P425/2
PRINCIPAL
MATHEMATICS
Paper 2
July/Aug. 2026
2½hours.

# MATIGO EXAMINATIONS BOARD

**Uganda Advanced Certificate of Education**

PRINCIPAL MATHEMATICS

Paper 2

2 hours : 30 minutes

## INSTRUCTIONS TO CANDIDATES

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

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

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

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

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

*Begin each item on a fresh page.*

**All** *necessary working* **must** *be shown clearly.*

*Graph paper is provided.*

*Where necessary, use* $g = 9.8\ m\ s^{-2}$.

*Silent, non-programmable scientific calculators and mathematical tables with a list of formulae may be used.*

## SECTION A

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

**Item 1**

A district local government is constructing a community water supply system to provide clean water to a newly established health centre. Before approving the construction, the District Engineer must verify the accuracy of the proposed water storage tank dimensions, assess the adequacy of the drainage channel, and confirm the required diameter of the main supply pipe.

The tank has a radius of 2.5 m, correct to one decimal place. The engineer estimates that the maximum relative absolute error in the calculated volume of the tank is 0.125. Before approving construction, the engineer wishes to determine whether the measured height of the tank is sufficiently accurate. If the maximum relative absolute error in the measured height exceeds 0.10, the height of the tank will be measured again before construction begins. Otherwise, the existing measurements will be approved for construction.

To protect the water tank from flooding during the rainy season, the District Engineer designed a drainage channel. The cross-sectional profile of the channel is modelled by

$$y = \frac{50x + 27\tan^{-1} x}{1 + x^2}$$

where $x$ and $y$ are measured in metres.

The engineer recorded the vertical distances (ordinates) from the ground level to the channel profile at five equally spaced positions between $x = 0$ and $x = 6$, inclusive, and used these measurements to estimate the cross-sectional area correct to three decimal places. If the estimated cross-sectional area exceeds 120 $m^2$, the drainage channel cross-section will be enlarged to improve storm-water discharge. Otherwise, the current drainage design will be maintained.

To ensure adequate water pressure throughout the distribution network, the internal diameter (in centimetres) of the main supply pipe must satisfy the equation:

$$e^{\ln x} - \operatorname{cosec} x = 0$$

Preliminary calculations indicate that the required pipe diameter lies between 2.6 cm and 2.9 cm. Before purchasing the pipes, the engineer wishes to obtain a better approximation to the required diameter correct to three decimal places. If the better approximation exceeds 2.8 cm, a high-pressure commercial pipe will be purchased. Otherwise, a standard PVC pipe will be used.

**Task:**

Using appropriate mathematical methods, advise the District Engineer on the suitability of the proposed designs for the community water supply project before construction begins.

## SECTION B

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

### Part I.

**Item 2:**

A District Health Office is evaluating the performance of a new mosquito-net distribution programme to determine whether it should be extended to all government health centres. To support this decision, the District Health Office must evaluate the efficiency of the distribution process, the expected level of household participation, and whether the observed waiting times are representative of the district.

During a pilot distribution exercise, the waiting times of 90 households were recorded as shown below.

| Waiting Time (minutes) | Number of households |
|---|---|
| 0 – 2 | 6 |
| 3 – 7 | 14 |
| 8 – 14 | 35 |
| 15 – 24 | 20 |
| 25 – 39 | 15 |

The district has set a service standard that the most common waiting time should not exceed 15 minutes. The waiting-time distribution will therefore be analysed using a histogram to estimate the most common waiting time. If the estimated most common waiting time does not exceed the service standard, the current distribution procedure will be maintained; otherwise, the procedure will be reviewed before the programme is extended.

Previous records show that each household independently collects its allocated mosquito net with probability 0.82.

One government health centre serves 500 households. The district will only extend the programme if there is more than a 90% probability that at least 400 households will collect their mosquito nets. Otherwise, additional community mobilisation and sensitisation will be carried out before the next distribution exercise.

