

MOCK COLLECTION 2026 PRINCIPAL MATHEMATICS 2 (P425/2)**MATIGO****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

$$y = \frac{(50x + 27 \tan^{-1} x)}{(1 + x^2)} \quad \text{where } x \text{ and } y \text{ are measured in metres.}$$

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.

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.

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;

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.

Item 5:

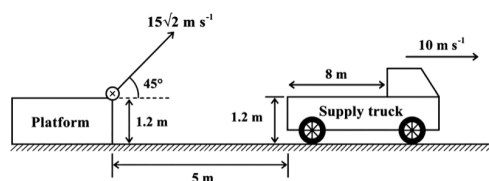
An emergency response agency is coordinating an air-and-ground relief operation to deliver medical supplies to a flood-affected area.

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 $15\sqrt{2} \text{ m s}^{-1}$ 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.

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.

Task:

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

- whether a mobile radar unit should be deployed to continue monitoring the aircraft;
- whether the planned flight paths should be approved or one aircraft should be assigned an alternative flight route; and
- whether the current loading procedure should be maintained or reviewed and adjusted before subsequent packages are launched.

JJEB**Item 1**

The Uganda National Roads Authority (UNRA) is upgrading a 50 km road that connects a trading centre to a lake community. A sino truck transports gravel from a quarry and off loads it at different points along the road according to the condition of the road surface. The following offloading records were made along the route.

At the trading centre 4 tonnes were offloaded. At the swampy area 40 km from the community 3.4 tonnes were offloaded. At the beginning of the hill 20 km from the centre 2.8 tonnes were offloaded. 30 km from the centre 2.2 tonnes were offloaded. At a distance

of 10 km from the lake community 1.6 tonnes were offloaded and at the lake community 1.0 tonnes were offloaded. The roads supervisor wants to plan the distribution of stones more effectively for the remaining sections of the road. The engineer wanted to offload stones at a distance of 9 km from the community and also wanted to offload 2.09 tonnes of stones

Engineers also established the relationship between the quantity of stones offloaded, $y \text{ tonnes}$, and the distance x in Kilometers as $e^{\cos x} + 1 = 0$ for the section $1 \leq x \leq 2$ (kilometers) for the road design in that particular area.

The engineer wanted to perform a dry run to identify actual location to a degree of accuracy of two decimal places.

Task

- (a) Advise the supervisor on the quantity of stones to be offloaded and the location for offloading from the centre.
- (b) (i) Help the supervisor to establish the road design graphically, and distance where offload was made.
- (ii) Advise the engineer on the most accurate location.

ITEM 2

A manufacturing company partnered with a nearby secondary school to improve efficiency in its community outreach programme. During a general cleaning exercise, the time taken by learners to complete an assignment task was recorded.

At the same time, the company monitored the quality of products manufactured by four machines (A, B, C and D). In addition, traffic flow on the road leading to the company was studied to help plan transportation for workers.

The following information was obtained: the times taken by learners to complete the activity recorded as follows:

Time (seconds)	5-	10-	15-	20-	30-	50-	100-
Number of learners	35	42	58	14	3	1	0

In order to report effectively the company required the average time, the variance from the mean and the most frequent time by the use of an appropriated statistical diagram.

The manufacturing company uses four machines to produce its products. Machine A produces 30% of the daily output, machine B produces 30%, machine C produce 15% and machine D produce 25%. The percentages of defective products are: Machine A 1%, Machine B 2%, Machine C 3% and Machine D 5%. In order to work on customer satisfaction, the company wanted the probability of product being defective and also that machine A would be used more to produce the products.

Between 8:00am and 9:00am, 40% of the vehicles travelling on the road move from west to east, while the remaining travel from east to west. A random sample of 250 vehicles is observed.

Task.

- (a) Help the company to find the statistical measures of time for informed decision making.
- (b) If a product selected at random is found to be defective, determine the probability that it was produced by machine A.
- (c) Determine the probability between 77 and 93 vehicles inclusive travel from west to east during the observation.

ITEM 3

A meteorological agency is studying rainfall patterns and student performance. In a simple model of the weather in July each day is classified as either fine or rainy. The probability that a fine day is followed by a fine day is 0.8. The probability that a rainy day is followed by a fine day is 0.4. The probability that 1 July is fine is 0.75.

The meteorologist wanted to discover whether 2 July would be fine and also 3 July could be fine.

