process records the instantaneous height (h) and the volume (V) of the fluid inside the canister after an elapsed time of t seconds according to the following models:

$$h = \left(\frac{t^2}{4} + 2t\right) \text{ cm} \quad \text{and} \quad V = \left(\frac{t^2 + 6t}{t + 2}\right) \text{ cm}^3$$

The technical team will approve the operation of this nozzle only if the rate of change of the fluid volume with respect to its height at the exact time $t = 2$ seconds does not exceed 0.5 cm^2. This threshold is strictly enforced to prevent fluid turbulence and splashing.
Furthermore, the weekly operational energy cost of running the filling system is modelled by the differential equation:

$$\frac{dc}{dt} = 30te^{-\frac{t}{4}}$$

Where c represents the cumulative maintenance and energy cost in thousands of Ugandan shillings, and t represents the continuous processing duration in weeks. The finance department will transition the facility to an alternative solar hybrid grid if the total accumulated cost of running the system over the first 4 weeks exceeds 180,000/=.
Task:
a) Analyze the geometric tolerance dimensions of the canisters and determine whether the filling nozzle configuration satisfies the non-spill criteria at the specified time interval.
b) Compute and solve the cost differential equation to advise the finance department on whether the refinery needs to switch to the alternative solar hybrid grid based on the four-week budget limit.

END

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1.4 Aceiteka Mock

Uganda Advanced Certificate of Education
Aceiteka Mock 2026
PRINCIPAL MATHEMATICS
$P425/1$
2 hours 30 Minutes

SECTION A
The item in this section is **compulsory**.

Item 1
A certain school is carrying out renovations ahead of re-opening. The school is to mount (install) flood lights at $C(1,-2,8)$ on the administration block to improve on lighting in the school. However, the school security guard patrols at night along the straight path corridor route from $A(2,3,1)$ to $B(5,7,4)$. For proper visibility during the night patrols, these flood lights should be at most 9 m from the patrol corridor, if not the school will find another location. (All coordinates in meters)
The girls' reading shelter is getting a modern, curved arched roof to prevent water logging. When viewed from the front, the cross-section of the roof forms a downward-opening vertical parabola modeled by the equation: $y = 4 - \frac{x^2}{8}$ (where y is the height in meters above the ground, and x is the horizontal distance from the center of the shelter).
Rainwater collects at a central overhead collection node located at $Q(0,6)$. A straight drainage down-pipe must be installed to run from Q, touch the roof curved surface and drain its water directly into a concrete collection trench located at ground level at $T(6,0)$ to keep the walkway dry.
The school management is also planning to install a CCTV camera to monitor activities in the school, and the camera rotation is modeled such that its distance of coverage in every rotation is:

$$D = 20(3\sin\theta + 4\cos\theta + 6) \text{ metres}$$

The school management wishes to monitor a distance in the range: $30 < D < 200$ (meters, but they don't know if this camera will reach their target.)
Task: Help the school administration using your mathematical skills to make valid decisions flood lights, drainage pipes, and CCTV camera.

Item 2
A large-scale poultry farmer is conducting a comprehensive audit of his farm records to optimize operational efficiency and cut unnecessary expenses. He needs to evaluate three core areas of his business: feed procurement costs, automated flock hydration safety, and wholesale egg inventory marketability. The farm's recent inventory ledger shows three bulk purchases of Layers Mash, Maize Bran, and Protein Concentrate as shown below;
The total amount used in the purchases A, B and C was 2,800,000, 1,800,000 and 2,600,000/= respectively. The farmer will consider these purchases cost friendly if he is to use less than 5,500,000 to purchase 400 kg of layers, 400kg of maize brand and 300kg

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	Mass of the feeds × 100 Kgs		
Purchase	Layers m.	Maize b.	Prot. conc.
A	3	1	2
B	1	2	1
C	2	1	3

of protein concentrate.
The farm uses an automated drinking system where a vital vitamin boost is dissolved into the flock's daily water supply. Sensor telemetry records show that the volume of water consumed during the daytime is $\sqrt{3x+700}$ litres, while the volume consumed at night is $\sqrt{x+600}$ litres. The automated system logs show that the total water volume consumed by the birds over a full 24-hour cycle is exactly 70 litres. The vitamin boost will successfully optimize egg production if its mass x doesn't exceed 300g.
The farm currently has an inventory of 33 trays of eggs sitting in storage. Due to market volatility, the farm's management software implements a strict regulatory rule to determine whether a batch of eggs is cleared for immediate sale or held back. A batch can only be sold if 130 times the number of available trays is strictly greater than the square of the number of trays plus 3000. The farmer does not know whether his current stock meets this safety margin to be cleared for the market.
Task: Help the poultry farmer to make decisions on his farm using knowledge of algebra

ITEM 3
A business man set up a large scale baking factory and it is facing some challenges which need to be addressed if the business is to continue.
He uses machines to mixes ingredients at a constant temperature. However, they have discovered that whenever they increase the temperature, the volume of bread obtained decreases and follows the model:
$V = ax^3 + bx^2 + cx + 30$
Where a, b and c are the constant amounts of ingredients used. The table below shows the volume of bread obtained at different temperatures using same amounts of ingredients.

Temp. × 10 (°C)	**Vol of bread,** V
1	28
2	22
3	18

A specialist in baking has advised the business man to always mix the ingredients at a temperature of 45°C which he claims to be the optimal temperature for mixing ingredients.
The bakery has two machines A and B for mixing these ingredients and their workloads relate with operational time, t minutes as:
Machine A: 2^{2t+2} and machine B: $33(2^t) - 8$.
To prevent delays before the heating stage begins, both machines must perfectly balance and operational time t should not exceed 5 minutes.

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The factory has a storage facility having 11 rooms represented by the terms of the expansion of

$$N = (x+2)^{10} \text{ hundreds of boxes}$$

where x is the height of the box used for storage and transportation of the breads
The business man would like to expand his storage space but this will be done if using the first four terms of the expansion with boxes of height 0.25 m the available space cannot store 300,000 boxes.
Task: Help the business man to make the necessary decisions in his factory using your knowledge of Algebra.

PART II

(Attempt one item in this part)

ITEM 4

A farmer practicing large-scale bee-keeping is facing a problem of large amounts of honey produced on his farm. He has decided to further process the honey and add value to it. He plans to pump filtered honey into cylindrical tins whose height is three times the radius. The tins on the market have a factory error in radius of 0.5%. The farmer will not accept these tins if their corresponding error in volume exceeds 2%.
The pump machine he intends to use records the height (h) and the volume (V) of the honey in the container after time t seconds as:

$$h = \left(\frac{t^2}{5} + 3t\right) \text{ cm} \quad \text{and} \quad V = \left(\frac{t^2+4t}{t+1}\right) \text{ cm}^3$$

He will use this machine only if the rate of change of volume with height when time is 3 seconds does not exceed 0.3 cm^2. This ensures no spilling or wasting of honey.
The power cost of this pump machine is modelled by the differential equation: $\frac{dp}{dt} = 20te^{\frac{-t}{5}}$
Where p is the cost in thousands of shillings per week.
The farmer should consider other sources of power if the cost for running the machine in 5 weeks exceeds 140,000/=.
Task: Use your mathematical skills to help the farmer make valid decisions basing on his plans.

ITEM 5

Students in a certain school have for a long time been complaining about unsafe drinking water. The school administration has come up with the following measures to solve this problem.
The administration contracted a welder to make a cuboidal tank whose height h metres relates with the diagonal angle θ as: $h = \tan\theta$ metres
The welder made a tank with diagonal angle 50° instead of 45°. The school administration will only accept this tank if the error in the height is less than 0.2 m.
They also plan to buy a machine which can pump water into the tank on daily basis. The available machine is rated:

$$\frac{dv}{dt} = \frac{100t}{(t+1)(t+2)} \text{ m}^3 \text{ per hour}$$

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To save power, the administration needs a machine which can fill the tank with at least 70 m^3 of water in 5 hours.
Once the tank is filled with the required amount of water, they plan to add a water treatment chemical which decomposes in the water at a rate

$$e^t \frac{dm}{dt} + me^t = t^2$$

Where m is the mass in grams of the chemical remaining in the water after t hours.
On a daily basis, initially 100 grams of the chemical is to be added to the water but the water can only remain pure and safe for drinking if after 6 hours the amount of chemical remaining is not less than 0.4 grams.
Task: Using your knowledge in calculus help the school administration to make valid decisions.

END

1.5 BURJEB

Uganda Advanced Certificate of Education
BURJEB MOCK EXAMINATIONS 2026
PRINCIPAL MATHEMATICS
$P425/1$
2 hours 30 Minutes

SECTION A
The item in this section is compulsory

ITEM 1
Opio is developing a radar system of a certain radio. For strength of signals, there is a cyclic formation that passes through $(1, 1)$ with a radius of $\frac{\sqrt{10}}{2}$ units. The centre of the cyclic formation lies on the line $y = 3x - 7$. The point $(4, 7)$ must be within the cyclic formation for stability of signals. Opio doesn't know whether by this, the signals will be stable.

The angle (θ) at which the radar system will transmit signals is given by equation $4\sin^2\theta + 8\cot^2\theta - 5\csc^2\theta = 0$. For the system to transmit signals at a higher radiation, there must be at least two angles (θ) between 100° and 200°. Opio wants to know whether the system will be able to transmit signals at a higher radiation or average radiation.

In the same radar system he is developing, the frequency wave will form a plane which passes through the points $(-3, 4, -7)$, $(6, -1, -3)$ and $(-4, 3, -2)$. Also, a radiation wave which follows a straight line given by equation

$$\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} 10 \\ 3 \\ 4 \end{pmatrix} + \mu \begin{pmatrix} 8 \\ 2 \\ 8 \end{pmatrix}$$

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The angle at which the frequency wave and radiation wave are to intersect should be at least 30° or else, there will be a lot of interferences. Opio is to record the point where the two waves will intersect and also make a decision on whether there will be a lot of interferences or not.

Task

Help Opio to;

a) determine whether the signals will be stable

b) find out whether the system will transmit signals at higher or average radiation.

c) find the point at which the frequency wave will intersect with the radiation wave

d) determine whether there will be a lot of interferences or not.

SECTION B

*Answer only **two** items from this section, choosing **one** item from each of the parts **I** and **II**.*

PART I

ITEM 2

Kenny is an engineer designing a curved bridge project that is to be constructed by his company. According to the design, the cable sag is to satisfy the relation $\frac{(x-2)(x+2)}{x} \leq 3$ where x is the number of wire points in the sag. Kenny must get the range in which the number of wire points in the cable sag are to be maintained.

On the bridge, the maximum number (x) of vehicles that can run on it at a time is modelled by the equation $\log(\sqrt{1+x}) + \frac{5}{2}\log(1-x) = \log\sqrt{1-x^2} + 2$. Kenny is to write a report indicating the maximum number of vehicles that can run on the bridge at a time to avoid over weighing.

For the small deflection that are to happen, the intensity (x) has been modelled by $(1-x)^{\frac{1}{3}}$ for only the first four terms. The intensity has to be maintained at $\frac{1}{9}$ and Kenny wants to use this intensity to find the approximate deflection of $\sqrt[3]{9}$ so as to find out the strength of the adapter to be used at the bridge.

Task

Help Kenny to;

a) get the range in which the number of wire points in the cable sag are to be maintained

b) determine the maximum number of vehicles that can run on the bridge at once

c) find the approximation of the deflection of $\sqrt[3]{9}$.

Item 3

A certain mathematics club is running a coding contest of eight contestants who are to participate in a math quiz. Three participants out of the eight are to be selected to take on the first, second and third places and the manager wants to know the number of selection in which this can be done.

The competition is to run in rounds where a contestant earns $10 in the first round and the amount triples every round. According to the arrangement, a contestant should not

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exceed a sum of \$20,000 to maintain the budget. With this, the manager doesn't know the number of rounds a contestant should participate in so as to maintain the budget.

Each participant in the contest is to be given an identity card (ID) following the code Z where $Z = (2+5i)^2 + 5\left(\frac{7+2i}{1-2i}\right) - i(4-6i)$. To avoid repetition of ID number, the $|Z|$ must be greater than 15 units and to maintain the ID quality, the arg Z must be between $\frac{\pi}{2}$ and $\frac{4}{5}\pi$. If these conditions are not satisfied, then another code has to be used.

The club plans to use total scores (n) of each participant which has been modelled by the equation $1^3 + 2^3 + \cdots + n^3 = \frac{1}{4}n^2(n+1)^2$. If this model holds, then the competition will take less than five days or else it will take more than 6 days. The manager wants to make a decision on the duration of the contest.

Task
Help the manager to determine; a) the number of selections that can be made for the three places.
b) the number of rounds a contestant should participate in so as to maintain the budget.
c) whether another ID code has to be used.
d) number of days in which the competition will take place.