To determine whether the waiting time observed during the pilot exercise is representative of the whole district, a random sample of 64 households is selected from different health centres. The sample gives a mean waiting time of 16.8 minutes and a standard deviation of 6 minutes. District policy requires a 91.86% confidence interval to be constructed for the true mean waiting time before a final decision is made. The programme will only be extended if the entire confidence interval lies below 18 minutes, providing sufficient evidence that the district service standard is likely to be achieved. Otherwise, further improvements will be made and another evaluation conducted before implementation.

**Task:**

Using appropriate mathematical and statistical methods, advise the District Health Office on the effectiveness of the mosquito-net distribution programme and its suitability for extension to all government health centres.

**Item 3:**

The District Education Office is reviewing the effectiveness of its Mathematics Challenge Competition, which is used to identify learners for an advanced Mathematics enrichment programme. Eight representative learners from different secondary schools participated in the competition and later sat the district end-of-term Mathematics examination. Their competition scores and examination scores are shown below.

| Learner | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| Competition score | 1 | 3 | 5 | 6 | 7 | 8 | 10 | 12 |
| Examination score | 50 | 54 | 65 | 62 | 70 | 67 | 78 | 82 |

The competition will continue to be used for selecting learners into the enrichment programme only if the association between the competition scores and the examination scores is significant at the 5% level based on Kendall's rank correlation coefficient, and the estimated examination score for a learner who obtains a competition score of 9 is at least 70 marks. Otherwise, the learner selection criteria will be reviewed before the next intake.

To encourage participation in future competitions, the organisers conduct a lucky draw at the closing ceremony. A money box containing 10 discs, of which 5 are red, 3 are black and 2 are green, is used. In this lucky draw, a disc is selected at random and its colour is noted. The disc is then returned to the box together with two additional discs of the same colour, after which a second disc is selected. The organisers consider the lucky draw to be sufficiently fair if the probability that the first disc selected was red, given that the second disc selected is black, is at least 0,40.

The organisers use the expected number of green discs selected in the two draws to estimate the number of green prizes required for future competitions. If the expected number is at least 0.40, the current allocation of green prizes will be maintained. Otherwise, additional green prizes will be budgeted for future competitions.

**Task:**

Using appropriate mathematical and statistical methods, advise the District Education Office on the effectiveness of the Mathematics Challenge Competition and the suitability of the lucky-draw arrangements for future competitions.

## Part I.

**Item 4:**

The Ministry of Works and Transport is investigating the safety of a steep section of a certain road during dry and rainy seasons for heavy trucks. The road section is inclined at an angle of **12°** to the horizontal and the estimated

coefficients of static friction between the tyres of heavy trucks and the road surface are as shown below.

| Road condition | Coefficient of friction |
|---|---|
| Dry season | 0.30 |
| Rainy season | 0.12 |

As part of the investigation, a fully loaded supply truck of mass 15 tonnes is positioned on the slope and is initially at rest with brakes engaged and engine switched off. The truck's parking brake is then released. If the truck remains stationary after the parking brake is released, the road will remain open to heavy vehicles during that season. Otherwise, a second safety test will be carried out to determine whether disabled heavy vehicles can be recovered safely.

For the second test, a breakdown truck of mass 20 tonnes, having a maximum engine driving force of 120 kN, is connected to the supply truck using a tow cable with a maximum safe working tension of 50 kN. If the breakdown truck is able to pull the supply truck up the slope without the tension in the tow cable exceeding its maximum safe working tension, the road will remain open to heavy vehicles during that season, provided that a fully equipped breakdown truck is kept on standby at the site. Otherwise, the road will be temporarily closed to heavy vehicles during that season until a higher-capacity tow cable or more effective recovery arrangements are put in place.