At the same time, the amount of rainfall (in cm) on a randomly selected day is modeled by the continuous random variable X with probability density function

$$f(x) = \begin{cases} 3\alpha x & ; 1 \leq x \leq 3 \\ \beta(6 - x) & ; 3 \leq x \leq 4 \\ 0 & ; \text{otherwise} \end{cases} \quad \text{where } \alpha \text{ and } \beta \text{ are constants.}$$

To assess academic performance, a random sample of 250 candidates is selected from the district. The sample has a mean examination score of 68.4 and a population variance of 182.25.

Task

- (a) (i) Help the meteorologist investigate probability that 2 July will be a fine day then the probability that 3 July is also a fine day.
- (ii) Investigate the probability that 3 July is rainy, given 1 July is fine.
- (b) Help to construct a cumulative distribution function X, and hence determine the median

(c) Investigate the standard error and construct a 98.4% confidence interval for the population mean.

ITEM 4

The Uganda Civil Aviation Authority (UCAA) is conducting a search and rescue training exercise on lake. The exercise involves a rescue helicopter, two emergency response vehicles and two rescue motor boats. During the exercise, the helicopter launches a rescue package from a cliff with an initial speed of 30 ms^{-1} towards a target located 60m horizontally from the point of projection and at the same level. For safety reasons the launch angle must be between 20° to 67° and at the same time, two emergency response vehicles from opposite ends, A and B, of a 20 m straight road. At the same instant one vehicle starts from rest at A and travels towards B with a constant acceleration of 2 ms^{-2} and the other vehicle starts from rest at B and travels towards A with a constant acceleration of 5 ms^{-2} . The intersection occurs for the vehicle to meet.

Meanwhile, two rescue motor boats P and Q begin moving on the lake. Boat P travels at a constant speed of 20 km/h on a bearing of 060° while boat Q travels at a constant speed of 10 km/h. At 2:00 pm the operator on the boat Q observes that boat P is 4km due west of Q. The intention of operator on Q is to pass as close as possible to P.

Task

- Investigate whether the rescue was successful.
- Investigate the point on the road where the particle would meet from A.
- (i) Investigate the course that must be set by boat Q to pass as close as possible to P and the shortest distance.
- (ii) Help the operators to know the time when the rescue will take place.

ITEM 5

An engineering team is transporting equipment to a construction site across a river. The equipment is first pulled up a rough inclined plane with an angle of inclination $\sin^{-1}(3/5)$. The coefficient of friction $1/8$ between P and the plane, by a light inextensible string passing over a smooth pulley. A 5kg mass on the incline is connected to a hanging load Q of 4kg. Q is initially 2m above the ground. The system is released from rest with the string taut.

At the top of the incline, four guide cables exert forces of 4N, 5N, 9N and $6\sqrt{2}$ N along EB, EC, ED and AC respectively, where ABCD is a rectangle and $AB = 2AD$. The engineers wish to replace these four forces with a single equivalent force.

After unloading the equipment, the team crosses a river 50m wide flowing at a constant speed of 3 ms^{-1} . Their boat has a speed of 2.5 ms^{-1} in still water. The boat leaves a point on one bank to reach a point 35m downstream from its starting point. The crew had two possible courses in crossing the river and the best would be where least time is taken.

Task

- Investigate the acceleration of the system and the time taken for the hanging mass Q to reach the ground and the distance mass P moves up the inclined plane.
- Investigate the single force that could replace the four forces.
- Advise the crew on the course to be taken.

KAYUNGA

Item 1

An aerospace engineer is designing a specialized cooling fin for a satellite component. The profile of the fin is modeled by a complex curve and the engineer needs to determine its cross - sectional area which can later help him to determine its weight and heat dissipation. The top boundary of the fin's cross section is defined by the function

$f(x) = \frac{10}{(x^2 + 2)}$ The width of the fin bases span from $x = 0$ to $x = 2$ m and he hopes to subdivide the interval into four equal sub-intervals. During testing, the same aircraft is used to deliver 20 packages in 45 minutes and another 40 packages in 75 minutes. He is wondering whether to take 60 packages if time does not exceed 105 minutes otherwise, he is to find time before he does the delivery of 60 packages to have the final decision.

The engineer also wishes to derive a formula for estimating the relative error he made in determining the volume of the cylinder of his aeroplane engine, the errors the radius, height and volume being Δr , Δh and Δv respectively.

Task: Help the engineer make appropriate decisions using mathematical methods.

Item 2

The manager of a food processing plant is conducting a dual audit on quality control and employee demographics due to a recent health advisory.

In the packaging department, three workers—Aileen, Barbara, and Cathy—handle the daily batch.

Aileen packs 55% of the total volume, Barbara packs 30%, and Cathy packs the remaining 15%.