PART II

Attempt only one item

ITEM 4

A certain biochemical company has secured a rectangular piece of land which is fenced on one of its sides. The industry is to fence the remaining sides of the land and there is 2500m length of wire to be used. The director wants to know the maximum area that the available wire can cover so as to find out whether it will be enough.

The engineer who has been contracted to put the fence has identified that two of the sides of the fence will be modelled by the equations $x = \frac{3t-1}{t}$ and $y = \frac{t^2+4}{t}$. With these models, the director wants to identify the point(s) at which the fence will be turned to avoid encroaching on the neighbourhood land.

The company is manufacturing a drug that kills infectious bacteria in the body of an organism. According to the available research, when the drug has been administered, the rate at which the bacteria die is directly proportional to the number of bacteria present at that time. On the first day, the research team administered the drug when there were 5500 bacteria and on the fourth day, they found out that there were 4000 bacteria. Administering of the drug is meant to stop when the number of bacteria is below 1375. The company director wants to use this information to know the day on which the patient should stop being administered with the drug for proper prescription.

Task
Help the company director to determine the;
a) maximum area that the available wire will cover.
b) point(s) at which the fence will be turned.
c) day on which the patient should stop being administered with the drug.

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Item 5
Musa is a director of a certain construction company that has been contracted to design and construct roads in a hilly area. In the plan, the first road will have a slope of $\cos 2x \sin 2x$ at the point $\left(\frac{\pi}{8}, \frac{1}{2}\right)$. This road must pass through the existing trading centre located at $\left(\frac{\pi}{24}, \frac{5}{4}\right)$. If the road is not to pass through this centre, the design has to be adjusted. Musa wants to decide whether the road design is to be adjusted or not but he is finding it difficult.

In the same design, the second road has an equation modelled by $y = \frac{3x+3}{x(3-x)}$. Before the construction begins, Musa must give in the sketch of this road manager for record purposes.

Task
Help Musa to;
a) decide whether the first road is to be adjusted or not. b) make a sketch of the second road.

END

1.6 JJEB Mock

Uganda Advanced Certificate of Education
JINJA JOINT EXAMINATION BOARD
PRINCIPAL MATHEMATICS
*P*425/1
2 hours 30 Minutes

SECTION A
The item in this section is compulsory

ITEM 1
An extension worker mapped a village demonstration farm on the cartesian coordinates in three dimensions. He installed a sprinkler at point $S(1, 3, 2)$ inside a green house.
The green house roof is the plane $3x - y + 2z = 7$. A water pipe which runs along the line $\mathbf{r} = (2 + \mu)\mathbf{i} + (-1 + 2\mu)\mathbf{j} + (1 - 2\mu)\mathbf{k}$ enters the green house roof at point P. The extension worker wishes to move the sprinkler closer if the distance between S and P is more than 5 m.
Two boundaries of the sprinkler spray zone on the green house floor have equations $y = 2x - 1$ and $3x + 4y = 8$. The extension worker wishes to change the nozzle if the angle between the two spray boundaries is less than $50°$.
During calibration, the sprinkler rotates through angle x which satisfies the equation $2 \sin x + 5 \cos x - 1 = 0$; $(0° \leq x \leq 180°)$. If the angle is less than $100°$, the sprinkler will be adjusted.
A faulty nozzle sprays water such that it hits the floor at a point $Q(x, y)$ whose distance from the point $A(2, 1)$ is twice its distance from the point $B(5, 3)$. The extension worker wishes to relocate a plant at $(7, 4)$ if water can't reach it.

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Task;Based on mathematical computations, advise the extension worker on the decisions to take.

SECTION B

*Answer only **two** items from this section, choosing **one** item from each of the parts **I** and **II**.*

PART I

ITEM 2

A college administration is planning activities for the Annual Academic Excellence and Innovation week. To ensure fairness in allocating study materials, organizing student's awards, and scheduling the official opening ceremony, the administration applies mathematical reasoning.

To allocate revision booklets fairly, **25** times the number of booklets given to each student minus the square of the number of booklets given to each student should be at least **144**. For fairness each student must get at least **8** booklets.

The administration has selected **8** student leaders, but only **5** of them will receive certificates of excellence. For their plan to continue, the number of possible selections of certificate winners should not exceed **60** and each cash prize should not be more than **120 million**.

The certificates for the **5^{th}, 4^{th}, 3^{rd}, 2^{nd} and 1^{st}** positions correspond respectively to the first five terms in ascending powers of x in the expansion of $(4+3x)^7$, where x represents **shs.5**.

The administration wishes to determine the number of possible ways of awarding the certificates while maintaining fairness. On the day of the ceremony, **50** invited guests are expected. The first guest arrives at **9:10a.m.**, and each subsequent guest arrives at t minutes after the previous one. The Guest of honour is the last person to arrive, and **15** minutes later, the ceremony will officially be declared open. The ceremony is to run for **3 hours 40 minutes** and must end by **5:59pm**.

Tasks: Help the administration whether to carry on the planned format of booklet distribution and certificate awarding and also advise on the arrival time interval (t) for the individual guests in order the function to end on time.

ITEM 3

The security team was tasked to design a stepped security pillar to be constructed in a sugar cane plantation to monitor and fight fire out break. The pillar will provide a high view point for surveillance and quick response.

The heights of the steps above the ground increase by the same vertical distance from one step to the next. The height of the **5^{th} step** is three times the **7^{th} step**. The total height of the first twelve steps is **21** m. The team wishes to redesign the pillar if the total height of the first five steps is less than **15** m.

The security(safety) team wishes to reduce response time by placing two communication radios a distance of x in tens of meters from the pillar. One radio shows a signal strength

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of $\mathbf{3}\log_{\mathbf{8}}\mathbf{x}$ and the other radio shows a signal strength of $\mathbf{6}\log_{\mathbf{x}}\mathbf{4}$.
For the safety team to hear clearly without echo, the sum of the two signal strengths must be **8**. The safety team wishes to adjust the radios if their distance from the pillar is less than **40** m.
The team wishes to position at least four solar powered lights. The main light is positioned $\mathbf{-8+8\sqrt{3}i}$ **meters(m)** on the plantation grid. The other three lights must be positioned at the cube roots of the main light position. The team wishes to relocate the positions of the lights if the sum of the moduli of the positions of these lights is less than **10** m.
Task. Based on mathematical evidence, advise the security team on the decisions to make.

PART II

Attempt only one item

ITEM 4

A farmer in **Buyende District** is establishing a beef cattle project on his land along a river.
He is to construct a rectangular paddock along the river forming one side of the enclosure, only the remaining three sides require fencing. The farmer has **1120** m of fencing available.
Veterinary guidelines recommend that each bull requires **500** $\mathbf{m}^2$ of grazing space. The farmer stocks the farm at a rate proportional to the square of the number of available bulls. Initially, there are **50** bulls on the farm. And after **8** weeks there are **75** bulls. The farmer wishes to start selling bulls when the farm is stocked to full capacity.
To maintain the pasture throughout the year, an irrigation system is installed. The main irrigation pipe follows the path $\mathbf{y=x^2\sqrt{(10-x)}}$,
Where x represents the horizontal distance (in meters) east of the water source and y is the distance (in meters) north of the water source. Engineers are to install inspection gadgets at points where the pipe changes direction which must be 10 meters apart.
Tasks

(a) Determine the maximum number of bulls that can be grazed according to the veterinary guideline.

(b) Advise the farmer on when to start the sales.

(c) Make a recommendation on the engineer's inspection points.

ITEM 5

A community irrigation project is constructing a decorative water feature and a storage system for a farm.
The side profile of the decorative basin is modelled by the; $\mathbf{y=x(4-x)^2, 0\leq x\leq 4}$. Units in meters (m).
The region enclosed by the curve and the x-axis is rotated about the x-axis to form a

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solid basin whose volume must be at least $\mathbf{450m}^3$ otherwise there is need to redesign that decorative feature.
At the same project, workers use a spherical water pot of radius **2.5 m** for processing the water. The pot is filled with water to a depth of **3.6 m**. The water is then poured into a cylindrical container of base radius **6 m**. For the project to be a success the height of the cylindrical tank must not be greater than **0.5 m**.
Tasks: With mathematical justifications, Analyse the project. ***THE END***

1.7 Matigo Mock

Uganda Advanced Certificate of Education
MATIGO EXAMINATION BOARD
PRINCIPAL MATHEMATICS
MATIGO Mock-2026
$P425/1$
2 hours 30 Minutes

SECTION A
The item in this section is compulsory

ITEM 1
A certain country is experiencing a crisis due to the war. The war has affected mainly three towns at locations $T_1(7,3,6)$, $T_2(1,3,9)$, and $T_3(5,-4,3)$, with all coordinates being in kilometers. An emergency response team is to supply relief items to the affected people in the towns T_1, T_2 and T_3. The helicopter has to be stationed at location $H(10,2,16)$ km. For efficient supply of these items, the shortest distance between H and the plane containing the three towns should be at least 8km. The team has also set up its own medical camp at position $P(7,1)$ metres and the casualties are in the circular health centre with boundaries at $A(5,0), B(0,5)$, and $C(-3,4)$, with all coordinates in hundreds of metres. The casualties are to be moved from the health centre to the medical camp using a straight road which touches one of the entrances of the health centre. For the safety of the ambulance, the journey should not exceed 1200m. From the medical camp, a helicopter is to pick up these casualties and transfer them to a specialized hospital for better medical attention.
The helicopter landing is modeled by $\cos 2\theta + \cos\theta = 0$
For safe landing, the acute angle of landing should not exceed $70°$.
Task: Using mathematical skills help the response team to know whether their plans will be successful.

SECTION B

*Answer only **two** items from this section, choosing **one** item from each of the parts **I** and **II**.*

Part I

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Item 2

A farmer is setting up a new solar pump to solve the problem of water on his farm. The pump uses a controller switch with components Z_1, Z_2 and Z_3 whose pumping force while operating is; $F = \frac{Z_1^2}{Z_2 Z_3}$ kN.

For the safety of the pump, the size of the pumping force of the switch should be greater than 2kN and its angle when switched on must be obtuse, where $Z_1 = 2+3i, Z_2 = 1-2i$, and $Z_3 = 2+i$. The pump sends water to the tank every hour such that the amount of water pumped per hour is defined by:

$V = 100(1+20x)^n$ litres

where n is the number of operational hours of the pump and the terms of the expansion represent the volume of water pumped each hour. x is the pump code which depends on the hours set for the pump to operate and on his farm, water is pumped for 10 hours and the code for this time is $\frac{1}{20}$. He will only use this pump if in the first 4 hours it pumps not less than 15000 litres.

The pump sends water to the tanks using pipes of length l_1 and l_2. $l_1 = 9^w$ and $l_2 = 3^{w+1}$ where w is the width of the pipes. The total length of these pipes is 108 m, but the required pressure on the farm can be realized only if the width of the pipe is not more than 2.

Task: Help the farmer to make a valid decision using mathematical skills.

Item 3

A certain telecom company is upgrading to 5G networks and some systems have to be checked before the upgrade is officially launched. They have two command centers whose signals are sent and move horizontally in x miles and vertically in y miles. The first command centre sends its signal of strength:

$S_1 = \frac{2x+4i}{2y+x}$

and the second command centre sends its signal of strength: $S_2 = \frac{x}{y-i}$

For the stability of the network, both signals must be of equal strength and the required coverage distance $D = \sqrt{x^2+y^2}$ should be atleast 2 miles.

The primary mast sends signals hourly such that in the first three hours the frequencies of the signals sent are 400, 800 and 1600 MHz respectively. This signal sequence will be approved if the difference between the signal sent in the 7^{th} and 5^{th} hour is not less than 1900MHz.

The secondary mast produces frequencies in two phases with phase one having carrier frequencies $F_1 = f^3 - 90$ and in the second phase $F_2 = 14f^2 - 63f$. This must operate on conditions that the frequencies in both phases are equal and should have only one carrier frequency between 1 and 4.

Task: Using your mathematical skills help the telecom company to make valid recommendations.

A telecom company is upgrading to a 5G network and running pre-launch stability checks on the following station components.

The engineering team is balancing the complex signal vectors coming from two independent transmitter sub-circuits. The first sub-circuit generates a complex signal value

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of $S_1 = \frac{2x+4i}{2y+x}$, and the second sub-circuit generates $S_2 = \frac{x}{y-i}$. For optimal modulation stability, both complex signal vectors must be equal. Furthermore, the total combined signal amplitude, calculated as $A = \sqrt{x^2 + y^2}$, must be at least 2 to clear the receiver's noise floor.

The primary antenna mast undergoes a stress test where its allocated aggregate channel bandwidth scales exponentially every hour. In the first three hours, the allocated bandwidth blocks are 400 MHz, 800 MHz, and 1600 MHz respectively. The automated scaling sequence passes verification if the difference in spectrum capacity between the 7^{th} hour and the 5^{th} hour is at least 1900 MHz.

