UGANDA ADVANCED CERTIFICATE OF EDUCATION

MOCK EXAMINATION

MATHEMATICS

PAPER 2 (APPLIED MATHEMATICS)

TIME: 2½ HOURS

INSTRUCTIONS TO CANDIDATES:

- This paper consists of two sections: **Section A** and **Section B**.
- **Section A is compulsory.** It contains **one (1) question** on Numerical Concepts.
- **Section B** consists of two parts:
    - **Part (i): Statistics and Probability** (Contains two questions; answer only **one**).
    - **Part (ii): Mechanics** (Contains two questions; answer only **one**).
- In total, candidates must answer **three (3) questions**: the single question in Section A, one from Section B Part (i), and one from Section B Part (ii).
- Graph paper and mathematical tables/calculators are provided where necessary.
- Clearly show all necessary steps, reasoning, and working.
- Where applicable, take acceleration due to gravity, $g = 9.8\ m/s^2$.

SECTION A (COMPULSORY)

ANSWER THE SINGLE QUESTION IN THIS SECTION.

Question 1 (Numerical Concepts)

(a) Two physical measurements, x and y, are recorded by an agricultural drone tracking soil moisture levels. The values are given as $x = 5.68$ and $y = 3.42$, each rounded to two decimal places.

1. Determine the absolute error intervals for both x and y.
2. Find the maximum possible absolute error and maximum percentage error when evaluating the quotient function:

$$Z = (x + y) / (x - y)$$

(b) A civil engineering firm models the structural deflection curve of a newly constructed pedestrian bridge over a river stream using the polynomial equation:

$$f(x) = x^3 - 4x - 9 = 0$$

1. Show that a real root for this equation lies within the open interval $(2, 3)$.
2. Use the linear interpolation method twice (two iterations) to approximate the value of this root correct to three significant figures.

SECTION B

ANSWER ONE QUESTION FROM PART (I) AND ONE QUESTION FROM PART (II).

PART (I): STATISTICS & PROBABILITY

Question 2

A district medical team carries out a health assessment across rural communities, recording the body mass index (BMI) scores of a sample of elderly citizens. The grouped frequency distribution table below shows the results:

BMI Range	15 – 19	20 – 24	25 – 29	30 – 34	35 – 39	40 – 44
Number of Citizens (f)	6	14	22	18	8	2

(a) Using an assumed mean of $A = 27$, calculate the actual mean and standard deviation of the BMI scores for this sample group.

(b)

1. Construct a cumulative frequency curve (Ogive) to represent this health data.
2. From your Ogive, estimate the median BMI score and the semi-interquartile range.
3. Health specialists classify individuals with a BMI above 32.5 as high-risk. Use your graph to estimate the percentage of this population that falls into the high-risk category.

Question 3

(a) To improve logistics and mitigate post-harvest crop loss, a cooperative stores grain in two distinct silos, S_1 and S_2.

- Silo S_1 contains 60 bags of high-grade maize and 40 bags of standard-grade maize.
- Silo S_2 contains 30 bags of high-grade maize and 70 bags of standard-grade maize.

A severe weather warning prompts a farmer to randomly select a silo, and from it, two bags of maize are extracted sequentially without replacement.

1. Construct a fully labeled probability tree diagram illustrating this selection process.
2. Find the probability that both chosen bags are of high-grade maize.
3. Given that the two extracted bags are found to be of completely different grades, calculate the conditional probability that they were taken out of Silo S_1.

(b) The discrete random variable X represents the number of solar-powered water pumps breaking down weekly in a sub-county. Its probability distribution is given by the function:

$$P(X = x) = kx^2 \text{ for } x = 1, 2, 3$$

$$P(X = x) = k(8 - x) \text{ for } x = 4, 5$$

$$P(X = x) = 0 \text{ otherwise}$$

1. Find the exact value of the constant k.
2. Calculate the expected value $E(X)$ and the variance $Var(X)$ of weekly pump failures.

PART (II): MECHANICS

Question 4

(a) A delivery truck leaves a central depot and travels along a straight stretch of highway. It starts from rest and accelerates uniformly at a rate of 1.5 m/s^2 until it reaches a cruising speed of 24 m/s. The truck maintains this constant speed for a duration of T seconds to cover a long, open distance. It then approaches a security checkpoint, decelerating uniformly at 2.0 m/s^2 until it comes to a complete halt.

1. Sketch a well-labeled velocity-time graph for the truck's entire journey.
2. Given that the total displacement between the depot and the checkpoint is exactly 1.8 km, calculate the value of the time duration T.
3. Determine the total time elapsed from the moment the truck started moving to the moment it stopped at the checkpoint.

(b) A heavy crate of humanitarian aid weighing 50 kg rests on a rough offloading ramp inclined at an angle of $25°$ to the horizontal. The coefficient of kinetic friction between the surface of the crate and the ramp is $\mu = 0.35$. A winch exerts a structural tension force P acting parallel to and up the incline. Calculate the value of P required to pull the crate up the ramp with a uniform acceleration of 1.2 m/s^2.

Question 5

(a) An environmental research buoy of mass ***8 kg*** floating in a tidal channel is simultaneously acted upon by three horizontal meteorological force vectors:

$$\boldsymbol{F_1 = (2ai + 3j)\ N}$$

$$\boldsymbol{F_2 = (-5i + bj)\ N}$$

$$\boldsymbol{F_3 = (4i - 2j)\ N}$$

If the buoy accelerates at a rate of $\boldsymbol{a = (0.5i + 0.75j)\ m/s^2}$:

1. Determine the exact numerical values of the constants ***a*** and ***b***.
2. Calculate the magnitude of the resultant force acting on the buoy and the precise angle it makes with the unit vector ***i***.

(b)

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                   W = 60 N (Uniform Plank)
A -----------------------G----------------------- B
   |<- 1.2m ->|                        |<- 1.8m ->|
        ▲                                   ▲
   Support C                           Support D
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A uniform scaffolding plank ***AB*** used in constructing a rural school block has a length of ***7.0 m*** and a weight of ***60 N***. The plank rests horizontally in static equilibrium on two smooth wooden trestle supports placed at positions ***C*** and ***D***, where ***AC = 1.2 m*** and ***BD = 1.8 m*** (as shown in the schematic above).

A mason weighing ***750 N*** steps onto the plank at end ***A*** and walks slowly toward end ***B***.

1. Calculate the initial vertical reaction forces exerted by the supports ***C*** and ***D*** before the mason steps onto the plank.
2. Determine the maximum distance past support ***D*** toward the outer edge ***B*** that the mason can safely walk before the scaffolding structure begins to tilt and fail.