Quality control records show that the probability of a packet containing broken biscuits is 0.7 if packed by Aileen, 0.2 if packed by Barbara, and 0.1 if packed by Cathy. During a routine inspection, the manager randomly selects a packet from the finished batch and finds it contains broken biscuits. He suspects Aileen is responsible.

On the same day, as part of a health-monitoring directive to track demographic vulnerability to an ongoing disease outbreak, the manager records the exact ages of all 40 workers on the factory floor:

19.2, 21.0, 22.5, 24.8, 25.0, 26.3, 27.1, 28.5,
29.0, 30.2, 31.5, 32.8, 33.0, 34.2, 35.5, 37.0,
38.4, 39.0, 40.2, 41.5, 42.1, 43.5, 44.0, 45.8,
46.2, 47.9, 48.0, 49.5, 50.3, 52.0, 53.4, 55.0,
56.7, 58.0, 59.2, 60.5, 62.1, 63.8, 64.0, 65.0

Task

- Evaluate the manager's suspicion. Based on the evidence of the broken biscuits, how likely is it that Aileen is responsible?
- Provide the manager with the average age of his work-force and by graphical analysis an estimate the age threshold below which the youngest 75% of the workforce falls.

Item 3

Umeme, a major electricity distributor, is evaluating the performance of their light bulbs and employee productivity to improve their operations.

They have two types of bulbs:

Type A: Expected to last around 1150 hour, with some variation.

Type B: Expected to last around 1900 hours, with some variation.

The company wants to determine:

For Type A bulbs, what percentage are expected to last more than 1200 hours? If this percentage is less than 50%, they plan to replace all Type A bulbs.

For Type B bulbs, out of 1000 units, how many are expected to last less than 1800 hours? If fewer than 500 are expected to fail early, they may decide to stop using Type B bulbs altogether.

Moreover, the company is interested in understanding whether drinking coffee influences the productivity of their engineers. They recorded the daily cups of coffee consumed and the number of lines of code written by two engineers over a month:

X	10	15	20	25	30	35
Y	68	60	55	48	38	32

Umeme will base on a calculation to know if there is a relationship between x and y and if found its exceeding 0.75 at 5% level of significance then coffee will be served daily

Task:

- Decide whether the company should replace Type A bulbs accordingly and calculate how many of the 1000 Type B bulbs will likely fall before 1800 hours. Also, advise if they should continue using this type.
- Recommend whether the company should serve coffee daily to improve employee output.

Item 4

A construction team at a logistics ware house is setting up an automated roof system. A crate of machinery (Body A, $m_1=20\text{kg}$) sits on rough inclined roof tilted at an angle of $\theta=30^\circ$ above the horizontal. This crate is connected by a light, inextensible cable passing over a frictionless pulley to a heavy counterweight (Body B, $m_2=15\text{kg}$) that hangs freely vertically.

The coefficient of kinetic friction between Body A and the roof is $\mu_k=0.15$. When the system is released from rest, the hanging counterweight pulls Body A up the incline.

The resultant force acting on each of the two bodies must be at least 140N, the tension in the cable more than 135N and the rate of change of velocity should not be less than 0.5 ms^{-2} if they are to continue with construction work.

A war missile (mass=5000kg) is stuck in a harbor channel. Two towboats tie cables to the front of the missile to pull it into the docks.

- Towboat A pulls with a force of $F_1=1,500\text{N}$ directed at an angle of 30° North of East.
- Towboat B pulls with a force of $F_2=1200\text{N}$ directed at an angle of 45° South of East.

Due to the narrow canal, there is a constant water drag (friction) resisting the forward motion with a force of $F_{\text{drag}} = 400\text{N}$ directly West.

Task: Help the construction team to;

- Determine whether the crate – plane goals above are achievable,
- discover what single force is required and the direction it should take in order take out the missile from water.

Item 5

The lake authorities have received reports of illegal fishing activities in a remote part of the lake Bunyonyi. To catch the offenders, a police patrol boat (Boat P) is dispatched from the main dock in position, A, given by $(3i + 8j)$. The patrol boat travels at a steady speed of 20 kmh^{-1} along a straight route heading 45° north of east.

Meanwhile, an illegal fishing boat (Boat F) has been spotted at position B, given by $(8i + 6j)$. The fishermen are trying to reach a protected area whose position is C, $(12i + 10j)$. They are moving at a steady speed of 15 kmh^{-1} directly towards point C.

The police are aiming to intercept the fishing boat before it reaches the protected area to prevent illegal fishing activities.

The authorities need to determine:

- When and where the police boat can intercept the fishing boat.
- Whether the police can catch the fishing boat before it reaches point C.