A secondary mast utilizes a dual-phase local oscillator to generate carrier frequencies. The frequency profile (in GHz) for Phase 1 is governed by $F_1 = f^3 - 61$, and Phase 2 is governed by $F_2 = 15f^2 - 74f + 59$. For stability, the frequencies of both phases must be equal and to comply with international regulations, the system must yield exactly one valid operational frequency between 1 GHz and 4 GHz.

Task: Using your mathematical skills help the telecom company to make valid recommendations.

Part II

Item 4

A fresh graduate in fisheries has decided to set up a fish pond to solve the problem of unemployment. He plans to construct a hemispherical pond whose radius is 5m and fill it with water to full capacity. The volume of the water in this pond is expected to be: $V = \frac{1}{3}\pi h^2(3r - h)$ m^3 where r is the radius of the pond and h is the depth of the water. Experts told him that in such a pond, water evaporates at a constant rate of 4π m^3 per day, and he needs to always top up the water whenever the depth is 2m. But for the safety of the fish, the pond should be topped up with water at a time when the rate at which the depth is falling is not less than 0.2 metres per day. The fish species he plans to take care of feed at a rate modeled by: $\frac{dM}{dt} + M = t$,
where M is the mass of the feeds in Kilograms remaining in the pond after t days. He plans to initially put 100 kg of feeds and add the same amount after every two days. To ensure that fish don't starve, the amount of the feeds remaining in the pond after two days should not go below 10 kgs.

The fish species he plans to care for increase at a rate proportional to the number of fish present in the pond at any time. He plans to initially place 200 fish in the pond and after 1 month he expects this number to double. He plans to start harvesting the fish after 6 months and if at the time the fish population is more than 1300 fish, then the quality of fish won't meet market standards.

Task: Using mathematical skills, help the fresh graduate make valid decisions on his fish pond plans.

Item 5

An agriculture student doing industrial training on a certain farm has discovered some challenges on the farm and come up with the following recommendations.

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The cows on the farm drink water from a cylindrical trough whose volume is
$V = 9\pi h^3$ m^3
When the cows start drinking, the depth h of water after t hours is $h = \ln(10-t)$ metres.
The farm manager has been filling the trough with water to a maximum capacity at 6:00am but the water has always not been enough for the cows for a full day. The student has recommended that they always top up thus water at noon but this will only be possible if at this time the volume of water is reducing at a rate not less than 10πm^3 per hour to ensure sufficient supply.
He also recommended that they add vitamin mixture to the water to boost the growth and help in digestion. The vitamin mixture that he recommended boosts growth at a rate
$\frac{dm}{dt} + 80t = 17$
where m is the mass in grams of the vitamin mixture remaining in the water after t hours.
Initially 1kg of the mixture is added to the water and the booster can only have the required effect if after 5 hours the mass remaining is not less than 50g.
He also discovered that the cows on the farm feed on grass provided at a rate proportional to the square root of the amount of grass remaining. He recommended that if the cows are given 900kg of grass in the morning, they can eat 500kg of this grass in 4 hours and at this rate he thinks that this amount is enough for the cows for atleast 10 hours.
Task: Help the agriculture student to make a valid report on his recommendations using your knowledge on calculus.

1.8 Sure A Mock

Uganda Advanced Certificate of Education
Sure A Examination Council
PRINCIPAL MATHEMATICS
Sure A Mock-2026
$P425/1$
2 hours 30 Minutes

SECTION A
The item in this section is compulsory

ITEM 1
A farmer in Kyampsi who practices agriculture has been facing a challenge of lack of spacing for movements in his old banana plantation. According to the new directives by the minister of agriculture, the distance from where the first seed is planted to where the second seed is planted successively must be at least 10 meters.
The farmer in his new banana plantation ,opted to follow the directives and they dug circular holes in the garden to start planting the seedlings and the first seedling was to be placed at the central point of the first circular hole with points $A(4,1), B(1,4)$ and $C(6,5)$ lying on it and the second seedling was also placed at the central point of the

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path described by the movement from a variable point $A(4,1)$ so that the movement to A and the movement to B are at right angles where the pattern remained the same for the whole garden in a straight form.
To address the issue of spacing the farmer also decided to plant the next seedlings in a straight format with seedlings placed at respective positions as $2i+3k-5j$, $-3i+4j+k$, $-2k+7i$. The farmer has used a thread to check whether his seedlings align and so the mathematical relationship of these positioning of seedlings.
The farmer also put two supports on each banana plant in the old garden. The height of the banana plant was 6meters (Ignore the height of the leaves) and the two supports from a common point on ground 4meters away. The first support touches the top part of the banana and the second is at the stem 2meters from the top to which the first support touch the banana plant.
TASK:
a) By calculations, help the farmer check whether he met the directives of the minister of agriculture?
b) Are the farmers seedlings properly aligned? Provide evidence.
c) Write the mathematical relationship that can determine the positioning of other points
d) What is the inclination between the two supports for effectiveness?

SECTION B

*Answer only **two** items from this section, choosing **one** item from each of the parts **I** and **II**.*

Part I

Item 2
During the construction of the high way from Mukono to Lugazi, the engineers faced a challenge of numerous anti- hills along the way and the first anti-hill appeared and was mathematically recorded as:
$y=(12-3x^2)$ meters that had to be removed in order to have a straight horizontal road. The engineers wanted to know the peak height of the anti-hill from ground and the horizontal distance x in meters corresponding to the peak point.
Amongst the available group of engineers 8 work in the monitoring department while 6 are directly involved in active working department. For an anti-hill to be worked there must be at least 3 engineers from each department so that 8 signatories approve the work to be complete.
But after the construction, they used rectangular pavers on the sides with length (l) and its width was three-quarters of the length. The dimensions of the paver satisfy the condition that twice the square of the length less four times the width plus ten is at least nine.
TASK
a)Help the engineer determine the peak height of the anti-hill.
b) How wide was the anti-hill hence clearly sketch it
c) In how many ways can an anti- hill be worked?

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d) Which range of the length does not satisfy the above condition?

ITEM 3

During a mathematics seminar at a school, the first presenters were Jean, James and Joel respectively. They presented after the teacher's speech and they introduced themselves with their respective ages. Their ages were consecutive in such a way that the sum of their ages was 36 and the product of their ages was 1680.

After introduction was done, Jean presented her work as the sketch of the roots of $Z^3 + 1 = 0$ while the second presenter Joel presented about obtaining the exact value of $(6.75)^5$ following what Joel had expanded previously in $(2x + 3y)^5$.

TASK

a) Help the colleagues present the ratio of jean's age to James' age

b) Clearly sketch the roots correctly as Jean did present them.

c) Obtain the value that Joel obtained without using the calculator

ITEM 4

A school owns a rectangular garden on the outside of the school for agricultural students to practice their projects using knowledge got from class. The garden consists of an existing wall and the other remaining sides are the ones to fenced with a barbed wire mesh. The total length of other sides to be fenced is 36feet. Based on the purchased materials, the school intends to know the dimensions of the garden as well as the greatest area that the school garden occupies.

For the other science students not offering agriculture, the girls chose to make conical pots as their project with radii 10cm and height 50cm using the available clay given to each person while the boys chose to make hollow hemispherical pots of radii 12cm. While the conical pot was still wet, a random girl chose to cut out a largest cylindrical pot from the conical pot without wastage to have a unique project work different from others. After the project work, a boy discovered that his pot had a radius of 11.95cm relative to the required one from the boys. This led in variations in the volume due to such mistakes during the moulding of the clay

Task

a) Help the school establish the largest area occupied by the school garden

b) Verify whether the capacity of the cylindrical pot cutout is exactly 625π cm^3

c) Determine percentage error that can occur while calculating the capacity of any liquid due to the reluctancy of a boy.

ITEM 5

The price fluctuations of maize (q) in kilograms in the market were recorded by an economist and the change in quantity demanded due to change in the price was recorded as $\frac{dp}{dq} = 120 - 0.2q$. No price is charged for no quantity demanded and so the economist is interested in determining the price (in USD) of 300kg of the commodity as well as the optimal output.

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He also took time analyzing the market value of coffee and he noticed that at the nearby shop, the quantity of the coffee sold varies at a rate directly proportional to the square of cube root of the quantity remaining unsold in the store. Initially, the shop store had 1000kg coffee and after two (2) days the quantity sold of coffee had reached 271kgs.
TASK
a) Help the economist to determine quantity of maize (q) and the respective optimal price of maize as well as the price charged for 300kgs of maize.
b) How long does it take for the coffee store to be emptied
c) Express the quantity of coffee sold in terms of time period hence determine the quantity that had remained on the end of the 14^{th} day.

1.9 Wakissha Joint Mock

Uganda Advanced Certificate of Education
Wakissha Joint Mock
PRINCIPAL MATHEMATICS
Wakissha Mock-2026
$P425/1$
2 hours 30 Minutes

SECTION A
The item in this section is compulsory

ITEM 1
A city planning authority is optimizing its urban transport infrastructure by mapping key service hubs using a three dimensional coordinate system.
The current hubs are located at $M(2,4,3)$ km, $N(8,6,1)$ km, and $P(4,10,2)$ km. The planners have identified a site for a new logistics depot at $Q(14,8,4)$ km. The project director will only approve the depot if it lies on the straight supply line defined by hubs M and N, as this ensures efficient traffic flow.
For emergency rapid - response, a fire station is proposed at $R(2,4,8)$ km. the planners must determine the shortest distance from the fire station to the plane containing hubs M, N and P to assess the response time. The fire service response will only be confirmed adequate if this distance is less than 10 km.
During the city's expansion, engineers mapped three sensor nodes along the perimeter of a circular restricted access zone surrounding a downtown square. The three nodes were recorded at $X(16,4)$ km, $Y(4,16)$ km, and $Z(-4,4)$ km. The city authority must determine whether a newly planned emergency access road passing through point $S(4,15)$ km lies within this restricted zone for security clearance.
Finally, during system testing, engineers discovered that the signal reach of a mobile weather station is defined by $S = (24\sin 2\theta + 7\cos 2\theta - 3)$ km. The weather bureau has a target that maximum signal reach for their stations of at least 20 km to guarantee coverage for all peripheral districts.
Task:

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a) Will the project director approve the new logistics depot location?

b) Help the planners to check whether the fire service response distance is adequate.

c) Does the emergency access road lie within the restricted security zone?

d) Will the engineers achieve the required signal reach for the weather station?

SECTION B

*Respond to only **two** items from this section, choosing **one** from each of parts I and II.*

PART 1

Item 2

A manufacturing enterprise has embarked on a strategic upgrade to optimize its industrial liquid filtration and power control systems. To ensure operational efficiency, the management team must make critical decisions regarding expansion, procurement, and system stability.

During the initial phase, the company planned to increase the number of filtration units installed annually. In the first year, 10 units were installed, and in the second year 20 units were installed. The engineering planners agreed that the annual installations would continue to grow by the same constant ratio. However, the operational budget can only support the expansion if the total number of units installed during the first ten years does not exceed 12,000.

To maintain the production line, the procurement office purchased three types of electrical components: voltage regulators, sensors, and transformers. The office received supplies from three different industrial vendors in "thousands of dollars" as shown in the table below;

Vendor	Vol. reg.	sens.	Transf.	Total cost
Alpha	2	1	3	45
Beta	3	2	1	35
Gamma	1	3	2	40

The finance department needs to determine the individual cost of each component and decide whether an allocated budget of 200,000 USD is sufficient to purchase an additional 5 voltage regulators, 4 sensors, and 6 transformers.

In the final phase of the project, a complex automation system was implemented to manage control signals. The reference signal of the system is $Z_0 = (2 + 3i)$ and the control signals are modelled by the equation $Z^3 - 3Z^2 + 7Z - 5 = 0$. The automation system will remain stable and operational if the modulus of the difference between the reference signal and each control signal, $|Z_0 - Z|$, is less than 4 units.

Task

a) Help the planning team establish if the installation programme is financially sustainable.

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b) Advise the management team to take well informed decisions as they undertake the remaining two projects.

