P425/1 PRINCIPAL MATHEMATICS MOCK COMPILATIONS 2026

SECTION A TYPE ITEMS (GEOMETRY)

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 an administration block to improve on lighting in the school. However, the school security guard patrols at night along a 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 9m from the patrol corridor, if not the school will find another location. (All coordinates in metres).

The girl's 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 modelled by the equation: $\boldsymbol{y = 4 - \frac{x^2}{8}}$ (where $\boldsymbol{y}$ is the height in metres above the ground and $\boldsymbol{x}$ is the horizontal distance from the centre of the shelter).

Rain water collects at a central overhead collection node located at **Q (0, 6**). A straight drainage downpipe must be installed to run from Q, touch the roof curved surface and 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 modelled such that its distance of coverage in every rotation is; $\boldsymbol{D = 20(3\sin\theta + 4\cos\theta + 6)}$metres. The school management wishes to monitor a distance in the range: $\boldsymbol{30 < D < 200}$ metres, but they don't know if this camera will reach their target.

Task: Help the school administration using mathematical skills to make valid decisions flood lights, drainage pipes and CCTV camera. (ACEITEKA)

ITEM 2:

Peter your close friend, lives in Kampala. During the last term holidays, many people complained about traffic congestion in the city. A KCCA engineer, speaking on UBC TV, explained that a new road would be constructed as the perpendicular bisector of a road passing through the points **(4, -2)** and **(6, 8).** Peter

wanted to determine the equation of this new road but did not know how to do it. This term he asks for your help.

The engineer also suggested constructing a roundabout at the intersection of the two roads. He explained that all the three points **A, B** and **C** had been marked forming a triangle **ABC**. He added that a water fountain would only be constructed if $\cos A + \cos B + \cos C - 1 = 4 \sin\left(\frac{A}{2}\right) \sin\left(\frac{B}{2}\right) \sin\left(\frac{C}{2}\right)$ that confirms that angles **A**, **B** and **C** form a triangle.

He further stated that some corners of the new road would be based on angles satisfying the equation $\sin 2\theta \cos\theta + Sin^2\theta = 1$, where the angle lies between 0° and 360° inclusive. This made Peter even more confused.

Task: **Using appropriate mathematical models, help Peter understand the engineer's explanation, from determining the equation of the new road to identifying all possible angles that satisfy the given condition. Advise whether the water fountain should be constructed, giving reasons for your responses.**

(KAMSSA PRE-MOCK)

ITEM 3:

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 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 communications 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 round passing through **T (6, -6) km**, lies within the secure zone, since it will be used by the maintenance team during late hours.

During testing, the engineers discovered that the signal transmission distance from any tower is given by: $\boldsymbol{D = (30\sin 2\theta + 40\cos 2\theta - 2)}$ km. The engineers require a maximum transmission distance of at least 40 km in order to ensure that 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.**

(WAKATA)

ITEM 4:

A zone in one of the districts is facing 3 challenges; traffic congestion, poor mobile network at 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: $\boldsymbol{x^2 + y^2 - 4x - 8y + 16 = 0}$, where all the distances are in kilometres. To reduce congestion, a new express road modelled by the equation $\boldsymbol{y = x + 4}$ 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 procurements records show that the cost of 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 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 $\mathbf{10°}$ and $\mathbf{20°}$**,** and the point **(3, 3, -7)** should lie on the solar panel.

Task: **Using mathematical justification 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. (ASSHU-BUSHENYI)**

ITEM 5:

At a certain national park, the rangers have established that zebras normally move along a straight path between two points **A (2, 3, 5)** and **B (10, 5, 5)** and the giraffes move along a straight path between two points **C (4,-2,-4)** and **D (6,7,9)**. 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 $\boldsymbol{t}$ can be converted into hours passed midday using the fact that for every $\mathbf{360°}$ 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 not later than **2:00p.m** 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 (14,5)** that are in the vicinity of the camp and told the tourists that these three trees are located at the boundary of a circular region that was safe for the tourists at night and that one should not go past this boundary at night to avoid danger. The tourist demanded to know whether the waterfall at point **Z (9,12)** in the park was within the safe zone. The rangers had never

established whether the waterfall was within this safe zone. They wish to know whether its 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 right decisions. (UTEC MOCK)

ITEM 6:

An extension worker mapped a village demonstration farm on 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 $\boldsymbol{3x - y + 2z = 7}$. A water pipe which runs along the line

$\boldsymbol{r = (2+\mu)i + (-1+2\mu)j + (1-2\mu)k}$ enters the green house roof at point **P.** The extension worker wishes to move the sprinkler closer to change if the distance between **S** and **P** is more than **5m.**

Two boundaries of the sprinkler spray zone on the green house floor have equations $\boldsymbol{y = 2x - 1}$ and $\boldsymbol{3x + 4y = 8}$. The extension worker wishes to change the nozzle if the angle between the two spray boundaries is less than $\boldsymbol{50°}$.

During calibration, the sprinkler rotates through the angle $\boldsymbol{x}$ which satisfies the equation $\boldsymbol{2\sin x + 5\cos x - 1 = 0; (0° \leq x \leq 180°)}$. If the angle is less than $\boldsymbol{100°}$,the sprinkler will be adjusted.

A faulty nozzle sprays water such that it hits the floor at a point

Q $\boldsymbol{(x, y)}$ 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.

Task:

Based on mathematical computations, advise the extension worker on the decisions to take. (JJEB MOCK)

ITEM 7:

A certain country is experiencing a crisis due to the war. The war has affected mainly three towns at locations $\boldsymbol{T_1}$**1(7, 3, 6),** $\boldsymbol{T_2}$ **(1, 3, 9),** and $\boldsymbol{T_3}$ **(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 modelled by $\boldsymbol{\cos 2\theta + \cos \theta = 0}$

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. (MATIGO MOCK)

ITEM 8:

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 $\boldsymbol{A(1,2)}$, $\boldsymbol{B(7,2)}$, and $\boldsymbol{C(4,5)}$. 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

$\boldsymbol{r = (4,3,0) + \lambda(0,1,14)}$ where the monitoring device is fixed at $\boldsymbol{\lambda = 1}$.

Its calibration includes a depression-angle control system governed by the trigonometric condition: $\boldsymbol{2\sin 5\theta \cos 5\theta - 2Cos^2 5\theta + 3 = 0}$, $0° < \theta < 90°$.

A maintenance officer stationed at $\boldsymbol{D(20, 15, 12)}$ carries out routine inspections of the system.

For operational efficiency, the device is designed such that it can operate in more than one direction. To improve coverage efficiency, the mast must be placed at the centre of the circular zone, the area enclosed by the zone must not exceed $30m^2$. 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. (HOIMA MOCK).