Tasks

Help the authorities determine the time at which the police boat is closest to the fishing boat during their journeys, whether the police can intercept the fishing boat before it reaches point C and if possible, the coordinates where the police boat should meet the fishing boat.

BUSHENYI

Item 1

A school canteen serves lunch to learners in shifts because the dining area is small. During one busy lunch break, the kitchen staff had to move food from the kitchen to the serving point using a trolley. Since learners often stand near the serving area while waiting for food, the teacher on duty asked the canteen team to check whether the trolley was moving safely, whether the sauce bucket measurements were reliable, and whether the prepared food would be enough for the expected serving demand.

During movement from the kitchen to the serving area, the trolley attendant recorded the speed of the food trolley at different times. The trolley was moving at 7 m s^{-1} after 2 seconds, 8 m s^{-1} after 3 seconds, and 10 m s^{-1} after 4 seconds. The trolley reaches the serving point after 5 seconds, which is beyond the last recorded time. For safety near the learners, its estimated speed at the serving point should not exceed 13 m s^{-1} . The attendant also needs the estimated speed after 3.5 seconds, when the trolley is still between two recorded times, and this speed should not exceed 10 m s^{-1} . The movement will be considered safe only if both speed conditions are satisfied.

For serving sauce, the head cook uses a cylindrical sauce bucket. The inside radius of the bucket was measured as 1.2 dm , correct to one decimal place, and its inside depth was measured as 3.15 dm , correct to two decimal places. The bucket will continue to be used for measuring sauce only if the possible percentage error in its volume is not more than 10%; otherwise, the bucket must be re-measured using a more accurate measuring tape.

The canteen attendant also recorded how quickly plates were being served during a 2-hour lunch period. The serving rate was recorded at equal time intervals as shown below, where t is the time in hours after serving began and $f(t)$ is the serving rate in plates per hour.

t	0	0.4	0.8	1.2	1.6	2.0
$f(t)$	81.3570	89.7140	103.4790	116.8260	134.3850	152.7610

The kitchen had prepared food for 240 plates. To avoid shortage during the next serving shift, the canteen attendant will ask the kitchen to prepare extra food if the percentage error in the number of plates served is more than 5%.

Task

As a Mathematics student, help the canteen team interpret the information using suitable numerical methods and measurement limits, then judge whether the trolley speed, sauce-bucket measurement, and food preparation plan are acceptable or need adjustment.

ITEM 2

A Mathematics teacher in a certain secondary school stays some distance from school and usually comes to school by either road A or road B. Road A is shorter but often becomes busy in the morning, while road B is longer but usually has smoother traffic. From his past movement records, the probability that he uses road A is 0.25. The probability that he arrives late when he uses road A is 0.60, while the probability that he arrives late when he uses road B is 0.30.

The teacher is responsible for opening the examination room and arranging answer booklets before the Mathematics test starts. Since the teacher commonly uses road B, the Head of Department will call one of the resident teachers to intervene if the probability that he uses this road, given that he arrives late, is greater than 0.50.

After the test, the Head of Department reviewed the performance of all the 100 senior Six students in Principal Mathematics. The results were recorded as cumulative frequencies as shown below.

Marks	Cumulative frequency
$20 < 30$	2
< 40	8
< 50	24
< 60	50
< 70	76
< 80	92
< 90	98
< 100	100

According to the Head of Department, the marks are approximately normally distributed. Since the school is preparing candidates for national examinations, Mathematics consultation forms will be introduced if the estimated proportion of students scoring between 50 and 70 marks is less than 45%. If the proportion is at least 45%, the department will continue with guided class discussions and weekly corrections.

The department had earlier set a target mean mark of 62. This target will be kept only if it lies within the 95% confidence interval for the population mean; otherwise, the target will be reviewed before the next test.

Task

As a Mathematics student, analyse the transport risk and test results, then advise the Head of Department on standby preparation, road advice, consultation forms, and whether the target mean of 62 should be kept.

ITEM 3

At a school canteen, students are served during break time using a numbered waiting system. From past records, the waiting time X , in minutes, for a student to be served is modelled by the probability density function

$$f(x) = \begin{cases} \frac{2}{13}(x + 1); & 0 \leq x \leq 2 \\ \frac{2}{13}(5 - x); & 2 \leq x \leq 3 \\ 0 & ; \text{ otherwise} \end{cases}$$

The canteen manager will add another serving point if the standard deviation of the waiting time is more than 0.8 minutes.