**Hint:**

Assume that:

- both trucks are on the same $12°$ incline;
- the tow cable is light, inextensible and remains parallel to the road surface;
- the coefficient of friction between the tyres and the road remains constant for each road condition throughout the investigation.
- rolling resistance and air resistance are negligible;
- acceleration due to gravity, $g = 9.8 \text{ m s}^{-2}$; and

**Task:**

Using appropriate principles of mechanics and mathematical justifications, advise the Ministry of Works and Transport on the appropriate measures for the safe operation and recovery of heavy vehicles on this road section during the dry and rainy seasons.

**Item5:**

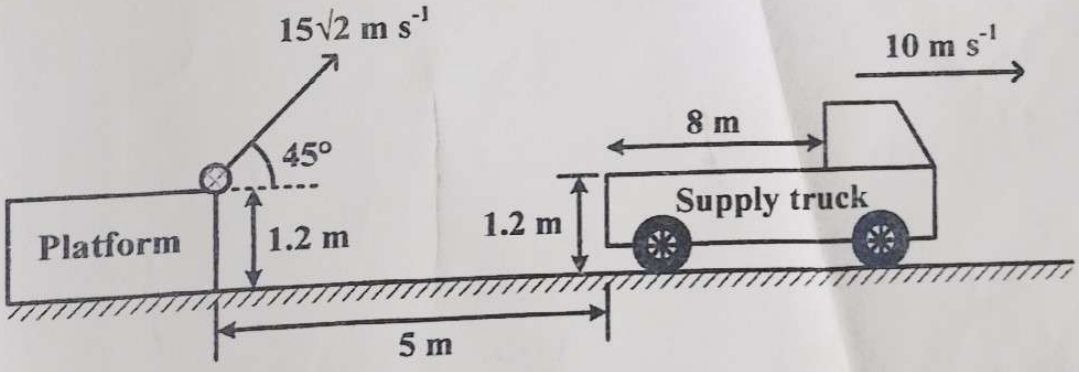
An emergency response agency is coordinating an air-and-ground relief operation to deliver medical supplies to a flood-affected area.

Two aircraft fly at the same altitude. Aircraft A flies at a constant speed of 720 km $h^{-1}$ on a bearing of 045°, while Aircraft B flies at 540 km $h^{-1}$ on a bearing of 310°. Initially, Aircraft B is 100 km from Aircraft A on a bearing of 065°.

The aircraft will remain under airport radar surveillance for only the first 6 minutes after departure. If their closest approach occurs after this period, a mobile radar unit will be deployed to continue monitoring the flight. Otherwise, the airport radar will provide sufficient surveillance.

In addition, aviation safety regulations require the aircraft to maintain a minimum separation of at least 30 km. If the minimum separation is less than 30 km, one aircraft must be assigned an alternative flight route before departure. Otherwise, the planned flight paths will be approved.

After landing, a worker launches a medical package from a stationary platform 1.2 m above the ground with an initial speed of $15\sqrt{2}$ m $s^{-1}$ at an angle of 45° to the horizontal. At the same instant, a supply truck with an open cargo bed 8 m long moves directly away from the platform at a constant speed of 10 m $s^{-1}$. At the instant the package is launched, the back of the truck is 5 m horizontally from the point directly below the launcher, and the cargo bed is also 1.2 m above the ground as shown in **figure.1**.




The emergency response agency will continue using the current loading procedure if the medical package lands inside the cargo bed of the moving truck. Otherwise, the loading procedure will be reviewed and adjusted before the next package is launched.

**Hint:**

Take acceleration due to gravity, $g = 9.8\ \text{m s}^{-2}$.

**Task:**

Using appropriate principles of mechanics and mathematical calculations, advise the emergency response agency on:

(i). whether a mobile radar unit should be deployed to continue monitoring the aircraft;

(ii). whether the planned flight paths should be approved or one aircraft should be assigned an alternative flight route; and

(iii). whether the current loading procedure should be maintained or reviewed and adjusted before subsequent packages are launched.

**END**