ITEM 9:

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 $\boldsymbol{M(2, 4, 3)\ km}$, **N (6,6,1) km**, and **P (4,10,2) km**. The planners have identified a site for a new logistics depot at $\boldsymbol{Q(14, 8, 4)\ km}$. 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 $\boldsymbol{R(2, 4, 8)\ km}$, 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 $\boldsymbol{X\ (16, 4)\ km}$, $\boldsymbol{Y\ (4, 16)\ km}$, and $\boldsymbol{Z\ (-4, 4)\ km}$. The city authority must determine whether a newly planned emergency access road passing through point $\boldsymbol{S(4, 15)\ km}$ 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 $\boldsymbol{S = (24sin\,2\theta + 7Cos2\theta - 3)\ km}$.

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:

(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? (WAKISSHA MOCK)

ITEM 10:

Masaka road passes in points $(\mathbf{3}, \mathbf{-2})$ and $(\mathbf{2}, \mathbf{1})$. Mityana road passes at a point $(\mathbf{6}, \mathbf{-7})$ but meets Masaka Road at **90°** at Busega. Engineers are planning to construct Kajjansi road to obey the equation $\mathbf{5x + 12y - 18 = 0}$ but Busega is a very busy trading Center and it must be **at least 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

$\boldsymbol{A}$ $(\mathbf{3}, \mathbf{2}, \mathbf{-6})$, **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 $\mathbf{6Cosec^2 + 7\cot\theta = 9}$.

Before Busega business centre, there is a roundabout that satisfies the equation $\boldsymbol{x^2 + y^2 + 2x - 4y - 11 = 0}$. A straight road touches this roundabout and moves to Nateete where Nateete is at point $(\mathbf{3}, \mathbf{5})$. 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 $\boldsymbol{5km}$.

(Hint: Assume 1 $unit = 1.4km$)

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. **(UTES MOCK)**

ITEM 11:

The administration of a certain secondary school plans to install a public clock in the school's recreational park so that students and visitors can easily read the time. The park is a triangular area on a flat horizontal surface. During a survey, three vertices of the park were recorded as $\boldsymbol{P(2,1)}$, $\boldsymbol{Q(3,5)}$, and $\boldsymbol{R(1,3)}$, enabling students to determine the boundary lines, side lengths, perimeter, area, and centroid of the park for accurate clock placement.

The supporting pole is represented by the vector equation

$\boldsymbol{r = (2,3,0) + \lambda(1,1,20)}$, with the clock mounted at $\boldsymbol{\lambda = 1}$, while a student observes it from point $\boldsymbol{A(20,12,0)}$ outside the park.

For the engineering design, the pole must pass through the centroid of the triangular park, the area must be less than $\boldsymbol{7m^2}$ to minimize land usage, the observer's distance from the clock must be less than $\boldsymbol{30m}$ for a clear view, and the pole must be almost vertical with an inclination between $\boldsymbol{85°}$ and $\boldsymbol{90°}$.

TASK:

Analyze all design conditions and justify installation.

(STEM MOCK)

ITEM 18:

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 $\boldsymbol{r_1} = \begin{pmatrix} \mathbf{1} \\ \mathbf{-1} \\ \mathbf{4} \end{pmatrix} + \boldsymbol{\mu}\begin{pmatrix} \mathbf{-1} \\ \mathbf{-3} \\ \mathbf{1} \end{pmatrix}$ while the other drone took the route described by equation $\boldsymbol{r_2} = \begin{pmatrix} \mathbf{0} \\ \mathbf{-2} \\ \mathbf{5} \end{pmatrix} + \boldsymbol{\lambda}\begin{pmatrix} \mathbf{1} \\ \mathbf{-2} \\ \mathbf{-1} \end{pmatrix}$.

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 design 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 $\boldsymbol{sin\,3A = 3sin\,A - 4sin^3A}$. 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 $\boldsymbol{A}$ 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 $\boldsymbol{x^2 + y^2 - 8x + 6y - 11 = 0}$ Far away from the city, an elliptical racing track is constructed for testing autonomous vehicles. The track has equation $\boldsymbol{\frac{x^2}{25} + \frac{y^2}{9} = 1}$

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. **(WENSSEC MOCK)**

ITEM 19:

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 $\boldsymbol{3x + 2y - 3z = 6}$, $\boldsymbol{4x - y + z = 8}$

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 $\boldsymbol{B(1, -15, -11)m}$. 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 $\boldsymbol{P(2, 3)m}$ and $\boldsymbol{Q(8, 11)m}$, which are the endpoints of a diameter. The nearest perimeter wall is represented by the line

$\boldsymbol{3x + 4y + 2} = 0$.

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 $\boldsymbol{D = 100\ \sin(\theta + 45°)\cos(\theta - 45°) + 12\cos 2\theta.}$

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' 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. **(UMTA MOCK)**

ITEM 20:

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

The angle $(\boldsymbol{\theta})$ at which the radar system will transmit signals is given by equation $\boldsymbol{4sin^2\theta + 8cot^2\theta - 5cosec^2\theta = 0.}$ For the system to transmit signals at a higher radiation, there must be at least two angles $(\boldsymbol{\theta})$ between $\boldsymbol{100°}$ and $\boldsymbol{200}$. 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 a plane which passes through the points $(\boldsymbol{-3, 4, -7})$, $(\boldsymbol{6, -1, -3})$ and $(\boldsymbol{-4, 3, -2})$**.** Also a radiation wave which follows a straight line given by equation $\begin{pmatrix} \boldsymbol{x} \\ \boldsymbol{y} \\ \boldsymbol{z} \end{pmatrix} = \begin{pmatrix} \boldsymbol{10} \\ \boldsymbol{3} \\ \boldsymbol{4} \end{pmatrix} + \boldsymbol{\mu}\begin{pmatrix} \boldsymbol{8} \\ \boldsymbol{2} \\ \boldsymbol{8} \end{pmatrix}$**.** The angle at which the frequency wave and radiation wave are to intersect should be at least $\boldsymbol{30°}$ or else, there will be a lot of frequency 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 interference or not.**

(BURJEB MOCK)

ITEM 21:

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 location of the four depots are mapped as coordinates A $(\boldsymbol{2, 6})$, $\boldsymbol{B}$ $(\boldsymbol{5, 10})$, $\boldsymbol{C}$ $(\boldsymbol{8, 6})$ and $\boldsymbol{D}(\boldsymbol{5, -2})$ 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 maximise efficiency, a central security and

monitoring tower is to be built at the exact point where these two diagonal pathways intersect.