In another daily activity, the school store keeps two boxes of coloured tokens used when assigning students to cleaning groups. Box A contains 4 white tokens and 2 red tokens, while box B contains 3 white tokens and 3 red tokens. Box A is three times as likely to be selected as box B. After a box has been selected, two tokens are picked one after another without replacement.

If the two tokens picked are white, the storekeeper wants to find the chance that the selected box was box B. Box B will be considered a likely source of the two white tokens only if this chance is at least 0.40.

During a weekly class exercise, each student has a probability of 0.6 of getting a short question correct. Ten students attempt the question independently. The teacher will give a class reward only if exactly six students get it correct, and this outcome will be considered reasonable if its probability is at least 0.20.

Task

As a Mathematics student, interpret each situation, choose an appropriate method for the waiting-time model, the token activity, and the class exercise, then advise the canteen manager, the storekeeper, and the teacher based on the stated conditions.

ITEM 4

A secondary school has received a donation of computers that must be installed in a newly constructed computer laboratory before the beginning of the next term. The school administration is concerned about the safety of the installation process. A loaded trolley carrying computers and related equipment has a total mass of 1000 kg, including the operator. The trolley is moved along a straight horizontal corridor PQ from the store to the laboratory. Robert applies a force of 200 N at 35° above PQ, James applies a force of 270 N along PQ, and Sarah applies a force of 240 N at 25° below PQ. The computers are delicate and may be damaged if the trolley shakes excessively. The transportation method will therefore be approved only if the resultant force perpendicular to the corridor PQ does not exceed 40 N.

The network cable connecting the laboratory to the administration block must pass over a building situated between the two blocks. To determine a suitable separation between the cable-support poles, technicians carry out a test using two marker projectiles. Projectile P is launched from point A towards point B with an initial speed of 45 m s^{-1} at an angle of 30° to the horizontal. Two seconds later, projectile Q is launched from point B towards point A with the same speed and angle of projection. The proposed installation will be accepted only if the projectiles meet at

a height not greater than 30 m, ensuring that the cable can safely pass below the roof level of the building, and if the distance AB is at least 120 m to provide adequate clearance from areas frequently used by learners.

At the entrance to the laboratory, the school intends to mount a sign post to guide visitors. The sign post has a mass of 4 kg and is attached to the lower end of a light inextensible string fixed to a beam. A horizontal force of 24 N and an upward vertical force of 6 N act on the sign, keeping it in equilibrium while the string makes an angle α with the vertical. The installation will be approved only if the tension in the string does not exceed 50 N, beyond which the support may fail.

Task

As a mathematics student, determine the relevant quantities and advise the school administration whether each of the proposed activities satisfies the stated safety requirements before the laboratory is commissioned for use.

ITEM 5

A group of students from a secondary school in western Uganda is travelling to represent the school at a national science and innovation exhibition. Their journey requires them to cross a river before proceeding to an airstrip, so the teacher in charge must confirm that the movements are safe and properly coordinated.

At the river crossing, a boat can move at 5 m s^{-1} in still water. The river is 150 m wide, and the current flows downstream at 2 m s^{-1} . Since the team is expected to keep time, the boatman decides to cross in the shortest possible time. The school van will only pick the team from the opposite bank if the downstream drift does not exceed 65 m.

Later, aircraft A, carrying part of the school delegation, is flying due south at 300 km h^{-1} . To the pilot of aircraft A, aircraft B appears to be moving at 540 km h^{-1} in the direction $\text{N}40^\circ\text{W}$. The air traffic controller must determine the true speed and direction of aircraft B, and aircraft B will only be cleared to continue if its true speed does not exceed 750 km h^{-1} .

At 1.00 p.m, a passenger aircraft has position vector $(-90\mathbf{i} + 180\mathbf{j}) \text{ km}$ and velocity vector $(260\mathbf{i} + 300\mathbf{j}) \text{ km h}^{-1}$. At 1.20 p.m, a cargo aircraft has position vector $(10\mathbf{i} + 290\mathbf{j}) \text{ km}$ and velocity vector $(240\mathbf{i} + 240\mathbf{j}) \text{ km h}^{-1}$. The air route will be declared unsafe if the two aircraft are found to occupy the same position at the same time; otherwise, the route will be approved.

Task

As a student of Mathematics, help the teacher and the air traffic controller analyse the movements, select appropriate mathematical methods, calculate the required quantities, and decide whether each practical safety condition is satisfied.

ALLIANCE

ITEM 1.