Item 3
In a rural village, the village development committee agreed to collect funds every month from households to install a community solar power grid. They decided to contribute UGX. 20,000 in the first month, and the monthly contribution then increases by UGX 5,000 each month thereafter for 20 months. The committee chair wants to determine whether the planned contributions will be sufficient to meet the budget target for the solar equipment of UGX 50 million, given a total of 400 households participating in the scheme.
The local cooperative has also introduced a productivity bonus for the solar technicians based on their hours worked per week. The total number of hours (x), accumulated by one technician in a week must satisfy the conditions: "the square of the hours plus 4,000 must be less than or equal to 125 times the number of hours" for the technician to qualify for the performance bonus. A senior technician has worked a total of 55 hours in a certain week and is unsure whether he qualifies for the bonus.
The maintenance crew consists of 6 junior technicians and 5 senior technicians. The supervisor wants to create a daily maintenance team of 5 technicians with an equal number of junior and senior technicians (or as close as possible to maintain balance). This is intended to ensure proper mentorship and will only be effective if the total number of possible districts teams exceeds 100.
To improve the safety of the remote monitoring software, the I.T department is installing a new encryption system. The strength of the system depends on a security key representedby x units, where for a strong security key, x must be at least 2 units. During testing, the software engineer finds that the overall security rating is obtained by combining two separate measurements: the first measurement is $\log_x 9$; the second measurement is $2\log_3 x$. The system will function correctly only when the total security rating is equal to 3 units.
Task:

a) Perform a financial feasibility study for the village development committee to determine if they will meet the set budget target.

b) Advise the maintenance supervisor on the effectiveness of the team selection process based on the number of district teams possible.

c) Determine the eligibility of the senior technician for the performance bonus.

d) Evaluate the technical viability of the new encryption system.

PART II

Item 4
A local cooperative is establishing an an apiary project and intends to use 100 metres of

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protective netting to enclose a rectangular area for the bee hives. The project requires a minimum area of 500 m^2 for the hives and pollinator gardens to be effective.
Additionally, the cooperative has designed a central honey-processing facility with a cylindrical storage vat. The vat is to be constructed such that the sum of its height and its base radius is 15 metres. The facility requires a storage capacity of at least 400 m^3 for the harvest to be considered viable.
To monitor hive health, the cooperative recorded an initial bee colony population of 2,000. The population changes over time due to seasonal growth and natural attrition, modelled by
$\frac{dp}{dt} = 0.05p - 150$,
where P is bee population after time (t years). For the project to be deemed sustainable, the colony population must reach at least 4,000 within 10 years.
Task
Help the cooperative establish whether;

a) the available netting is sufficient to enclose the required area for the apiary.

b) the proposed storage vat design, can provide enough capacity to sustain the processing facility.

c) the colony population will remain sustainable after 10 years.

Item 5
A local paint company manufactures specialized industrial coatings, and its production profit function over time (t years) is modelled by $\frac{dp}{dt} = 0.04p(1 - 0.02)$. After the first year of operation, the company recorded a profit of 500,000. Management forecasts that in five years, the profit will reach Ugx 2 million. The board requires an assessment to determine if this growth target is realistic.
To package the paint, the company designs a container made from a square sheet of reinforced plastic measuring 60 cm $\times$ 60 cm. The container is formed by cutting squares of side y cm from each corner and folding the sides upward. For efficient shipping, the company requires a container with maximum volume; however, only containers with a volume between $15,000$ cm^3 and $18,000$ cm^3 meet the durability standards for high-pressure storage.
The company also contracts a specialized firm to produce small, spherical metallic canisters for sample batches. During the manufacturing process, a 1.5% measurement error occurred in the radius of the canisters. According to the industry safety guidelines, any canister with a volume error exceeding 5% will not be certified for distribution.
Task
a) Help the company know whether;
i) The projected profit growth target is achievable.
ii) The container design meets the required volume standards for durability.
b) Will the spherical metallic canisters be certified for distribution?

END

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1.10 UMTA Mock

Uganda Advanced Certificate of Education
UGANDA MUSLIM TEACHERS' ASSOCIATION
PRINCIPAL MATHEMATICS

P425/1

2 hours 30 Minutes

SECTION A

The item in this section is compulsory

ITEM 1

A secondary school plans to construct a modern classroom block with a hidden roof, an underground rainwater harvesting tank, and a CCTV security system. As a technical consultant, you have been asked whether the engineers design satisfies the school's requirements. The roof surfaces are represented by the planes

$$3x + 2y - 3z = 6 \quad \text{and} \quad 4x - y + z = 8$$

Rainwater from the roof flows into a central gutter formed by the line of intersection of the two planes. The gutter empties into a collection box located at $B(1, -15, -11)$ m. For effective drainage, the collection box should lie on the line of intersection of the two roof planes. The angle between the two roof surfaces must not exceed $70°$. The circular top of the underground water tank passes through the points $P(2, 3)$ m and $Q(8, 11)$ m, which are the endpoints of a diameter. The nearest perimeter wall is represented by the line $3x + 4y + 2 = 0$.

For safe construction the shortest distance from the centre of the tank to the wall must be at least 8 metres. The maximum coverage distance D (metres) of the CCTV camera is;

$$D = 100 \sin(\theta + 45°) \cos(\theta - 45°) + 120 \cos 2\theta$$

The school requires a camera whose maximum distance coverage exceeds 150 metres in order to monitor the entire school compound.

Task: As a technical consultant, use mathematical justifications to analyse the engineer's blueprint and provide a comprehensive evaluation report advising the school administration on whether the hidden roof, the water tank placement, and the CCTV camera specifications meet the operational and structural requirements.

SECTION B

*Answer only **two** items from this section, choosing **one** item from each of the parts **I and II.***

Part I

Item 2.

A certain company offers three-year renewable contracts for its employees. In the existing

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contract, each employee has been getting a basic pay of **600,000/=** monthly multiplied by a positive performance factor **X**. **X** is calculated using the initial efficiency index $P = 3^x$ and the final efficiency index $Q = 3^{4-x}$. To validate payroll calculations, the system requires a total combined index value of **82**. This contract is soon ending and in the next three years the company wishes to come up with a new payment plan. This is aimed at increasing the total amount an employee earns at the end of **36 months**.

Scheme A:

This offers an initial monthly pay of **2,000,000/=** with guaranteed **1%** compound growth rate applied at the end of every month throughout the **36 months**.

Scheme B:

This offers a fixed monthly pay of **1,800,000/=** for **3 years** with a large lump sum gratuity payout at end of the **3 years**.

The company's performance model states that final gratuity $R(t)$ in millions after t years is defined by: $P(t) = g(t)Q(t) + R(t)$ where $P(t) = 2t^3 - 7t^2 + 13t + 5$ and $g(t) = t^2 - t$ evaluated at the end of the contract.

The company needs to know which scheme to adopt. The company has many operational branches with **5** female and **6** male supervisors. In the new contract these supervisors should do supervisory roles daily in teams and each daily team should have **4** supervisors with an equal number of males as females. The company will consider having more supervisors if this arrangement does not yield more than **130** team days off.

Task:

Help the company to make valid decisions using your knowledge of algebra.

Item 3.

Old students of a certain school have fundraised money to construct a new academic block, which will house four distinct rooms to serve different purposes. They contracted an engineer who had records of his material purchases on the most recent projects he had worked on, as shown below.

PROJ.	Cement ×**100 bags**	Trucks of sand × **10**	Trucks of stones × **10**
A	26	5	3
B	46	9	5
C	12	4	2

The total amount of money spent on purchases for projects **A**, **B** and **C** was **128 million**, **226 million** and **70 million Ugandan shillings** respectively. The school's building committee had allocated **100 million** for the purchase of **1000 bags** of cement, **80 trucks** of sand and **50 trucks** of stones.

An architect designed the block such that the floor areas of the four distinct rooms correspond to the first four terms of the expansion of: $A = \frac{200}{(1-x)}$ m^2 where **x** is the architectural reduction factor between successive rooms. The building committee will only adopt this architectural design if the total area of the *four rooms* is at most **600**

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square meters using a reduction factor of **0.8**.
The school surveyor used digital mapping and identified $\mathbf{Z_0} = (30 + 40i)$ m as the centre point for the new block. The proposed site sits between two existing classroom blocks whose coordinates $\mathbf{Z}$ are linked by a structural alignment equation: $\mathbf{Z}^2 = (119 + 120i)$ m^2
The building committee will only approve the proposed site for the new block if it satisfies the condition: $|\mathbf{Z_0} - \mathbf{Z}| \geq 35$ metres
Task:
Using your knowledge of algebra, help the building committee analyse the recommendations and make valid decisions on the proposed new block.

Part II

Item 4
A certain boy dropped out of school due to lack of school fees. He decided to apply the skill of making soap that he acquired while still studying.
He contracted a welder to manufacture containers with square cross-section in which he is to mold bars of soap. The welder made a percentage error of **1%** when measuring the side of the cross-section. The length of the bars of soap he wishes to mold is **10** times the side of the cross-section.
Under acceptable standards, only bars of soap whose percentage error in volume does not exceed 4% are allowed on the market.
He also has square sheets of hard paper of dimensions 50cm by 50cm from which he wishes to make the biggest boxes for packaging the bars of soap. The box is to be made by cutting off equal squares from each corner of the rectangular sheet and then folding it so as to contain 10 bars of soap each of approximately $900cm^3$. He wishes to know whether the sheets will serve the purpose. He also conducted a market survey of the available bars of soap and discovered that they sold at a rate of:

$$\frac{dN}{dt} = \frac{4t^2 + 13t + 7}{(t+1)(t+2)}$$

where N is hundreds of bars of soap sold after t days. From this survey, he will consider the business profitable if after every 7 days, he can sell more than 2000 bars of soap.
Task: Using your skills in calculus, help the young entrepreneur to make valid decisions.

Item 5.
Suzan has discovered that there are many nursery schools in her locality and has decided to start a small business of making ice cream. She purchased molds that can make conical ice cream packs; however, she discovered that the vertical angle θ is 32^0 instead of 30^0. This will result in losses if the corresponding error in the radius of the cone exceeds 0.2cm.
The relationship between the radius of the cone and the vertical angle is:

$$r = 9 \tan \frac{\theta}{2}$$

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She plans to use two primary ingredients, milk and sugar, mixed according to the formula;

$$\frac{ds}{dm} = m \ln m$$

where m is amount of milk in litres and s is amount of sugar in grams, with 1 litre of milk requiring 30g of sugar. She will only use this formula if her expected daily usage of 50 litres of milk requires less than 5kg of sugar.
Suzan plans to use a mixture of chocolate and vanilla flavors. Experts informed her that this mixture degrades at a rate proportional to the amount remaining. Specifically, 5% of the flavor mixture degrades in 3 hours. She will only consider this mixture if, after 12 hours, not more than 20% of the flavor mixture has degraded.
Task: Help Suzan to make valid decisions on her new ice cream business plans using your calculus skills. **END**

1.11 Hoima Mock

Uganda Advanced Certificate of Education
Hoima Diocese Examination Board
PRINCIPAL MATHEMATICS
P425/1
2 hours 30 minutes

SECTION A
The item in this section is compulsory

ITEM 1
A district water authority plans to establish a solar-powered water monitoring station within a circular water distribution zone located on level ground. During the site survey, three boundary points of the zone were recorded as $A(1,2)$, $B(7,2)$, and $C(4,5)$. These points will be used by the engineering team to determine the equation of the circular zone and its area so that the monitoring station can be accurately positioned at the centre. The monitoring equipment is mounted on a mast represented by the vector equation

$$\mathbf{r} = (4,3,0) + \lambda(0,1,14),$$

where the monitoring device is fixed at $\lambda = 1$.
Its calibration includes a depression-angle control system governed by the trigonometric condition:
$2\sin 5\theta \cos 5\theta - 2\cos^2 5\theta - 2\sin^2 5\theta + 3 = 0$
for $0^\circ < \theta < 90^\circ$.
A maintenance officer stationed at $D(20,15,12)$ carries out routine inspections of the system.
For operational efficiency, the device is designed such that it can operate in more than

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one direction. To improve coverage efficiency, the mast must placed at the centre of the circular zone, the area enclosed by the zone must not exceed 30 m^2. To minimise construction costs, the distance between the maintenance officer and the monitoring device must be less than 35 m to ensure effective visual inspection, and the mast must be nearly vertical, making an angle between 87° and 90° with the horizontal ground.

Task

Using mathematical justification, verify whether the proposed design satisfies all operational and structural requirements.

SECTION B

*Answer only **two** items from this section, choosing **one** item from each of the parts I and II.*

Part I

Item 2.

A national infrastructure agency is evaluating three salary schemes for new technical posts in an East African infrastructure programme over 4 months. The first job pays a monthly salary following an arithmetic progression starting at 1,000,000 UGX with a common difference of 75,000 UGX, plus a bonus following a geometric progression starting at 30,000 UGX and doubling each month. The second job bases monthly pay on committee efficiency, where a committee of at least 9 staff is chosen from 12 members. Each valid formation contributes 3,050 UGX to the compensation index. The third job uses a monthly pay of a logarithmic performance indicators given by two times log base ten of 100 plus log base ten of 10 minus log base ten of 5, and this index is scaled using a factor of 320,000 UGX to match monthly compensation levels for fair comparison. After 4 months, total earnings from all three models are computed and compared.

Task

Determine the best job to choose based on earnings.

Item 3

A construction company is undertaking the construction of a 12-storey smart classroom tower for a secondary school. The project manager applies mathematical modelling to plan materials, staffing, structural safety, and overall efficiency of the project. For cost balancing under engineering standards, the unit costs of the materials are constrained by two structural pricing conditions: five times the cost of cement plus four times the cost of sand plus three times the cost of gravel equals 530 million shillings, three times the cost of cement plus six times the cost of sand plus twice the cost of gravel equals 370 million shillings, and seven times the cost of cement plus four times the cost of sand plus five times the cost of gravel equals 790 million shillings.