To 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 of 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. (AITEL MOCK)**

ITEM 22:

Peter your friend lives in Kampala. During the last term holidays, many people complained about traffic congestion in the city. A KCCA engineer, speaking to UBC Tv, explained that a new road would be constructed as the perpendicular bisector of a road passing through the points $(\mathbf{4}, \mathbf{-2})$ and $(\mathbf{6}, \mathbf{8})$. Peter wanted to determine the equation of this new road but did not know how to do it. This term, he asks for your help.

The engineer also suggested constructing a round about at the intersection of the two roads. He explained that three points **A, B** and **C** had been marked, forming a triangle **ABC**. He added that a water fountain would only be constructed if $\mathbf{\cos A + \cos B + \cos C - 1 = 4 \sin\left(\frac{A}{2}\right) \sin\left(\frac{B}{2}\right) \sin\left(\frac{C}{2}\right)}$ that confirms that angles **A, B** and **C** form a triangle.

He further stated that some corners of the new road would be based on angles satisfying the equation $\mathbf{\sin 2\theta \cos\theta + sin^2\theta = 1}$, where the angle lies between $\mathbf{0°}$ and $\mathbf{360°}$, inclusive. this made Peter more confused.

Task: Using appropriate mathematical models, help Peter understand the engineer's explanation, from determining the equation of the new road to identifying all the possible angles that satisfy the given conditions. Advise

whether the water fountain should be constructed, giving reasons for your responses.

SECTION B PART I TYPE ITEMS (ALGEBRA)

ITEM 1.

A large-scale poultry farm is conducting comprehensive audit of his farm records to optimize operational efficiency and cut necessary 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.

	Mass of the feeds × 100 kgs		
Purchase	Layers mash	Maize Bran	Protein concentrate
A	**3**	**1**	**2**
B	**1**	**2**	**1**
C	**2**	**1**	**3**

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 bran and ***300kg*** of protein concentrate.

The farm uses an automated drinking system where vital vitamin boost is dissolved into the flock's daily water supply. Sensor telemetry records show that the volume of water consumed during day time is $\sqrt{\mathbf{3}\boldsymbol{x}\ \mathbf{+700}}$ litres, while the volume consumed at night is $\sqrt{\boldsymbol{x}\mathbf{+600}}$ litres. The automated systems log show that the total water volume consumed the birds over a full 24-hour cycle is exactly **70 litres**. The vitamin boost will successfully optimize egg production if its mass $\boldsymbol{x}$ doesn't exceed **300g.**

The farm currently has an inventory of 33 trays of eggs sitting in storage. Due to the 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 market.

Task: Help the poultry farm to make decisions on his farm using knowledge of algebra. **(ACEITEKA)**

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;$\frac{{Z_1}^2}{Z_2 Z_3}$ 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 $\boldsymbol{Z_1 = 2 + 3i}$, $\boldsymbol{Z_2 = 1 - 2i}$, and $\boldsymbol{Z_2 = 2 + i}$. The pump sends water to the tank every hour such that the amount of water pumped per hour is defined by:

$\boldsymbol{V = 100(1 + 20x)^n}$ 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. $\boldsymbol{l_1 = 9^w}$ and $\boldsymbol{l_2 = 3^{w+1}}$ 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 valid decisions using mathematical skills.

(MATIGO MOCK)

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 $\boldsymbol{D = \sqrt{x^2 + y^2}}$ should be **at least 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 **7th** and **5th** hour is **not less than 1900MHz**.

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

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

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 $\boldsymbol{F_2 = 15f^2 - 74f + 59}$. 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. (MATIGO MOCK)

ITEM 4:

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 $(\mathbf{4}+\mathbf{3}\boldsymbol{x})^{\mathbf{7}}$, where $\boldsymbol{x}$ 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. **(JJEB MOCK)**

ITEM 5:

The security team was tasked to design a stepped security pillar to be constructed in a sugar cane plantation to monitor and fight fire outbreak. 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 5th step is three times 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(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 of $\mathbf{3}\log_{\mathbf{8}}\boldsymbol{x}$ and the other radio shows a signal strength of $\mathbf{6}\log_{\boldsymbol{x}}\mathbf{4}$.

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 $-\mathbf{8}+\mathbf{8}\sqrt{\mathbf{3}}\,\boldsymbol{i}$ 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. (JJEB MOCK)

ITEM 6:

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.

(HOIMA MOCK)

ITEM 7:

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 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 $\boldsymbol{Z_1 = 3 + 3\sqrt{3}i}$.

The beam undergoes a structural transformation due to load redistribution represented by multiplication with $\boldsymbol{2 + i}$. After this, a stabilizing adjustment is applied $\boldsymbol{Z_2 = 3 + 3i}$. 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. (HOIMA MOCK)

ITEM 8:

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 department 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	Voltage regulators	Sensors	Transformers	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

$\boldsymbol{Z_0 = (2 + 3i)}$ and the control signals are modelled by the equation

$\boldsymbol{Z^3 - 3Z^2 + 7Z - 5 = 0}$. The automation system will remain stable and operational if the modulus of the difference between the reference signal and each control signal, $\boldsymbol{|Z_0 - Z|}$, is **less than 4 units**.

Task:

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

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

ITEM 9:

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 ($\boldsymbol{x}$), 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 represented by $\boldsymbol{x}$ 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 $\mathbf{log}_{\boldsymbol{x}}\ \mathbf{9}$; the second measurement is $2\ \mathbf{log}_{\mathbf{3}}\ \boldsymbol{x}$. 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.

(WAKISSHA MOCK)

ITEM 10:

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, 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 $\boldsymbol{shs.90,500}$. Cissy spent $\boldsymbol{shs.18,500}$ **less than** Annet. John needs **7** books**, 4** sets and **6** compo pens however he was given only $\boldsymbol{sh\ 27,000}$ 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 $\boldsymbol{shs.180,000}$ 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 diagonal of the first room. The area of the second room is in the form $\boldsymbol{a + b\sqrt{c}}$ and this room is locked with a three-digit pin obtained by arranging the roots of the equation $\boldsymbol{x^3 - 9x^2 + 23x - 15 = 0}$ from the biggest to the smallest.

Task:

(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. **(UTES MOCK)**

ITEM 11:

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 $\boldsymbol{(9 + 2i)^2(3 - i)}$ 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 $\boldsymbol{shs.3,000}$, the second will be at $\boldsymbol{shs.6,000}$ while the third will be at $\boldsymbol{shs.12,000}$. 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 $\boldsymbol{x^7}$ in the expansion

$\left(3x^2 + \frac{4}{x}\right)^8$. During the meeting, the students were told to go for lunch at $\mathbf{1{:}\,15}\boldsymbol{pm}$ and they were expected to come back after time **t (in hours)** where $0 < t < 1$ and $\mathbf{\log_3 t - \log_t 9 = 1}$.