A telecommunications company is evaluating the reliability of a newly installed signal transmission system. During each transmission, a signal is either received successfully or lost due to interference. Based on previous tests, the probability that a transmission is received successfully is 0.8, and the outcome of each transmission is independent of the others. To assess performance, a network engineer randomly selects five transmissions made during a particular period. During the monitoring session, an automated flag is flashed, confirming that it met the basic operational threshold by recording at least three successful transmissions. The quality control manager now wants to assess how reliable the system is when operating under these flagged conditions.

Let the random variable X denote the number of successful transmissions among the five selected transmissions.

Tasks

(a) Using the information provided, construct the probability distribution of the random variable X . Hence, determine the expected number of successful transmissions and the variance of X .

(b) From the probability model obtained, evaluate the likelihood that the system records at least four successful transmissions during the five selected transmissions. Hence, comment on the overall reliability of the transmission system.

(c) Based on the alert received by the quality control manager, compute the probability that the system achieved perfect performance (all five transmissions successful) given that the batch met the basic operational threshold.

ITEM 2.

A food processing company has introduced a preventive maintenance programme to improve the efficiency of its packaging machines. To determine whether increased maintenance expenditure improves machine performance, the company monitored eight identical packaging machines over a production cycle. For each machine, the amount spent on maintenance and the corresponding number of hours the machine operated continuously before requiring servicing were recorded. The results are shown in the table below.

Machine	A	B	C	D	E	F	G	H
Maintenance cost, (x) (million UGX)	2	3	4	5	6	7	8	9
Operating time, (y) (hours)	180	205	215	245	260	290	310	335

In a follow-up assessment, engineers used the performance model

$$T = \frac{5x^2}{y},$$

where T is the machine performance index, x is the maintenance cost (in million Uganda shillings) and y is the operating time (in hours). During one inspection, the maintenance cost and operating time of another machine were measured as 6.50 ± 0.05 million Uganda shillings and 275 ± 2 hours respectively.

Tasks

(a) Using the data provided, determine the Spearman's rank correlation coefficient between the maintenance cost and the operating time of the machines. Hence, comment on the suitability of maintenance expenditure as a predictor of machine operating time.

(b) Using the performance model $T = \frac{5x^2}{y}$, determine the maximum percentage error in the calculated value of T. Hence, determine the maximum absolute error in the performance index.

ITEM 3.

A dairy processing company recently installed a new automatic packaging machine to improve the accuracy of filling milk powder into retail bags. Before the machine was approved for continuous production, the quality assurance department randomly selected 80 bags from different production batches and recorded their masses. The results obtained are shown in the table below.

Mass (g)	Frequency
450 – 454	6
455 – 459	10
460 – 469	18
470 – 474	20
475 – 484	14
485 – 489	8
490 – 499	4
Total	80

The production manager intends to use the information to determine whether the machine fills the bags consistently and whether the quantities packed are centred around the expected value before authorizing full-scale production.

Tasks

(a) Using appropriate statistical techniques, investigate the overall performance of the packaging machine based on the data provided. Hence, comment on whether the machine is suitable for continuous production.

(b) Analyse the distribution of the packaged masses and assess the spread of the central

observations. Hence, state whether the packaging process appears to be reasonably uniform.

ITEM 4.

During the commissioning of a cable-operated material handling system at a quarry, engineers conducted a performance test to evaluate the efficiency of a lifting mechanism used to transport construction materials up a rocky hillside. The system consisted of two loads connected by a light inextensible cable passing over a small smooth pulley fixed at the top of the slope. Load A, of mass 18 kg, rested on a rough plane inclined at 30° to the horizontal, while load B, of mass 16 kg, hung freely on the opposite side of the pulley.

The coefficient of kinetic friction between load A and the inclined plane was 0.20. When the locking mechanism was released, the system moved immediately with load B descending vertically and load A moving up the incline. The cable remained taut throughout the motion, and after travelling a distance of 5.0 m, load B reached a safety buffer while load A was still on the inclined surface. Throughout the test, air resistance was neglected, the pulley was assumed to be smooth, and the cable was taken to be light and inextensible.

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

Tasks

(a) Using the information provided, determine the acceleration of the system and the tension in the cable. Hence, verify whether the observed direction of motion is consistent with the forces acting on the system.

(b) Determine the work done against friction as load A moves up the incline. Hence,

calculate the speed of the system immediately before load B reaches the safety buffer.

ITEM 5.