The company wishes to use 100 bags of cement, 15 trips of sand and 120 bags of gravel. The total budget available for construction materials is 15,000 million shillings. The engineer uses these constraints and material quantities to check if the total cost fits the budget. After determining cost behaviour, then analyses the actual staircase design, which follows an arithmetic progression (AP), where the 4th floor requires 37 tiles and

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the 10th floor requires 91 tiles.
Using this information, the learner determines the common difference, the first term, and finally computes the total number of tiles required for all 14 floors. The results from model are then used to check whether the available 1000 tiles are enough. The Engineers model the position of a steel beam tip using complex numbers. The initial position is $z_1 = 3 + 3i\sqrt{3}$.
The beam undergoes a structural transformation due to load redistribution represented by multiplication with $2 + i$. After this, a stabilizing adjustment is applied $z_2 = 3 + 3i$. The final position is used to assess stability of the monitoring system. In project scheduling, four engineers are assigned to supervise four critical floors. The number of possible inspection arrangements is determined to ensure efficient planning of supervision schedules, with a requirement of at least 15 distinct valid schedules.
Task
Using mathematical modelling, verify whether the construction project is feasible in terms of cost, design, structural stability, and scheduling efficiency.

Part II

Respond to one item from this part

Item 4
Kiin Industrial Manufacturing Complex consists of two major production units: a metal fabrication section and a shoe manufacturing section. In the metal fabrication section, a worker is designing an open-top storage box from a rectangular sheet of metal measuring 4800 cm by 1300 cm. Equal squares of side x cm are cut from each of the four corners and the remaining edges are folded upwards to form the sides of the box. The resulting box is intended to store finished shoe products from the factory.
The management observes that t hours after production begins, the rate of shoe production is given by $t^2e^{0.01t}$ shoes per hour, where P represents the total number of shoes produced.
At the start of production, no shoes had been manufactured. The shoes produced are packed into standard storage boxes made from the rectangular sheet above. After 120 hours of continuous production, the management intends to use the model to forecast total output for planning export contracts. Each shoe produced occupies a volume of 530 cm^3. The box is required to have sufficient capacity to store the total shoe production from the factory.
Task
Help the Kiin Industrial Manufacturing Complex find out whether the metal box has sufficient capacity to store all the shoes produced.
Item 5
A geological research team in Western Uganda is investigating a mountain suspected to have a dormant volcanic activity. The mountain profile is modelled by $y = -0.01x^2+100$, where y is the height (m) and x is the horizontal distance (m) from the central axis. A cross-sectional sketch of the curve is required to determine the mountain's topography and verify whether it has a single symmetrical peak suitable for magma accumulation. The mountain is assumed to form a solid of revolution when the curve is rotated about

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the y-axis. The resulting volume represents the volcanic rock structure used to estimate magma storage capacity. Geologists state that volcanic activity is possible only if the volume of molten magma underground is at least 1.2×10^6 m^3. The temperature of rock within the mountain varies with depth. The rate of change of temperature is proportional to the difference between the geothermal reference temperature of 900°C and the rock temperature. At the surface, the temperature is 60°C. At depths of 200 m and 400 m, the temperatures are 180°C and 420°C respectively. Geologists further state that volcanicity is possible when the temperature reaches 800°C or higher when the height is below 3000 m.

Task

Determine whether: a) its symmetric central peak favours volcanic accumulation from an accurate sketch.

b) volume of the volcanic rock structure is sufficient for the volcanic activity

c) the region shows evidence of possible volcanic activity due to the temperature at 800°C

1.12 PEA Mock

Uganda Advanced Certificate of Education

Provincial Examination Agency

PRINCIPAL MATHEMATICS

P425/1

2 hours 30 minutes

SECTION A

The item in this section is compulsory

ITEM 1

A farmers' association operates three mixed farms that supply food to a nearby trading Centre. To improve resource management, the association monitors the use of nitrogen fertilizer (x), organic compost (y) and irrigation water pumping hours (z). Data collected from three production cycles produced the following system of equations:

$3x + 2y - z = 4$, $2x + y + 3z = 9$, and $x + 3y - 2z = -1$

The association's research team analyses the seasonal crop yield variability and further establishes that crop productivity is governed by the quadratic function: $3x^2 - 6x + 2 = 0$ where α and β are the roots of the above quadratic equation. To design a new automated nutrient dispenser, engineers proposed a mathematical model whose roots are:

$\left(2\alpha + \frac{1}{\beta}\right)$ And $\left(2\alpha + \frac{1}{\alpha}\right)$

Task;

a. Using either the matrix method or the elimination method, solve the system of equations and determine the values of x, y and z.

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b. Without solving the quadratic yield equation, determine value of:

i. $\alpha + \beta$

ii. $\alpha\beta$

c. Hence, form the new calibrated quadratic function equation for the automated dispenser

SECTION B

*Answer only **two** items from this section, choosing **one** item from each of the parts I and II.*

Part I

Item 2.
Mr. Madiba is willing to put roof on his newly constructed house; he was told by his site engineer that the roof of his building should be in a triangular form ABC. He also told him the following statements
The ties and struts are to be strong if;

$$\frac{\sin(A-B)}{\sin(A+B)} = \frac{a^2-b^2}{b^2}$$

The angle of inclination of ties to struts must be α defined by $7\cos 2\alpha + 6\sin 2\alpha = 5$ where $0° \leq \alpha \leq 180°$.
Length of sides a and b of the roof must make

$$x^4 + 6x^3 + 13x^2 + ax + b \text{ a perfect square.}$$

Task:
However, Mr. Madiba could not understand any of these statements since literally illiterate and he has approached you to help him through the following;
a) If the ties and struts are strong.
b) Angle of inclination of ties to struts.
c) Length of sides a and b of the roof.

Item 3
Palm oil growing is one of the main farming activities performed in Kalangala district, during the agricultural expo ceremony, the government of Uganda suggested land of 946400 km^2 along the shores of Lake Victoria. The land was supposed to be used in the partial fractions of

$$\frac{11x+12}{(2x+3)(x+2)(x-3)}.$$

However, the resident farmers were told to use the sum of the positive partial fractions for growing palm oil and the fraction with the negative integral sign will be used for construction of a house.

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Task:
Mr. Kakeeto, the head the farmers' association in Kalangala district was actually unable to turn up to the occasion due to poor health issues and one of the farmers have approached you to help them in the following;
Express the fraction given above into simple fractions. Taking $x = 5$ obtain the real fractions for growing palm oil and construction. Determine the exact land in km^2 maent for growing palm oil and construction.
Obtain the remaining land in km^2 and with a reason, suggest any activity that can be done on it

Part II

Item 4
The chairman from your hometown has requested your engineering group to design a local water supply and drainage channel network near village trading center. The cross-section profile of a natural hill ridge valley is modeled mathematically by the parabolic function curve $y = 6x - x^2$.
A straight pipeline must be constructed along the valley floor following a path modeled by the linear equation $y = x$. For drainage pipeline safety, you must first establish the exact geometric boundaries where the pipeline cuts through the hill ridge and then map out a cross-section safety exact measurement of the total surface area enclosed between the parabolic hill ridge and straight pipeline path to allocate the correct environmental compensation funds to the surrounding community is required by the local planning authority.
Task:
As the leading hydraulic structural engineer on the project

a. Find out the coordinate points on the grid map where the drainage pipelines intersect the parabolic ridge

b. Sketch the enclosed cross-section profile of the valley safety zone showing the boundaries clearly.

c. Setup a structural definite integral expression and evaluate it to compute the exact regional area enclosed between the curve.

Item 5
On 7^{th} of June 2026 your school is going to attend a seminar at Uganda Martyrs Namugongo and your class has been given the following set of questions to discuss during the seminar;
Using small changes in differential calculus, show that $627.5^{\frac{1}{4}} \approx 5\frac{1}{200}$

a. If $x(t) = (t-2)^{\frac{3}{2}}$ and $y(t) = t^2$, prove that

$$\frac{d^2y}{dx^2} = \frac{4(t-4)}{9(t-2)^2}$$

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b. If $y(t) = \tan t$ and $x(t) = \ln(1 + \sin t)$, show that

$$\frac{d^2y}{dx^2} = \sec^5 t(1 + \sin t)^2(1 + 2\sin t)$$

c. A curve $f(x)$ is given by parametric equations $x(\theta) = 2\cos\theta$ and $y(\theta) = \cos(\theta) - 2\sin 2\theta, \quad 0 \leq \theta \leq 2\pi$

d. The point, p lies on $f(x)$ where $\theta = \frac{\pi}{4}$

e. Find the coordinates of point p.

f. Show that the equation of the normal to $f(x)$ at point p is given by $4x + 2y = 5\sqrt{2}$

1.13 UTEC Mock

Uganda Advanced Certificate of Education

Provincial Examination Agency

Uganga Teachers' Education Consult

P425/1

2 hours 30 minutes

SECTION A

The item in this section is compulsory

ITEM 1

At a certain national park, rangers have established that zebras normally move along a straight path between two points $A(2, 3, 15)$ and $B(10, 5, 5)$ and the giraffes move along a straight path between two points $C(4, -2, -4)$ and $D(6, 7, 19)$. In order to save time for the tourists, the rangers want to take tourists interested in seeing these two animals at the location P, where these paths intersect such that these tourists can see these animals at once from this location. The rangers wish that the Z component of this location should not exceed 10m for the tourists to be able to climb to this point. In case it exceeds then other options will be used.

These animals have been observed to meet at this location at times that satisfy the relation $3\cos 2t - 2\sin t = 2$. Where t can be converted in to hours passed midday using the fact that; for every 360° there are 24 hours. Some tourists have decided to see all these animals in the same place and see how they interact. The rangers wish to determine the exact time these animals will be meeting so that they can decide on when to start the journey to the location. They wish to be at the location at a time not later than 2 : 00pm for safety reasons or else they will postpone the visit.

The rangers have also showed the tourists three trees whose locations are $W(20, 12)$, $X(16, -2)$ and $Y(14, 15)$ that are in the vicinity of the camp and told the tourists that these trees were located at the boundary of a circular region that was safe for the tourists at night

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and that one should not go passed this boundary at night to avoid danger. The tourists demanded to know whether the water fall at point $Z(9, 12)$ in the park was within this safe zone. The rangers had never established whether the water fall was within this safe zone. They wish to know whether it is within this zone or not so that they can give feedback to the tourists.

Task;

Help the rangers obtain the information they need and make the right decisions.

SECTION B

*Answer only **two** items from this section, choosing **one** item from each of the parts I and II.*

Part I

Item 2.

Your neighbor is planning to start a fish farming business. He attended a workshop concerning fish farming and he was told that fish grows very well if the pond was of the right measurements. The right length L, width W and height H, all measured in meters for the pond for every n (in thousands) fingerlings, are given by $L \pm W\sqrt{H}$ obtained by dividing the number n of fingerlings to be put in the pond by the magnitude of the square root of $14 + 6\sqrt{5}$. The neighbor plans to start with 4000 fingerlings. Due to limited space, he wishes that the size of the pond to start with does not exceed 20 m^3 for the available space to be enough. If it exceeds this capacity, then he will have to reduce on the fingerings to fit the available space.

He has also been told that the profits P (in millions) from this business depend on the number n (in thousands) of fingerings sold per harvest. He has been told that these profits equal to the ratio of the fingerings increased by 2 all divided by the square of the fingerings less five times the fingerings and increased by 6. He wants to determine the range of fingerings that will give him at least one million shillings per harvest to establish whether his choice of starting with 4000 fingerlings will be feasible.

He has also been told that the cost (in hundreds of thousands) for farming n (in thousands) fingerings is given by dividing the number of fingerings with the magnitude of principal argument of the complex number. $z = \frac{(2-i)(5+12i)}{(1+2i)^2}$. He wishes that the cost does not exceed his planned budget of 300,000. If it does exceed, he will reduce on the fingerings.

Task;

Help your neighbor to make informed decisions before starting this business.