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. **(UTES MOCK)**

ITEM 12:

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 $\boldsymbol{L}$, width **W** and height **H**, all measured in meters for the pond for every **n (in thousands)** fingerlings, are given by $\boldsymbol{L \pm W\sqrt{H}}$ obtained by dividing the number $\boldsymbol{n}$ of fingerlings to be put in the pond by the magnitude of the square root of $\mathbf{14 + 6\sqrt{5}}$. 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 $20m^3$ for the available space to be enough. If it exceeds this capacity, then he will have to reduce on the fingerlings to fit the available space.

He has also been told that the profits **P** (in millions) from this business depend on the number $\boldsymbol{n}$ (in thousands) of fingerlings sold per harvest. He has been told that these profits equal 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 $\boldsymbol{n}$(in thousands) fingerlings is given by dividing the number of fingerlings with the

magnitude of principal argument of the complex number $\boldsymbol{z} = \frac{(\mathbf{2}-\boldsymbol{i})(\mathbf{5}+\mathbf{2}\boldsymbol{i})}{(\mathbf{1}+\mathbf{2}\boldsymbol{i})^{\mathbf{2}}}$. He wishes that the cost does not exceed his planned budget of 300,000. If it does exceed, he will reduce on the fingerlings.

Task: Help your neighbor to make informed decisions before starting this business. (UTEC MOCK)

ITEM 13:

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 these new breeds 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 she bought three of these breeds 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 $\boldsymbol{n}$ 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 500 sheep**, 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

$\mathbf{1} + \sqrt{\mathbf{3}}\,\boldsymbol{i}$ 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. (UTEC MOCK)

ITEM 14:

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

$\boldsymbol{f(\alpha) = 3^{2\alpha} + 59049}$ and $\boldsymbol{g(\alpha) = 59050\,(3^{\alpha})}$

where Engineers find the tuning parameter $\boldsymbol{\alpha}$ by solving $\boldsymbol{f(\alpha) = g(\alpha)}$ 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 $\boldsymbol{x}$ represents one unit of budget allocation for a standard service package covering essential party requirements. The total Projected Expenditure is modeled by: $\boldsymbol{2x^4 + 3x^3 - 4200x^2 + 6000x + 900000}$ and the standard service package cost structure is given by $\boldsymbol{x^2 + 50x + 200.}$ 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: $\boldsymbol{Z_1 = 5 + 12i}$, $Z_2 = \mathbf{2 - i}$, $Z_3 = \mathbf{1 + 2i}$.

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 $\boldsymbol{9\,\Omega}$, confirming clear and stable sound output throughout the Celebration.

Task:

Design and analyse an S.6 Leavers' Party System by solving stability, arrangement, vibration, and impedance problems.

(ASSHU-ANKOLE MOCK)

ITEM 15:

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 $\boldsymbol{E(x) = \sqrt[3]{1 + 4x}}$, where $\boldsymbol{x}$ is a small performance improvement. The expansion is used to approximate **E(x)** up to the term in $\boldsymbol{x^2}$, to estimate $\boldsymbol{E(0.2)}$, and to determine system stability when the efficiency increase must not exceed $\mathbf{25}\%$.

The Telecommunications Unit is testing a digital signal represented by a complex number $\boldsymbol{Z}$. During calibration, Engineers find that the signal and its complex conjugate satisfy the condition; the product of $\boldsymbol{Z}$ and $\boldsymbol{Z'}$**plus eight times the imaginary unit multiplied by** $\boldsymbol{Z}$**, is equal to** $\mathbf{9360 + 480i}$. 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. **(ASSHU-ANKOLE MOCK)**

ITEM 16:

Jinja Industrial Manufacturing Company plans a production expansion project to meet growing demand in Uganda and East Africa. The company intends to form a production oversight committee of **11 members** from **8 male** engineers and **10 female engineers**, requiring at least 6 men to ensure sufficient technical representation.

A newly installed machine produces 5 units initially and doubling every cycle. The management wants the cycle when total production first **exceeds 400,000** units to plan production timelines. The expansion is analyzed using the binomial expansion $\left(\mathbf{3}\boldsymbol{x}+\frac{\mathbf{1}}{\boldsymbol{x}}\right)^{\mathbf{16}}$ to determine the constant term of $\boldsymbol{x}$, representing the optimal distribution of resources necessary for project viability.

The electrical maintenance department models machine load with $\frac{(\mathbf{2}-\boldsymbol{i})^{\mathbf{5}}(\mathbf{1}-\sqrt{\mathbf{3}}\,\boldsymbol{i})^{\mathbf{9}}}{(\mathbf{2}+\boldsymbol{i})^{\mathbf{7}}}$ to compute the modulus, ensuring the machine operates safely under stress, while the data analysis team evaluates efficiency with $\mathbf{2}\log_{\mathbf{2}}\left(\frac{\mathbf{10}}{\mathbf{9}}\right)-\mathbf{3}\log_{\mathbf{2}}\left(\frac{\mathbf{5}}{\mathbf{2}}\right)-\log_{\mathbf{1}}\left(\frac{\mathbf{1}}{\mathbf{30}}\right)$ to determine the efficiency rating index, indicating overall system performance.

Management criteria for approval are:

1. Number of ways to form committee $>$ $\mathbf{8000}$
2. Production between $\mathbf{15}\boldsymbol{th}$ and $\mathbf{20}\boldsymbol{th}$ cycle
3. Load magnitude $>$ $\mathbf{100}$
4. Efficiency index $<$ $\mathbf{4}$
5. Constant term from binomial $>$ $\mathbf{80}\ \boldsymbol{million}$

Task : Using the above criteria and reasons, determine whether the expansion project should be approved. **(STEM MOCK)**

ITEM 17:

A teacher of physical education is preparing the school field for an inter-house athletics competition involving football, basketball, relay races, agility drills and throwing events. In order to organise the field symmetrically and efficiently, the teacher applies concepts from mathematics,

First, the teacher plans to make a rectangular training zone using filed line strings and pegs. The total rope available to mark the boundary of the field is $\boldsymbol{200m}$. The teacher also requires the field to have an area of $\boldsymbol{2400m^2}$ so that different activities can occur simultaneously. The teacher intends to determine the exact dimensions that will efficiently use the available rope while maintaining the required area.