During a flood relief operation along a wide section of the River Nile, an automated humanitarian supply drone D flying at a constant altitude of 78.4 m is deployed to deliver a 5 kg medical capsule to a moving rescue boat B. A uniform horizontal wind blows from the South-West towards the North-East at a constant speed of 10 m s^{-1} on a bearing of 045° , while the drone navigates relative to the surrounding air at a constant speed of 25 m s^{-1} directed due North. At time $t = 0 \text{ s}$, the rescue boat B is observed at position vector $\mathbf{r}_B(0) = (120\mathbf{i} + 180\mathbf{j}) \text{ m}$ relative to the drone's initial horizontal location $(0, 0)$, traveling downriver at a constant ground velocity of $\mathbf{v}_B = (15\mathbf{i} - 5\mathbf{j}) \text{ m s}^{-1}$. At the exact instant when $t = 0 \text{ s}$, the drone's launch mechanism projects the medical capsule relative to itself with an initial upward vertical velocity component of 14.7 m s^{-1} and an unknown horizontal velocity vector at an elevation angle α above its flight plane, ensuring the capsule lands directly on the deck of the moving boat below.

(Take $g = 9.8 \text{ m s}^{-2}$ and neglect air resistance on the capsule post-launch.)

Tasks

- Determine the actual velocity vector $\mathbf{v}_D$ and bearing of the drone relative to the ground, hence find the rate at which the horizontal distance between the drone and the boat is changing at $t = 0 \text{ s}$.
- Calculate the total time of flight T for the package to reach the water level, and determine the relative horizontal velocity vector and elevation angle α required to hit the boat.

UMTA

Item 1

In a certain school, the headteacher wishes to improve security around the corners of the compound by installing security cameras. He contacted a technician to identify suitable positions for the installation.

Upon mapping, the technician established an initial position and drew a baseline through the compound. He realized that the path across the compound is modelled by the function $f(x) = 2\cos x - x^2$, where x is the distance in hundreds of meters from the initial position along the baseline.

He also noticed that the path intersects the baseline at two points; the most suitable positions where the cameras are to be installed.

However, due to financial constraints, the headteacher prefers the position on the positive side of the initial position. He needs to determine the exact location where the camera should be installed using an iterative method to avoid miscalculation.

Additionally, the headteacher discovered that the area between the path and the baseline can accommodate a tent to serve as a consultation area, provided the area is at least 10,000 square meters.

The technician uses a numerical method with 5 sub-intervals along the baseline to ascertain this area.

Task:

- Justify the exact position where the headteacher will install his camera.
- Is the area of interest being enough for the consultation tent? Make recommendation basing on the technician method.

Item 2.

During an inter-university sports tournament, a survey was conducted to gauge the viewing habits of students regarding the two most popular sports: Football and Cricket.

The survey results showed the following probabilities:

- 35% watched Football but not Cricket
- 10% watched Cricket but not Football
- 40% did not watch either of the sport

With the next inter-university tournament expected to attract 500 students, and assuming viewing habits remain unchanged, the organizing committee is currently facing a challenge: They need to estimate the number of students expected to watch Cricket, given that they do not watch Football such that if the number exceeds 50, they would prepare a separate court outside the university.

However, a sample of 138 supporters was selected from the previous tournament who watched football. The table below shows the number of supporters and the time taken (in minutes) to enter the stadium, measured from the start of the game until halftime.

Time (minutes)	Number of supporters
$0 < x < 10$	10
$10 < x < 15$	35
$15 < x < 20$	65
$20 < x < 30$	107
$30 < x < 35$	123
$35 < x < 45$	138

The committee wishes to know the number of supporters who will arrive before the most likely time. If this number exceeds 50, they intend to offer a free drink to promote the game.

After the tournament, a survey was conducted among the spectators. A sample of 20 spectators was taken. If the probability of finding at most 12 spectators watching football is less than 0.4, the university plans to invest in activities other than football.

Task:

- Evaluate whether the university will prepare a separate court outside and ascertain whether the committee will offer a free drink to promote football on.
- Justify whether the university is planning to invest in other activities other than football.

Item 3.

A school board is reviewing the effectiveness of their Mock Examinations as a predictor of final A-Level success. The Director of Studies (DOS) has selected a sample data for 11 students from last year's performance in Mathematics to check on the relationship between Mock exams and final A level grades:

Marks in mocks	76	41	78	59	14	29	61	86	32	64	51
Grades in A level	A	B	B	C	D	E	B	A	D	C	E

The DOS need to assess whether mock examination marks provide a true and reliable estimate of students' expected performance in the final A-Level exams

However, a sample of 81 students is taken, the chance of getting student scoring above the mean mark is 0.4 but board defines good performance if the chance of getting at least half the number of students scoring above the mean mark is greater than 0.5.

Basing on the district mock results, the marks of the whole district were normally distributed with a mean of 45 and standard deviation 5. The board wants to know the average mark for a sample of 100 students who sat for same mock examination in their school since the chance of getting a student above the average mark is 0.46. If the average exceeds 48 the budget of academics will be increased in order to improve on the performance in school.