Item 3

An old woman rearing cows and goats wants to start rearing a new breed of sheep to supply her with wool. Due to old age, she had lost truck of the market prices of these three animals. She recalls that on some day she sold a cow and three goats to the market and she bought one of this new bread of sheep and she had 2.4 million resulting from this transaction. On another day, she sold three cows and one goat and also bought one of this sheep and she had 4.4m left from this transaction. She also noted that on the day

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she bought three of this breed of sheep, she had sold a cow and a goat on the same day and she was only left with 200,000 shillings from the transaction. She now wants to buy 5 sheep at once. She wishes to get this money from the sale of two cows and 2 goats and remain with a balance not less than 1million for her needs and if she cannot have this balance, then she will be forced to sell another goat to achieve her plan.
The old woman wants to also construct a shelter for the sheep. Her veterinarian has advised her that the number n of sheep per shelter depends on the length and the width of the shelter to be constructed. The veterinarian told her that the number of sheep per shelter permutation the width of the shelter must equal 30 times the number of sheep per shelter combination the length of the shelter. The old lady wants the length of the shelter to be 5m and the width to be 4m. she wishes that the number of sheep per shelter exceeds 7 for her to implement the plan or else she waits for some time.
The veterinarian told her that this breed of sheep multiplied geometrically at a common ratio of 2 sheep per year. The old lady was impressed and thought of how many sheep she will be having after 5 years having started off with only 10 sheep. She wished that if in five years the number of sheep on her farm exceeded 300 sheep, the she will give up rearing goats and concentrate on cows and sheep only.
She has also been told that the price of sheep in the next five years will be three times the sum of the modulus of the square roots of the complex number $1 + i\sqrt{3}$ in hundreds of thousands. She wants to know what this price will be and if it exceeds 800,000, then she can take a loan now.
Task.
Help the old woman make informed decisions.

Part II
Attempt any one item from this part.

Item 4

A company dealing in ceramics wants to design a new vessel. whose edge is defined by the curve $y = 8 - x^3$. the vessel surface is to be formed by the rotating the area cut off by this edge and the axes about the x-axis and then made hollow on the inside. The company wants to determine the area enclosed by the edge of the vessel and the axes. The company wishes that this area does not exceed 13 sq units or else the available machinery will need adjustments. The company wishes that volume of the vessel should not be less than 250 cubic units to meet the available capacity standards.
The company has projected that the rate of increase in its earnings will be directly proportional to product of the square of its earnings increased by twenty times the earnings and the twice the time less 1. Time is determined from the start of manufacturing of this new vessel. The company experts have suggested that at the start of manufacturing of this vessel, the total earnings will be 50millions and after half a year, the total earnings will have doubled. The company wants to know what the earnings will be after two years of manufacturing this vessel. The company wishes that if these earnings after two years do not exceed 150millions, then it will have to venture into another product.
Task.
Help the company obtain the right information to direct its decisions.

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Item 5.
The roads authority of a certain country wants to construct two straight roads. It plans that one road l_1, should be tangential to the river defined by $2x^2 + xy = 5$ at the point where $x = 1$ and the other road l_2, should be perpendicular to the first road at the very point the first road just touches the river. the authority wants to determine the equations that define these two roads so that it can arrange to clear the paths for construction to start. The authority also wishes to fund the construction bridge to be constructed where road l_2 meets the river again as long at the sum of the coordinates at this point exceeds 5 or else funding will be got from another source. The authority also wishes to use the area enclosed by the river and road l_2 from $x = 0.2$ to $x = 1$ for a recreational center if it exceeds 5 square units or else it will be left as it is.
The authority also wants to contract a company that will construct the two roads. The authority has learnt that the rate at which this company constructs a given length of the road is inversely proportional to the length constructed reduced by ten. Where time is in months. From previous records, the company constructed 10km in a period three months and it also constructed 50km in a period of a year. The two roads have a total length of 100km. the authority wants to determine the time it takes the two roads to be constructed and wishes that it takes less than three years or else it will have to contract another company and two companies share the roads.
Task: Help the authority to obtain the necessary information and make informed decisions.

END

1.14 Wakata Mock

Uganda Advanced Certificate of Education
Wakiso-Kampala Teachers' Association Mock Examination
P425/1
2 hours 30 minutes

SECTION A
The item in this section is compulsory

Item 1
A telecommunications company is expanding its network coverage in a certain country by constructing additional communication towers and installing transmission equipment to serve several communities. The company engineers use a three-dimensional coordinate system to map the locations of the existing towers at $A(4, 6, 5)$ km, $B(10, 8, 3)$ km, and $C(6, 12, 1)$ km. They have identified the need to install another tower at $D(16, 10, 1)$ km. However, the company manager will approve the installation only if the proposed tower lies on the straight transmission path determined by towers A and B, since this would

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guarantee the anticipated improvement in signal coverage and transmission.
For emergency operations, a new control station is proposed at $E(4, 6, 10)$ km. The engineers must determine the shortest distance from the control station to the plane containing towers A, B, and C in order to assess the efficiency of the communication links. The links will be considered reliable only if that distance is less than 8 km.
During the expansion project, the engineers also mapped three inspection points on the boundary of a circular security zone surrounding a control station. The points were recorded as $P(18, 6)$ km, $Q(6, 18)$ km, and $R(-6, 6)$ km. They are required to determine whether a road passing through $T(6, -6)$ km lies within the secure zone, since it will be used by the maintenance team during late hours.
During system testing, the engineers discovered that the signal transmission distance from any tower is given by;

$$D = (30 \sin 2\theta + 40 \cos 2\theta - 2) \text{ km}$$

The engineers require a maximum transmission distance of at least 40 km in order to ensure the nearby underserved towns are covered.
Task:
a) Will the manager approve the new tower location?
b) Determine whether the communication links will be reliable.
c) Determine whether the road lies within the secure zone.
d) Determine whether the required signal transmission distance will be achieved.

SECTION B

*Answer only **two** items from this section, choosing **one** item from each of the parts I and II.*

Part I

Item 2.
In a certain school, parents agreed at a meeting to contribute money every term in addition to each student's school fees in order to buy a school bus. They planned to contribute Shs 30, 000 in the first term, and the contribution would increase by Shs 10, 000 each term thereafter for 15 terms.
The head teacher wants to determine whether the planned contributions will be sufficient to meet the target budget of Shs 700 million for the bus, given the current enrolment of 500 students.
The school administration has also introduced a weekly performance allowance through the teachers' canteen to improve teachers' availability at school. The total number of hours, x, worked by a teacher in a week must satisfy the condition that the square of the hours plus 3600 is at most 136 times the number of hours for the teacher to qualify for the bonus. The Senior Four English teacher worked 56 hours in a certain week because of many extra lessons and is unsure whether she qualifies for the bonus.
The prep committee consists of 5 male and 4 female teachers. The teachers want to form

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daily teams of four teachers with an equal number of males and females. The arrangement will be considered effective only if the number of possible teams exceeds 50.
To improve the security of its digital financial records, the school is installing a new encryption system. The strength of the system depends on a security key represented by x units. A security key is considered strong if x is at most 3 units.
During testing, the ICT officer finds that the overall security rating is obtained by combining two measurements:
$\log_x 4$ and $2\log_2 x$
The system will function correctly only when the total security rating is equal to 4 units.
Task:
a) Help the head teacher determine whether the parents' contributions will be sufficient for the purchase of the school bus.
b) Determine whether the English teacher qualifies for the bonus.
c) Determine whether the prep committee's daily team arrangement will be effective.
d) Determine whether the security key is strong.

Item 3.
A regional development authority has embarked on a major project to improve water supply, energy production, and digital monitoring services for several rural communities through international funding programmes. At each stage, the management team is required to make important decisions.
During the first phase of the project, the authority planned to increase the number of household water tanks installed each year as more villages joined the programme. In the first year, 24 tanks were installed, and in the second year, 48 tanks were installed.

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The planners agreed that annual installations would continue to grow by the same constant ratio. However, the project budget could support the expansion only if the total number of tanks installed during the first nine years did not exceed $130,000$. Before approving the next stage of the programme, the planning team needed to determine whether the proposed installation programme was financially sustainable.
At the central stores, three types of equipment were purchased: water pumps, filtration units, and solar control panels. Supplies were received from three contractors, with costs given in hundreds of dollars.

Contractor	**Water Pumps**	**Filtration Units**	**Solar Control Panels**	**Total Cost**
A	2	1	3	86
B	3	2	1	91
C	1	4	2	104

The finance department knows that each item has a fixed unit cost, but the individual costs were not recorded separately. Before authorising another order, the department must determine the cost of each item and decide whether the remaining budget of USD $44,000$ is sufficient to purchase an additional 10 water pumps, 8 filtration units, and 12 solar control panels.
In the final phase of the project, a digital monitoring system was installed to monitor the distances over which the pumps can deliver water. The reference point of the pumps is $Z_0 = (5 + 12i)$ km, and the stations are modelled by the equation

$$Z^3 - 8Z^2 + 37Z - 50 = 0$$

The water pressure will be sufficient if the distance $|Z_0 - Z|$ from each station to the pumps is less than 20 km.
Task: Using mathematical reasoning, advise the management team so that it can make informed decisions during the project.

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1.15 WENSEC Mock

WEST NILE SECONDARY SCHOOLS EXAMINATION COUNCIL(WENSSEC)

Uganda Advanced Certificate of Education

P425/1

2 hours 30 minutes

SECTION A

The item in this section is compulsory

Item 1

A technology company in Kampala City Innovation Mathematics Club is designing drone-navigation and signal-processing system for agricultural monitoring. Two drones were launched and their movement from the control station is represented by the vectors. They were launched using different routes and at one point they are supposed to meet. One of the drones took the route described by the vector equation

$$r_1 = \lambda \begin{pmatrix} 1 \\ -3 \\ 4 \end{pmatrix} + \mu \begin{pmatrix} -1 \\ -3 \\ 1 \end{pmatrix},$$

while the other drone took the route described by equation

$$r_2 = \lambda \begin{pmatrix} 0 \\ -2 \\ 5 \end{pmatrix} + \mu \begin{pmatrix} 1 \\ -2 \\ -1 \end{pmatrix}.$$

The controller is not sure where the two drones will meet and the angle between the two routes if they are to meet. The same company were asked to designed a rotating spotlight to shine on the students performing during their cultural galas as they move on stage. They discovered that the brightness of the light at any instant depends on the angle of rotation. From the design notes, students observed that when the rotation angle is A (where A is acute angle), the brightness after three rotations can be expressed as $\sin 3A = 3\sin A - 4\sin^3 A$. Before presenting their project to the judges, the company were task to confirm that this rotation is mathematically correct and to determine the value of A when $3\cos A - 4\sin A = 5$ but lack idea on how to confirm it. The same company plans to install a modern signal transmission system in a newly developed city. The engineers in the company decide to use different mathematical models to design the system efficiently. At the Centre of the city, a circular recreational park is constructed such that its boundary is represented by the equation $x^2+y^2-8x+6y-11=0$. Far away from the city, an elliptical racing track is constructed for testing autonomous vehicles. The track has equation

$$\frac{x^2}{25} + \frac{y^2}{9} = 1.$$

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Task
a) Help the controller out of the challenge.
b) As a student of pure mathematics, help the company clearly verify that the two equations are equal and to find the value of A.
c) Help the company determine the Centre and radius of the circular park and determine the eccentricity of the ellipse.

SECTION B

*Answer only **two** items from this section, choosing **one** item from each of the parts I and II.*

Part I

Item 2.
Company wants to install two signal boosters to improve communication between fishing boats and the mainland along Lake Albert in Panyimur. One emergency signal beacon was located at the complex point $z = x + iy$, where x and y are real numbers. The engineers discovered that the beacon always satisfied the condition $|z - (3 + 2i)| = 5$, meaning that the beacon remained at a constant distance from the relay station located at $3 + 2i$. Technicians in the same company were investigating the performance of an automated glaze-mixing and delivery system used during porcelain tile production. The rate at which a liquid glaze moved through one section of the pipe network was modeled by the rational function,

$$G(t) = \frac{5t + 9}{(t - 2)(t^2 + 3t + 4)}$$

where t represents time in minutes and $G(t)$ represents the flow rate in litres per minute. To simplify the model for analysis, the engineering students working in the company were asked to express the function into partial fractions in the form

$$\frac{5t + 9}{(t - 2)(t^2 + 3t + 4)} = \frac{A}{t - 2} + \frac{Bt + C}{(t^2 + 3t + 4)}.$$

As the students were calibrating the machine for modeling the tiles, they discovered that three operating parameters x, y and z satisfies the equations

$$\begin{aligned} 2x + y - z &= 7 \\ x - 3y + 2z &= -4 \\ 3x + 2y + z &= 12 \end{aligned}$$

The laboratory supervisor in the company requested the students to analyze both mathematical models before the machine could be approved for use.
Task
a) Interpret geometrically the locus represented by $|z - (3 + 2i)| = 5$ and determine its centre and radius, hence sketch the locus.

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b) Express $G(t)$ into partial fraction and hence determine the value of $G(1)$.
c) Solve the simultaneous equations to determine x, y and z.

Item 3
A technology company designs a data storage system in which the amount of the data processed in the n$^{\text{th}}$ cycle is modeled by the polynomial $f(x) = x^3 + ax^2 + bx + 2$ such that when $f(x)$ is divided by $x - 1$, the remainder is 4 and when divided by $x + 2$, the remainder is also 4.
The company also observed that the total amount of data processed after n cycles follow the sequence $5, 10, 20 \ldots$ so that it can gives a sum greater than $500,000$.