To organize sprint drills, cones are arranged along a straight training lane such that the spacing between consecutive cones increases geometrically. The first spacing between cones is $\boldsymbol{2m}$ and the common ratio is $\boldsymbol{1.2}$. If the teacher uses 8 spacing's, the teacher needs to determine the total length covered by the cones in order to allocate adequate space on the field.

During basketball practice, the teacher studies the trajectory of the ball. After a player throws the ball towards the hoop, the height of the ball above the ground after seconds is modeled by $\boldsymbol{y = -5t^2 + 20t + 2}$, where $\boldsymbol{y}$ represents the height in metres. The teacher needs to determine the maximum height reached by the ball and the time at which it occurs to ensure that the ball will not collide with nearby tents.

To monitor athlete performance, the teacher monitors athletes' sprint performance modeled by $\boldsymbol{v = v_0(1.08)^t}$, where $\boldsymbol{v}$ is speed after $\boldsymbol{t}$ weeks and $\boldsymbol{v_0}$ is the initial speed. The teacher wants to determine how long it takes for an athletes' speed to double to guide training planning.

Finally, for the relay race event, the teacher has **12** athletes available and must select **5 athletes** to form a training squad. The number of possible selections can be determined. After selecting **4** athletes for the final relay race, the teacher considers the different possible running orders of the athletes. The number of arrangements can be determined.

Analysis	**Standard /valid range**
Rectangular training zones dimensions	$\boldsymbol{30m - 40m}$
Total length of cones	$\boldsymbol{30m - 35m}$

Sprint lane length	$\mathbf{55m - 65m}$
Maximum basket height	Height: $\mathbf{20m - 25m}$, Time $\mathbf{1.5s - 2.5s}$
Time to double sprint speed	$\mathbf{8 - 12weeks}$
For Relay Training squad	$\mathbf{750 - 800\ ways}$
For running order	$\mathbf{20 - 25ways}$

Task: Using the given models, help the teacher to perform event planning, justifying all decisions. **(STEM MOCK)**

ITEM 18:

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 $\boldsymbol{z = x + iy}$, where x and y are real numbers. The engineers discovered that the beacon always satisfied the condition $\boldsymbol{|z - (3 + 2i)| = 5}$, meaning that the beacon remained at a constant distance from the relay station located at $\boldsymbol{3 + 2i}$.

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

where $\boldsymbol{t}$ represents time in minutes and $\boldsymbol{G(t)}$ 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 $\boldsymbol{\frac{5t+9}{(t-2)(t^2+3t+4)} = \frac{A}{(t-2)} + \frac{Bx+C}{(t^2+3t+4)}}$.

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

$$\boldsymbol{2x + y - z = 7\ ,\ x - 3y + 2z = -4\ ,\ 3x + 2y + z = 12}$$

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.

(b) **Express $G(t)$ into partial fraction and hence determine the value of $G(1)$. (NOTE: This part of the item is classified under calculus)**

(c) Solve the simultaneous equations to determine x, y and z.

(WENSSEC MOCK)

ITEM 19:

A technology company designs a data storage system in which the amount of the data processed in the n^{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.

Task:

(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. **(WENSSEC MOCK)**

ITEM 20:

A certain company offers three-year renewable contracts for its employees. In the existing 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 $\boldsymbol{R(t)}$ in millions after t years is defined by $\boldsymbol{P(t) = g(t)Q(t) + R(t)}$

where $\boldsymbol{P(t)} = 2t^3 - \boldsymbol{7t^2 + 13t + 5}$ and $\boldsymbol{g(t) = t^2 - t}$ evaluated at the end of the contract.

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. **(UMTA MOCK)**

ITEM 21:

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.

Project	Cement × 100 bags	Trucks of sand × 100	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: $A = \frac{200}{(1-x)}\boldsymbol{m^2}$

where $\boldsymbol{x}$ 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 square meters** using a reduction factor of **0.8**.

The school surveyor used digital mapping and identified $Z_0 = (30 + 40i)\boldsymbol{m}$ as the centre point for the new block. The proposed site sits between two existing classroom blocks whose coordinates Z are linked by a structural alignment equation: $Z^2 = (119 + 120i)m^2$. The building committee will only approve the proposed site for the new block if it satisfies the condition:

$|\boldsymbol{Z_0 - Z}| \geq \mathbf{35}$ metres.

Task:

Using your knowledge of algebra, help the building committee analyse the recommendations and make valid decisions on the proposed new block.

(UMTA MOCK)

ITEM 22:

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 $\boldsymbol{x}$ 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 ($\boldsymbol{x}$) of vehicles that can run on it at a time is modelled by the equation $\log\left(\sqrt{1+x}\right) + \frac{5}{2}\log(1-x) = \log\left(\sqrt{1-x^2}\right) + 2$. 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 ($\boldsymbol{x}$) has been modeled by $(\mathbf{1}-\boldsymbol{x})^{\frac{1}{3}}$ for only the first four terms. The intensity has to be maintained at $\frac{\mathbf{1}}{\mathbf{9}}$. and Kenny wants to use this intensity to find the approximate deflection of $\sqrt[3]{\mathbf{9}}$ 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 $\sqrt[3]{\mathbf{9}}$.

(BURJEB MOCK)

ITEM 23:

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 selections 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 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 $\boldsymbol{Z}$ where $\boldsymbol{Z}=(\mathbf{2}+\mathbf{5}\boldsymbol{i})^{\mathbf{2}}+\mathbf{5}\left(\frac{\mathbf{7}+\mathbf{2}\boldsymbol{i}}{\mathbf{1}-\mathbf{2}\boldsymbol{i}}\right)-\boldsymbol{i}(\mathbf{4}-\mathbf{6}\boldsymbol{i})$. To avoid repetition of ID number, the $|\boldsymbol{Z}|$ must be **greater than 15 units** and to maintain the ID quality, the $\boldsymbol{argZ}$ must be between $\frac{\boldsymbol{\pi}}{2}$ and $\frac{\mathbf{4}\boldsymbol{\pi}}{\mathbf{5}}$. If these conditions are not satisfied, then another code has to be used.

The club plans to use total scores ($\boldsymbol{n}$) of each participant which has been modelled by the equation $\mathbf{1}^{\mathbf{3}}+\mathbf{2}^{\mathbf{3}}+\cdots+\boldsymbol{n}^{\mathbf{3}}=\frac{\mathbf{1}}{\mathbf{4}}\boldsymbol{n}^{\mathbf{2}}(\boldsymbol{n}+\mathbf{1})^{\mathbf{2}}$. 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.

(BURJEB MOCK)

ITEM 24:

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)
A	2	1	1
B	1	3	2
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 $\sqrt{\mathbf{11}\boldsymbol{x}+\mathbf{7}}$ 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.