To estimate the future storage requirements, engineers use the expansion of $\sqrt{\frac{1+x}{1-x}}$ in ascending powers of x to the terms in x^2 and use the expansion $(1+x)^{\frac{1}{2}}$ up to the terms in x^3 to find the value of $\sqrt{1.08}$ to 4 decimal places.
a) Find the values of a and b.
b) Help the company to find the smallest number of terms of the geometrical progression.
c) Help the engineers to expand what is before them and use the information appropriately.

PART 1

Attempt only one item from this section

Item 4
At a carpentry workshop in Ombaci, decorative wooden panel is being designed for the reception area of the hotel. The edge of the panel is shaped using computer controlled cutting machine following a mathematical model $y = x^3 - x^2 - 5x + 6$. The designer wants to identify the exact point where the curve changes direction in order to smoothen sharp bends and ensure structural stability. The same carpenter also deals in metal fabrication and were instructed to design arch frame for advertising board at the roadside sign-post workshop in Ediofe Trading Centre. To ensure accuracy before cutting the metal sheets, the shape of the upper edge is first modelled using mathematical curves on the coordinate grid. The arc is modelled by $y = x^2 + 4x + 3$ and the fabricators needs clear sketch of the curve in order to identify the key features before fabrication begins.
Task
As a mathematics student,
a) Help the designers to find the coordinates of the turning points and distinguish its nature. b) Help the fabricator to sketch the above curve, clearly showing all important features.

Item 5
In a certain village, Agricultural extension officer carried out research to investigate the effect of a certain chemical on a virus infection crops. The research revealed that the rate at which the virus population is destroyed by the chemical is directly proportional to the population of the virus at that time. Initially, the population was p_0, but at t months

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later, it was found to be p. In his research, the extension officer wanted to know how long it will take for only 5% of the original population of the virus to remain but lack interpretation skills. The extension officer was also tasked to find the particular solution of the differential equation $x\frac{dy}{dx} + 3y = 5x^2$ at $y(1) = 3$ but express no idea on how to solve it.

Task You have been contacted to help the Agricultural extension officer to have proper interpretation of the data obtained;

a) Form a differential equation connecting p and t.

b) Given that the virus population reduced to one third of the initial population in four (4) months, solve the equation in (a) above.

c) Find how long it will take for only 5% of the original population to remain.

d) Help the extension officer solve the equation.

END

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1.16 UTES Mock

Uganda Advanced Certificate of Education

Uganda Teachers Examination Scheme

P425/1

2 hours 30 minutes

SECTION A

The item in this section is compulsory

Item 1

Masaka road passes in points $(3,-2)$ and $(2,1)$, Mityana road passes at a point $(6,-7)$ but meets Masaka Road at 90° at Busega. Engineers are planning to construct Kajjansi road to obey the equation $5x+12y-18=0$ but Busega is a very busy trading Center and it must be at leat 2km from Kajjansi road for the safety of the people doing business in Busega town. Due to the increased crime rate on Masaka Road, the Engineers installed three cameras at points $A(3,2,-6)$, $B(7,8,4)$ and $C(13,17,19)$ but the engineers are not sure whether these three cameras are in the same line or not. The pole on which camera C was installed is supported by a strong wire to the ground. This supporting wire makes an angle of θ to the horizontal where θ is acute and $6\text{cosec}^2\theta + 7\cot\theta = 9$.

Before Busega business centre, there is a roundabout that satisfies the equation $x^2+y^2+2x-4y-11=0$. A straight road touches this roundabout and moves to Nateete where Nateete is at point $(3,5)$. Peter is planning to ride his motorcycle from Nateete to the roundabout through this straight road just to stop at the roundabout but the fuel he has can only cover 5km.

Hint; Assume 1unit = 1.4km

Task

a) Determine whether Busega trading centre is at a safe location from Kajjansi road for the people doing business in this centre.

b) Establish whether the cameras on Masaka Road are in one straight line and determine the angle the wire supporting the pole on which camera C was installed makes to the horizontal.

c) Recommend, based on calculations if Peter should rely on the fuel he has in the motorcycle for the journey from Nateete to the roundabout at Busega.

SECTION B

*Answer only **two** items from this section, choosing **one** item from each of the parts I and II.*

Part I

Item 2.

Three students made shopping from the same shop on the same day. All items were of the same quality. Annet bought 5 books, 9 sets and 7 compo pens. Betty bought 8 books,

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a set and 4 compo pens. Cissy bought 6 books, 2 sets and 8 compo pens. Annet used a total of sh 65,500. Betty and Cissy spent a total of sh 90,500. Cissy spent sh 18,500 less than Annet. John needs 7 books, 4 sets and 6 compo pens however, he was given only sh 27,000 for the shopping but he is not sure whether this money will be enough to buy what he wants. The profit made by Mr. Luuti, the shop owner, after selling books is given by squaring the number of books sold add 300,000 and subtract seven hundred times the number of books sold. Mr Luuti made the smallest profit on Wednesday 3rd June 2026 because it was a public holiday in the country but he created several strategies of increasing sales such that he could get at most sh 180,000 as profit on Sunday 7th June 2026 but he was not certain on the number of books to sell that Sunday. Mr Luuti's shop has two rooms. The first room is 4 metres by 2 metres while the second room has a square base whose length is 1 meter more than the length of diagonal of the first room. The area of the second room is in the form $a+b\sqrt{c}$ and this room is locked with a three digit pin obtained by arranging the roots of the equation $x^3-9x^2+23x-15=0$ from the biggest to the smallest.
a) Check whether John has enough money for the items he needs.
b) Compute the profit Mr.Luuti got on 3rd June 2026 and the range of number of books he had to sell on Sunday 7th June 2026.
c) Determine the base area of the second room and the three digit pin used to lock this room.

Item 3
A group of seven students from SSENDE SS (excluding prefects) is needed from the 6 boys and 5 girls available to represent the rest in a workshop. The girls must be more than boys. These students will move with teachers and prefects to keep order on the way and in the workshop where the coordinate given from $(9+2i)^2(3-i)$ represents teachers and prefects in that order. They will also take some craft materials to be sold in this workshop. The prices of the craft materials will be in a certain progression. The cheapest craft will be at sh 3,000, the second will be at sh 6,000 while the third will be at sh 12,000. Mike is interested in buying the ninth craft material but he does not know how much to pay. Mike is also interested in knowing the actual number of members in the work shop who never came from SSENDE SS where these members from other schools are the coefficient of x^7 in the expansion $\left(3x^2+\frac{4}{x}\right)^8$. During the meeting, the students were told to go for lunch at 1 : 15pm and they were expected to come back after time t (in hours) where $0<t<1$ and $\log_3 t-\log_t 9=1$.
Task a) Determine the number of ways the group needed can be selected and the number of teachers and prefects to move with the students for the workshop
b) Based on calculations, help Mike to know the price of the craft material he is interested in and the number of members in the workshop who never came from SSENDE SS
c) Generate the time at which the students are expected to come back from lunch

PART II

Item 4
On a certain fundraising ceremony, Mr. Dodo was hired to decorate the venue. The

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place was to have disco lights which obeys the equation $y = \frac{x^2-2x-8}{x^2-1}$.
On this ceremony there will be p **VIP** seats and q **ordinary** seats were $\frac{257x-1392}{x^2+x-12} = \frac{p}{x-3} + \frac{q}{x+4}$. Each member who attended had to either buy a seat or keep standing. Each VIP seat was hired at sh 50,000 while an ordinary seat was hired at sh20,000. On this party, all seats from both categories were hired out. The tent in which the ordinary seats were placed obeys the equation
$y = 8 + 2x - x^2$ where x is distance from its centre.
Task a) Sketch the region to be decorated by lights
b) Determine the total amount of money received from the hired seats
c) Calculate the area covered by the tent hosting ordinary seats with the ground.

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1.17 Other Mock

1.17.1 SET 1

UACE SET-1 (CODE HIGH SCHOOL)

Uganda Teachers Examination Scheme

P425/1

2 hours 30 minutes

SECTION A

The item in this section is compulsory

Item 1

In Mukono trading center, cargo vehicles move following a particular road pattern described by the curve $2x^2+4x-1=0$ whose roots are α and β. However, when the Mayor of the municipality visited the area for inspection, he realized that there was congestion and decided to construct a new road of the same nature as the existing one with roots being $\frac{1-\alpha}{\beta}$ and $\frac{1-\beta}{\alpha}$.

The revenue department in the Mayor's office advised the Mayor that to construct this new road easily, the tax levied on the traders should be increased by an approximate factor of $\sqrt[3]{24}$ corrected to three significant figures got by expanding $(1+x)^{\frac{1}{3}}$. To get a favorable value that does not exploit traders, the expansion should be to the term in x^3 and the value of $x=\frac{1}{9}$ should be substituted.

After analyzing the length of this new road by the engineering department team, they found it to be:

$$\left(\frac{2\sqrt{2}}{3-\sqrt{2}} \div \frac{4+\sqrt{2}}{3+\sqrt{2}}\right) \text{ km}$$

However, the Mayor tasked them to express it as a linear expression of the form $a+b\sqrt{2}$.

The Mayor has decided to form a committee of four members among whom is the chairperson of the market. He is choosing from a group of four engineers and 5 revenue specialists. The committee can have one or two engineers.

To protect the account where the revenue money has to be placed, he has decided to hide the last value of the password in the solution of the equation $\sqrt{x-5}+\sqrt{x}-5=0$. But he is not sure of this value and wants this information summarized in report form.

Task:

Help the Mayor to formulate the report for proper documentation.

SECTION B

*Answer only **two** items from this section, choosing **one** item from each of the parts I and II.*

Part I

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Item 2.
At Code High School, the security team was tasked to install cameras in the library to monitor the noise makers in the library. The technical team led by Teacher Maganda discovered that the sitting plan of the library was designed such that the columns follow the plane $2x + y - z = 5$, the rows follow the plane $x + 3y + 2z = 5$, and the book shelf follows the plane $x - y + z = 1$. They came up with a plan of installing a 3-dimension camera at the center of the three planes.

The estimated cost after consulting one of the installation companies was UGX 18 millions, which looked expensive for the school. However, Teacher Bonny suggested that the school should invest UGX 1.5 millions at the beginning of every month in CODE TEACHER'S SAVING CREDIT SACCO that offers a compound interest of 14% per month for eight months without withdrawals. In this way, the school can use the interest earned to fix the cameras.

The security team has also identified that to boost the security around the school, they should incorporate non-teaching staff, and a group of 8 members should be selected from 15 non-teaching staff. Also chairs whose area is the product of the solution of the expression $9^m - 12(3^m) + 27 = 0$ to minimize on congestion in the library should be brought. However, they don't know the number of ways of selecting the team and the value of the area of the chair.

The technical team has also discovered that the library lights that emit a light of a frequency $\left(\frac{1+\sqrt{3}i}{1-2i}\right)$ Hz should be used so as not to interfere with the new camera; however, turning off these lights in order not to affect the camera depends on modulus and its principal argument which need to be known.

The head of the security needs to compile a logical report to the head teacher about their findings and possible solutions.
Task:
Help the security team to design the logical report which has to be presented to the head teacher.

Item 3
The electrical grid at Code High School has two grid lines. One for non-lighting electrical components and the second one for the lighting system in a school; however, the head teacher has discovered that the lighting system in the school is mismanaged and this has led to unnecessary losses in the school. After a careful study, he discovered that the teaching faculty is at coordinate $(2, 9)$, Girls dormitory at a coordinate $(5, 0)$, and boys dormitory at a coordinate $(-1, 8)$ and are in circular form. He needs to determine the central point where the switch can be placed to control the three buildings and the cost of the length of the wire connecting each building from the central switch.

To eliminate the challenge of trespass, the head teacher is supposed to construct a pathway of pavers, R_1, passing through $(2, 2)$ and $(3, 3)$ to connect directly from the teaching faculty to the dining hall. A pathway of pavers, R_2, passing through $(2, 0)$ and $(-1, -1)$

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such that it connects the girl's dormitory and the canteen. However, he discovered that the two pathways meet and he plans to put at this point a school monument of the director, but is not sure of this point.

To make the school security tight, the cameras should be placed at point $A(2, \sqrt{3}, -3)$ on the girls dormitory and $B(1, 0, -1)$ on the teaching faculty block such that it follows a given Cartesian equation joining the two points; however, the head teacher does not know this equation. To make the cameras to have a wide field of view, they should be positioned at angles that satisfy the equation $12\cos\theta + 5\sin\theta = 2$ within the range of $0° \leq \theta \leq 360°$.

The parabolic lamp placed at $(at^2, 2at)$ to enhance security by producing a parallel beam of light, is tangentially sending a light ray to the head teacher's office making him uncomfortable. He wants to position the lamp at the same point but perpendicular to the current path. HINT: (Cost of 1 unit of a wire is UGX 20,000. The equation of a parabola is $y^2 = 4ax$).

Task:

Help the head teacher to address the concerns.

PART 1

Item 4

Mama Jane's daily cost of producing x batches of produce is defined by the equation $\frac{2x^2+5x+7}{(x+1)(x+1)^2}$ and her accountant explains to her that this cost function can be broken down into simpler parts for better analysis. Motivated by her success in the business, Mama Jane has started a juice business on the side. She uses conical disposable cups that are popular with the customers. These cups are of height h cm and radius r cm which are related by $r = \frac{h}{2}$. While filling the cups, the juice is pumped at a rate of 10π cm^{3}s^{-1} and she wants to use this to analyze the rate at which the height of the juice rises in the cups when the height of the juice is 6 cm to serve her customers faster.

Mama Jane having received a lot of customers would like to construct a good restaurant on a piece of land enclosed by the curve $y = (2 + x)^2$ from $x = 0$ to $x = 1$. She tries to estimate the area by using trapezium rule with 6 ordinates correct to 4 decimal places and later performed an integration to get the actual value, but needs to know the percentage deviation of the area from the actual area of the land.

Task:

Use the knowledge of calculus to break down Mama Jane's concerns following the logical steps to make her clearly understand and plan for her business.

Item 5

A chemical factory dealing in production of pesticides deals with a concentrate x and concentrate y to come up with a final product. The two concentrates are related by the equation $y = \frac{\sin x}{x}$. They hired a new female chemical engineer who confirmed to the manager that the concentrates satisfy the model $x\frac{d^2y}{dx^2} + 2\frac{dy}{dx} + xy = 0$. However, the manager was not convinced by her submission.

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The factory packs their product in a bottle container of volume 10 cm^3; however, the company auditor advised the company manager that they are making losses due to much cost of production of the packaging material. The manager has tasked the new engineer to design a cylindrical container of the same volume but while using the radius and the height that give the least possible area of the material to be used. The manager also needs to know step by step how the surface area can be modeled to $A = 2\pi r^2 + \frac{20}{r}$.

The manager wants to build the warehouse in the company land that is bounded by the functions $y = 2x^2 + 7x + 3$ and $y = 9 + 4x - x^2$. However, he is not sure of the shape of land and size of land bounded by the two functions. He has also tasked the engineer to perform for him this task before he contacts the construction company.
HINT: Leave π in your solutions where necessary.
Task:
Help the female engineer to satisfy the demands of the manager.

Item 6
Mr. Kamau is a farmer who has built a new fish pond. He needs to understand several mathematical concepts to manage his pond's efficiency. When he invited the expert, the expert said his fish growth pattern modeled $p(t) = e^{2t}\cos t$ or $\frac{d^2p}{dt^2} - 4\frac{dp}{dt} + 5p = 0$. But Kamau didn't accept the fact that fish growth could model both of the above functions.

The expert advised Kamau that the quantity of food, x, to be given to his fish satisfies the function $Q(x) = x^3 - 2x^2 - 4x + 10 = 0$. However, the exact quantity of food that does not waste food (is a root) lies between $x = 3$ kg and $x = 4$ kg. The expert informed him that the exact value can be obtained mathematically using the Newton-Raphson Method correct to 4 decimal places. However, Kamau has limited information about this method.
The expert advised Kamau that:
i) The volume of the water reservoir to maintain the ponds should be generated by rotating the curve $y = kx^2$ about the y-axis so that when the surface depth of the central reservoir is h meters, the surface area, A, is proportional to h and the volume is proportional to h^2.
ii) Since the pond is located in a dry place, the rate of loss of water from the reservoir due to evaporation is λA m^2 per day. To monitor this effect, a differential equation that relates the height, h, and time, t, should be formed.
iii) Due to the intensity of the solar radiation, the differential equation is modeled to have a constant $\lambda = \frac{1}{2}$. Kamau asked the expert how many days it will take for the depth of the water in the reservoir to decrease from 20 m to 2 m.

However, the expert demanded an additional fee of UGX 1.5 millions to help him solve all the concerns step by step. This made Kamau to leave the expert with the preliminary information attained since he had no money to add him.
Task:
Help Kamau to address his concerns step by step based on the information given by the expert.

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1.17.2 SET 2

JOINT EXAMINATIONS BOARD
UGANDA ADVANCED CERTIFICATE OF EDUCATION
PRINCIPLE MATHEMATICS
PRINCIPAL MATHEMATICS
$P425/1$
2 hours 30 Minutes
SECTION A
The item in this section is compulsory

ITEM 1
An extension worker mapped a village demonstration farm using Cartesian coordinates in three dimensions. He installed a sprinkler at the point $S(1, 3, 2)$ inside a greenhouse. The greenhouse roof is the plane $3x - y + 2z = 7$. A water pipe, which runs along the line $\mathbf{r} = (2+\mu)\mathbf{i}+(-1+2\mu)\mathbf{j}+(1-2\mu)\mathbf{k}$, enters the greenhouse through the roof at point P. The extension worker wishes to move the sprinkler closer if the distance between S and P is more than 5 m.
Two boundaries of the sprinkler spray zone on the greenhouse floor have equations $y = 2x - 1$ and $3x + 4y = 8$. The extension worker wishes to change the nozzle if the angle between the two spray boundaries is less than $50°$.

During calibration, the sprinkler rotates through an angle x which satisfies:

$$2\sin x + 5\cos x - 1 = 0, \quad 0° \leq x \leq 180°.$$

If the angle is less than $100°$, the sprinkler will be adjusted.
A faulty nozzle sprays water such that it hits the floor at a point $Q(x, y)$ whose distance from the point $A(2, 1)$ is twice its distance from the point $B(5, 3)$. The extension worker wishes to relocate a plant at $(7, 4)$ if water cannot reach it.
Task: Based on mathematical computations, advise the extension worker on the decisions to take.

Section B
PART I
Attempt only one item from this section.

Item 2
A college administration is planning activities for the Annual Academic Excellence and Innovation Week. To ensure fairness in allocating study materials, organising students' awards, and scheduling the official opening ceremony, the administration applies mathematical reasoning.
To allocate revision booklets fairly, 25 times the number of booklets given to each student minus the square of the number of booklets given to each student should be at least 144. For fairness, each student must get at least 8 booklets.

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The administration has selected 8 student leaders, but only 5 of them will receive certificates of excellence. For their plan to continue, the number of possible selections of certificate winners should not exceed 60, and each cash prize should not be more than Shs. 120 million.
The certificates for the 5th, 4th, 3rd, 2nd, and 1st positions correspond respectively to the first five terms in ascending powers of x in the expansion of $(4 + 3x)^7$, where x represents Shs. 5.

The administration wishes to determine the number of possible ways of awarding the certificates while maintaining fairness.
On the day of the ceremony, 50 invited guests are expected. The first guest arrives at 9:10 a.m., and each subsequent guest arrives t minutes after the previous one. The Guest of Honour is the last person to arrive, and 15 minutes later the ceremony will officially be declared open. The ceremony is to run for 3 hours 40 minutes and must end by 5:59 p.m. **Task:** Help the administration decide whether to carry on with the planned format of booklet distribution and certificate awarding. Also advise on the arrival-time interval t for the individual guests so that the function ends on time.

ITEM 3 The security team was tasked to design a strong security pillar to be constructed in a sugar-cane plantation to monitor and fight fire outbreaks. The pillar will provide a high viewpoint for surveillance and quick response.
The heights of the steps above the ground increase by the same vertical distance from one step to the next. The height of the 5th step is three times that of the 7th step. The total height of the first twelve steps is 21 m. The team wishes to redesign the pillar if the total height of the first five steps is less than 15 m.

The security team wishes to reduce response time by placing two communication radios a distance of x tens of metres from the pillar. One radio shows a signal strength of $3\log_8 x$, and the other radio shows a signal strength of $6\log_x 4$.
For the safety team to hear clearly without echo, the sum of the two signal strengths must be 8. The team wishes to adjust the radios if their distance from the pillar is less than 40 m.

The team wishes to position at least four solar-powered lights. The main light is positioned at $-8 + 8\sqrt{3}i$ metres on the plantation grid. The other three lights must be positioned at the cube roots of the main light position. The team wishes to relocate the lights if the sum of the moduli of the positions of these lights is less than 10 m. **Task:** Based on mathematical evidence, advise the security team on the decisions to make.

Part II

Attempt only one item from this section.

Item 4
A farmer in Buyende District is establishing a beef-cattle project on his land along a

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river.
He is to construct a rectangular paddock along the river, which forms one side of the enclosure; only the remaining three sides require fencing. The farmer has 1120 m of fencing available.
Veterinary guidelines recommend that each bull requires 500 m^2 of grazing space. The farmer stocks the farm at a rate proportional to the square of the number of available bulls. Initially, there are 50 bulls on the farm, and after 8 weeks there are 75 bulls. The farmer wishes to start selling bulls when the farm is stocked to full capacity.

To maintain the pasture throughout the year, an irrigation system is installed. The main irrigation pipe follows the path $y = x^2\sqrt{10 - x}$, where x represents the horizontal distance, in metres, east of the water source and y is the distance, in metres, north of the water source. Engineers are to install inspection gadgets at points where the pipe changes direction; these points must be 10 metres apart.
Tasks:
a) Determine the maximum number of bulls that can be grazed according to the veterinary guideline.
b) Advise the farmer on when to start the sales.
c) Make a recommendation on the engineers' inspection points.

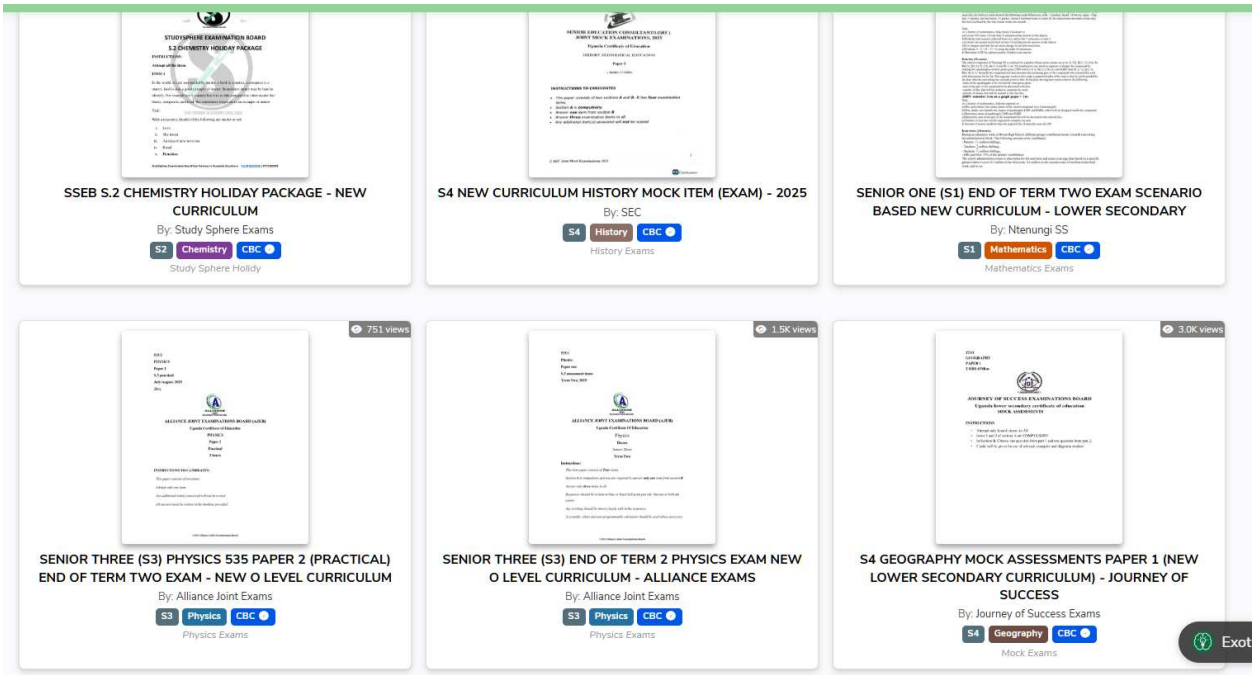
Item 5
A community irrigation project is constructing a decorative water feature and a storage system for a farm.
The side profile of the decorative basin is modelled by $y = x(4 - x)^2$, $0 \leq x \leq 4$, where the units are metres.
The region enclosed by the curve and the x-axis is rotated about the x-axis to form a solid basin whose volume must be at least 450 m^3; otherwise, the decorative feature must be redesigned.

At the same project, workers use a spherical water pot of radius 2.5 m for processing the water. The pot is filled with water to a depth of 3.6 m. The water is then poured into a cylindrical container of base radius 6 m. For the project to be successful, the height of water in the cylindrical tank must not be greater than 0.5 m.
Task: With mathematical justifications, analyse the project.

END

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