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

ITEM 25:

A commercial fruit processing factory near the Njeru 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	40

An external production consultant recommends that the factory should aim to run the extraction process at a pressure factor of $\boldsymbol{x = 4}$ 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, $\boldsymbol{t}$ minutes, according to the mathematical models: Pump P: $\boldsymbol{32^{t+1}}$, Pump Q: $\boldsymbol{28(3^t) - 9.}$

To prevent fluid congestion in the pipeline, both pumps must achieve a perfect equilibrium of workloads, and the operational time $\boldsymbol{t}$ 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: $\boldsymbol{N = (x + 3)^8}$ hundred crates, Where $\boldsymbol{x}$ 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 $\boldsymbol{x = 0.2m}$ shows that the facility can accommodate **at least 500,000 crates**.

Task:

a) Help the factory officials to get the system of equations from the efficiency log to determine the constants $\boldsymbol{a, b}$, and $\boldsymbol{c}$, 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.

(AITEL MOCK)

ITEM 26:

Lawrence is a businessman in your village who buys food items from town and sells them to customers in different villages. According to his records, on one occasion he bought **3** kilograms of beans**, 1** kilogram of maize flour, and **1** kilogram of millet for a total of **Ugx.17,000**. On another visit, he bought 1

kilogram of beans, **2** kilograms of maize flour, and **1** kilogram of millet for Ugx.**16,000.** Last week, he bought **1** kilogram of beans, **1** kilogram of maize flour, and **2** kilograms of millet for **Ugx.19,000**. Today, he is unwell and wants to send his son to make purchases. He needs to give him the exact amount required to buy **4** kilograms **of** beans, **5** kilograms of maize flour, and **8** kilograms of millet.

Lawrence is also concerned about inconsistencies in his daily profits. According to his business partners, he tracks his daily profits using the function $\boldsymbol{p(x) = 4x^2 + 2x + 3}$ where $\boldsymbol{x}$ represents the total number of items sold each day. He also said that the roots of his equation are $\boldsymbol{\alpha}$and$\boldsymbol{\beta}$ he advised Lawrence that he can also track his daily profits using an equation basing on his equation with the roots $\boldsymbol{\alpha^2 - \beta}$ and$\boldsymbol{\beta^2 - \alpha}$. However, Lawrence is unable to form this new equation and asks for your help.

In addition, Lawrence wants to buy a mini truck valued at **Ugx.15 million** to transport his goods. Since he does not have the full amount, his friend suggested that he deposits **Ugx.1,000,000** at the beginning of each year for **10 years** in a bank that offers **10%** compound interest per annum. Lawrence will only accept this plan if the total amount at the end is more than the current value of the truck, but he is unable to confirm this.

Task: Analyze the information given and help Lawrence decide how much money to give his son for today's purchases, determine the required profit function, and advise whether he should follow the savings plan or consider another option. Give reasons for your responses.

(KAMSSA MOCK)

ITEM 27:

Oburu is a computer programmer who is faced with a bug in his program. According to his manager, they want a program which tracks the production efficiency such that $\boldsymbol{a^x = b^y = c^z}$and $\boldsymbol{b^2 = ac}$ **.** According to his research, this program will only work if $\boldsymbol{y = \frac{2xz}{x+z}}$. However, Oburu can't really confirm if this is true.

The company also tracks their daily profits (in millions of shillings) using the function $\boldsymbol{y = \frac{3-2x}{4+x^2}}$ where $\boldsymbol{x}$ represents the number of products produced every

day. Oburu is required by the company to determine the possible daily profit levels (region where **y** lies) so they can plan their workload effectively.

At the same time, Oburu tracks the company's savings using two different patterns. One follows a geometric progression and the other an arithmetic progression. Both patterns start with the same first amount. The sums of the first, second, and third corresponding amounts from the two patterns are **Ugx.60,000**, **Ugx.105,000**, and **Ugx.180,000** respectively. The company has decided that they will only continue saving their money if the sum of the **fifth** amounts from the two patterns exceeds **Ugx.500,000.**

Task: Using this information, help Oburu evaluate if the program will work, know the daily profit levels and also advise the company whether they should continue saving their profits using these two patterns.

(KAMSSA MOCK)

SECTION B PART (II) TYPE ITEMS (CALCULUS)

ITEM 1:

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:$\boldsymbol{V = \frac{1}{3}\pi h^2(3r - h)m^3}$ where $\boldsymbol{r}$ 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 $\boldsymbol{4\pi m^3}$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 modelled 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 d**ouble**. 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. **(MATIGO MOCK)**

ITEM 2:

An agriculture student doing industrial training on a certain farm has discovered some challenges on the farm and come up with the following recommendations. The cows on the farm drink water from a cylindrical trough whose volume is $\boldsymbol{V = 9\pi h^3}$ When the cows start drinking, the depth h of water after t hours is $\boldsymbol{h = In(10 - t)}$ **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** $\mathbf{10\pi m^3}$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 at least 10 hours.

Task: Help the agriculture student to make a valid report on his recommendations using your knowledge on calculus. (MATIGO MOCK)

ITEM 3:

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 $\mathbf{500\ m^2}$ 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 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.

(JJEB MOCK)

ITEM 4

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 $y = x(4 - x)^2$,

$0 \leq x \leq 4$ Units in meters (m).

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** $450m^3$ 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.**

Task: With mathematical justifications, Analyse the project.

(JJEB MOCK)

ITEM 5:

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 $\boldsymbol{t}$ **hours** after production begins, the rate of shoe production is given by $\boldsymbol{t^2e^{0.01t}}$ 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 $\boldsymbol{530\ cm^3}$. 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.

(HOIMA MOCK)

ITEM 6

A geological research team in Western Uganda is investigating a mountain suspected to have a dormant volcanic activity. The mountain profile is modelled by $\boldsymbol{y = -0.01x^3 + 100}$ where **y** is the height (m) and $\boldsymbol{x}$ 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 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** $\boldsymbol{1.2 \times 10^6} m^3$. 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 $\boldsymbol{900}$℃$ and the rock temperature. At the surface, the temperature is 60℃ At depths of $\boldsymbol{200\ m}$ and $\boldsymbol{400\ m}$, the temperatures are $\boldsymbol{180}$℃ and $\boldsymbol{420}$ ℃ respectively. Geologists further state that volcanic activity is possible when the temperature reaches $\boldsymbol{800}$℃ or higher when the height is below $\boldsymbol{3000\ m}$.

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℃. **(HOIMA MOCK)**

ITEM 7:

A local cooperative is establishing an apiary project and intends to use **100 metres** of protective netting to enclose a rectangular area for the bee hives. The project requires a minimum area of $\mathbf{500}\ \boldsymbol{m}^2$ 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** $\mathbf{400}\ \boldsymbol{m}^3$ 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 $\frac{dP}{dt} = \mathbf{0.05}P - \mathbf{150}$, 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 8:

A local paint company manufactures specialized industrial coatings, and its production profit function over time (t years) is modelled by

$\frac{dP}{dt} = 0.04p(1 - 0.02p)$. 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 $60\ cm\ x\ 60\ cm$. 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 cm³** 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?

(WAKISSHA MOCK)

ITEM 9:

On a certain fundraising ceremony, Mr. Dodo was hired to decorate the venue. The 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 $\boldsymbol{shs.50,000}$ while an ordinary seat was hired at $\boldsymbol{shs.20,000}$. On this party, all seats from both categories were hired out. The tent in which the ordinary seats were placed obeys the equation $ $\boldsymbol{y = 8 + 2x - x^2}$ where $\boldsymbol{x}$ 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. **(UTES MOCK)**

ITEM 10:

An athlete runs such that after time t in seconds, he is $\boldsymbol{\tan^{-1} 20t}$ metres from the starting point. His trainer promised him some gifts if he can run at a speed more than $\boldsymbol{5ms^{-1}}$ after **two seconds**. He is running to keep his body fit in addition to getting some income from international competitions. He was inspired to do so after getting information that the rate at which a certain virus was spreading was proportional to the number of people having it at the time. The chances of getting the virus were higher in members who never wanted to do physical exercises for instance in **2012**, only **400** people had the virus but in the year **2024,** the number had reached **600**. The worry is that if the number reaches **1400 people**, the World Health Organisation will have to save the world by introducing a vaccine. The first vaccine will be kept in a box that will be cut from an aluminium rectangular material which is **2 metres by 1 meter**. Small equal squares are to be cut from each corner of the material, fold the remaining faces and cover the top with a strong material but the maximum space it can occupy is not known.

Task:

(a) Establish whether the athlete will get the gifts from his trainer as promised

(b) Determine the;

(i) year in which the World Health Organisation is likely to introduce the vaccine for the virus

(ii) maximum space which can be occupied by the box made for keeping the vaccine. **(UTES MOCK)**

ITEM 11:

A company dealing in ceramics wants to design a new vessel, whose edge is defined by the curve $\boldsymbol{y = 8 - x^3}$. The vessel surface is to be formed by the rotating the area cut off by this edge and the axes about the $\boldsymbol{x}$ −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 $\boldsymbol{13\ sq}$ 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 **50 million** 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 150 million**, then it will have to venture into another product.

Task.: Help the company obtain the right information to direct its decisions. **(UTEC MOCK)**

ITEM 12

The roads authority of a certain country wants to construct two straight roads. It plans that one road $\boldsymbol{l_1}$, should be tangential to the river defined by $\boldsymbol{2x^2 + xy = 5}$ at the point where $\boldsymbol{x = 1}$ and the other road $\boldsymbol{l_2}$, 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 $\boldsymbol{l_2}$ 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 $\boldsymbol{l_2}$ from $\boldsymbol{x = 0.2}$ to

$\boldsymbol{x = 1}$ for a recreational centre 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 $\boldsymbol{10km}$ in a period of three months and it also constructed $\boldsymbol{50km}$ in a period of a year. The two roads have a total length of $\boldsymbol{100km}$. 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 obtain the necessary information and make informed decisions. **(UTEC MOCK)**

ITEM 13:

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 $\boldsymbol{y = x^2 - 10x}$ and the straight-line $\boldsymbol{y = -2x + 20}$, 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 $\boldsymbol{350\ km^2}$.

In addition, a bush-fire is spreading through a dry forest Region with a total area of $\boldsymbol{288\ km^2}$. 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.**, $\boldsymbol{2.8\ km^2}$ of the forest had already been burnt, and by **9:30 a.m**. this had increased to $\boldsymbol{18.4\ km^2}$. 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 $\boldsymbol{100\ km^2}$ 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. **(ASSHU-ANKOLE MOCK)**

ITEM 14:

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 $\mathbf{9}\ \boldsymbol{m}$ and a height of $\mathbf{21}\ \boldsymbol{m}$ 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 modelled by the differential equation: $\frac{dV}{dt} = \frac{119622}{1200-v}$ where $\boldsymbol{V(t)}$ is the volume of water in the tank measured in $\boldsymbol{m^3}$, 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. **(ASSHU-ANKOLE MOCK)**

ITEM 15:

Working in certain factory, Stella faces a problem of determining whether her daily routine and the factory operations are efficient, safe, and reliable.

In the early morning, she leaves home and drives **5 km** to the factory. Her velocity $\boldsymbol{V(t)}$ in $\boldsymbol{ms^{-1}}$ at time $\boldsymbol{t}$ seconds is modeled by

$V(t) = 1.5 + 0.005t, t \geq 0$. For efficiency, Stella must reach the factory in **less than 20** minutes so that production starts on time.

When Stella arrives at the factory, she immediately starts operating a machine that produces Panadol continuously according to the model

$f(t) = \frac{140t+460}{(t+1)(t+5)}, 0 \leq t \leq 60$ minutes so that the management can determine the average production rate and estimate the total number of Panadol produced in one hour for planning supply and verifying whether the machine can meet the required target of **at least 500** Panadol per hour.

During a short break, Stella ordered a cup of tea at an initial temperature of 98℃, with surroundings at 18℃. After 4 minutes, the tea cooled to70℃. The cooling follows Newton's Law of Cooling, where the rate of temperature change is proportional to the difference between the tea and surroundings. Stella will drink the tea at 44℃ (drinkable temperature standard). It should cool to a drinkable temperature **within 15 minutes** (break standard).

TASK:

Assess whether Stella's travel, Panadol production, and tea cooling satisfy all factory efficiency and safety standards. (STEM MOCK)

ITEM 16:

Paul, an engineer, is supervising the arrangement of a football pitch at Buffa Regional Stadium. The stadium is designed to hold **6,000** spectators, and the football match is scheduled to start at **5 PM**. Paul's responsibility is to ensure the pitch, seating, and crowd entry are safe, functional, and well-managed, so that all spectators are seated comfortably before kick-off and the players, especially the goalkeeper, have enough space to perform safely.

Paul is designing the turf near the goal post. This turf is slightly curved to allow smooth play, modeled by $f(x) = 4x^2 + 6x + 3, 1 \leq x \leq 5$ meters. The area of this turf must be **greater than** $200m^2$ to provide enough space for the goalkeeper to move safely.

He is supervising the seating arrangement which is continuous such that seats are closely packed together in columns. The number of seats in one section are modeled by $p(x) = 81 - 2x, 0 \leq x \leq 50$ meters. The stadium has four seating

sections, each accommodating an equal number of spectators. Seating must ensure all 6,000 spectators can be seated safely and comfortably before the $\mathbf{5p.m}$ match.

Paul needs to manage how spectators enter the stadium. The number of spectators inside at time $\boldsymbol{t}$ hours after the gate opens is modeled by the logistic differential equation $\frac{dP}{dt} = 3p\left(1 - \frac{p}{6000}\right), p(0) = 1$ where $p(t)$ represents the number of spectators inside at time $\boldsymbol{t}$. This model helps Paul determine how early to open the gate, and the total time required to fill the stadium safely.

Task:

As a student, help Paul to make decisions on turf area adequacy, total seating and the time gates should be opened to have full capacity to ensure safe play and smooth crowd management. **(STEM MOCK)**

ITEM 17:

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. **(WENSSEC MOCK)**

ITEM 18:

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 $\boldsymbol{P_0}$, but at $\boldsymbol{t}$ months later, it was found to be $\boldsymbol{P}$. In his research, the extension officer wanted to know how long it will take for only $\mathbf{5}\%$ 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 $\boldsymbol{x\frac{dy}{dx} + 3y = 5x^2}$ at $\boldsymbol{y(1) = 3}$ 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.

(WENSSEC MOCK)

ITEM 19:

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 $\mathbf{4}\%$ are allowed on the market. He also has square sheets of hard paper of dimensions 50cm by $\boldsymbol{50cm}$ 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 $\mathbf{900}cm^3$. 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.

(UMTA MOCK)

ITEM 20:

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 $\theta$is $32°$ instead of $30°$This will result in losses if the corresponding error in the radius of the cone exceeds $0.2\ cm$. The relationship between the radius of the cone and the vertical angle is: $r = 9\tan\left(\frac{\theta}{2}\right)$.

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 5** kg 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 (to be continued) **(UMTA MOCK)**

ITEM 21:

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 $\boldsymbol{x = \frac{3t-1}{t}}$ and $\boldsymbol{y = \frac{t^2+4}{t}}$. 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.

ITEM 22:

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 $\boldsymbol{cos2xsin2x}$ at the point $\left(\frac{\pi}{8}, \frac{1}{2}\right)$. This road must pass through the existing trading centre located at $\left(\frac{\pi}{4}, \frac{5}{4}\right)$. 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 $\boldsymbol{y = \frac{3x+3}{x(3-x)}}$. 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.

(BURJEB MOCK)

ITEM 23:

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 $\mathbf{0.5\%}$. The refinery manager will reject the batch of canisters if the corresponding percentage error in the total volume **exceeds** $\mathbf{1.6\%}$.

The automated induction nozzle intended for the filling process records the instantaneous height ($\boldsymbol{h}$) and the volume ($\boldsymbol{v}$) of the fluid inside the canister after an elapsed time of $\boldsymbol{t}$ seconds according to the following models:

$\boldsymbol{h = \left(\frac{t^2}{4} + 2t\right) cm}$ and $\boldsymbol{v = \left(\frac{t^2+6t}{t+2}\right) cm^3}$.

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

$\boldsymbol{t = 2}$ seconds does not exceed $\boldsymbol{0.5 cm^2}$. 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: $\boldsymbol{\frac{dc}{dt} = 30te^{-\frac{t}{4}}}$, Where $\boldsymbol{c}$ represents the cumulative maintenance and energy cost in thousands of Ugandan shillings, and $\boldsymbol{t}$ 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.

(AITEL MOCK)

ITEM 24:

All schools following the Ugandan curriculum at Ordinary Level are now required by UNEB to carry out project work. At your school, Geography students are planning to make a spherical model of the Earth for their project. Due to an error in measurement, their Mathematics teacher informed them that there was a $\mathbf{2}\%$ error in measuring the radius of the sphere, but this would result in not more than a $\mathbf{5}\%$ error in the surface area. The students agreed to continue with the project only if this statement is correct, but they do not know how to verify it.

At the same time, Agriculture students proposed to the Head teacher that they would like to manufacture chicken feed as their project. They plan to pack feed in a closed cylindrical tin of volume $\mathbf{250}\boldsymbol{\pi}\boldsymbol{cm}^{\mathbf{3}}$, with the least possible surface area. However, the Head teacher is unsure of the appropriate dimensions and seeks your help.

The school is also facing a shortage of assembly space due to increased enrolment. Mathematics students suggested a solution by modelling the assembly area using a curve $\boldsymbol{y} = \boldsymbol{x}^{\mathbf{2}} - \mathbf{4}\boldsymbol{x}$. They identified two points, **A** and **B**, based on a normal to the curve at the point $(\mathbf{3}, -\mathbf{3})$, which cuts the $\boldsymbol{x}$ **−axis** and $\boldsymbol{y}$ **−axis** respectively. They believe the area formed between these points, the normal and the axes would be sufficient for the students, but the Head teacher insists that the space must be **at least 5 square units**. The students are unsure whether their proposal meets this requirement.

Task: Analyze the information given and help the geography students decide whether to proceed with their project, determine suitable dimensions for the cylindrical container proposed by the agriculture students, and advise whether the mathematics students' solution provides enough assembly space. Give reasons for your responses.

(KAMSSA MOCK)

ITEM 25:

Ham Agro-Processing Company is planning to establish a fruit-processing factory in Namanve Industrial Area. An engineer has been employed to study the performance of an automated juice-mixing machine. During testing, it was found that the relationship between the control setting and the output concentration level follows a certain mathematical model,

$x^2 \sec x - xy + 2y^2$**2xy = 15** where the output, **y** is a differentiable function of the control setting, x. The manager stated that the machine will only be used if the rate of change of the output concentration level with respect to the control setting, at $x = \frac{\pi}{3}$ and $y = 2$, **exceeds** -1**.**

The machine is operated using a rotating control knob, and its motion is described by parametric equations $x = \sin\theta$ and $y = \theta - \cos\theta$, which according to the production manual, on their current setting will only work if its second derivative $\frac{d^2y}{dx^2} = \frac{1+\sin\theta}{cos^3\theta}$. Further tests showed that the production efficiency depends on the control setting. $E = x^2e^{-x}$. The manager also requested the engineer to determine the maximum production efficiency, but the engineer was unable to do so.

Task: Using appropriate mathematical methods, help determine whether the machine should be used, show whether the control knob will work based on the production manual, find the control setting that gives maximum production efficiency, and determine the corresponding maximum efficiency. Give reasons for your responses.

TO BE CONTINUED:

JAH BLESS