Task:

- Justify whether mock examination marks provide a true and reliable estimate of students' expected performance in the final A-Level exams.

- Ascertain whether performance was good basing on the board's definition.

- Make a recommendation on whether the Academics budget will be increased.

Item 4.

A civil engineering firm is analysing the forces acting on a regular, two-dimensional steel truss component used in a pedestrian bridge design. The truss structure is shaped like a regular hexagon, ABCDEF, with each side measuring 2m has a mass 500kg

The structure is subjected to eight internal forces due its formation. These forces and their directions, indicated by the order of the letters of the truss, are as follows: 9N, 5N, 7N, 3N, 1N, 3N, 5N and 4N act in AB, BC, CD, DE, EF, FA, AD and AC. where AB and AE are in the X and Y planes respectively.

The engineering team needs a complete vector analysis to ensure the truss can withstand the resultant load of 12N.

However, in the process of lifting the truss to the bridge using a crane the rope snapped and the truss fell from a height of 5m vertically on to the rough ground inclined at 25° to the horizontal coefficient of friction of 0.3 and slides using an initial speed of 7ms^{-1} for a distance of 8m and hits the vertical wall. The team would wish to know the speed at which the truss hits the wall.

Engineers assert that for the truss to remain intact, it should not hit the ground with a velocity more than 2.5ms^{-1} or else it will be deformed

Task:

- Determine whether truss can withstand the resultant load and its direction of action
- Justify whether the truss will remain in its form and the speed with which it hits the wall

Item 5.

On a certain island around Lake Victoria, smugglers are loading one tonne of fuel containers onto a boat using a rough wooden ramp. The ramp is 10m long and inclined at 25° to the horizontal, with a coefficient of friction of 0.1. Each container, with a mass of 100 kg, is pushed up towards the boat by a horizontal force of 700N. The smugglers are uncertain about how much time it will take to load the containers, but they have a strict time window of only 2 minutes to complete their work.

Just after midnight, a marine patrol officer was patrolling the waters near Entebbe. At 1:00 AM, his spotter noticed a suspicious motorized boat believed to be smuggling fuel and untaxed goods that was 20 km due East of their position and heading due N15°E at 15 m/s. The smugglers were attempting to reach the safety of a protected island by 2:00 AM. The officer is not sure of the time it will take to intercept them, since the top speed of his boat is 20 m/s.

Task:

- Justify whether the smugglers will be able to complete their work in time.
- Is the patrol officer intercept the suspicious motorboat in time.

WAKATA

Item 1.

A small carrier business operating between Kabale and Mbarara uses motorcycles and small vans to transport parcels. The owner introduced a computerized system to estimate parcel charges, monitor fuel usage and determine container capacities. However, he is not sure whether the calculations are reliable enough for business decisions.

Previous records showed that parcels of masses 200g, 400g and 600g were charged Shs 700, Shs 1200 and Shs 3000 respectively. One customer brought a parcel weighing 185g, while another claimed to have Shs 2200, although the parcel mass was not recorded. The owner will keep the computerized charging system if the charge for the 185g parcel is less than 700, and the estimated mass corresponding to Shs 2200 less than 520g; otherwise, the fare estimates will be reviewed before use.

The business also manufactures conical metallic containers for motorcycles. One container had radius of 4.7cm and height of 12.65cm measured with possible errors of ± 0.3 and ± 0.45 respectively. The owner will use the container measurements for production if the difference between the upper and lower limits of the possible volume does not exceed 140cm³; otherwise, the container dimensions will be re-measured.

In addition, the fuel consumption of one motorcycle while climbing a hilly road near Kabale was represented by the function $y = \tan x$ over the interval $\pi/6 \leq x \leq \pi/3$. The transport officer used 6 ordinates to estimate the total fuel used during the climbing session. The officer will use this fuel estimate for planning if the percentage error is less than 5%; otherwise, a more accurate method for determining the fuel consumption will be required.

Task:

Help the owner of the carrier company interpret the information, choose suitable method and make justified decisions about the charging system, container measurements, and fuel consumption estimate.

Item 2.

The management committee of a secondary school became concerned about learners' academic performance, staff punctuality and the safety of the school transport system after several complaints from parents and teachers. During a planning meeting, the committee resolved that future decisions should be guided by proper mathematical analysis and evidence rather than assumptions. They therefore wished to study examination performance in order to improve academic standards, evaluate reliability of the staff punctuality arrangements, and assess whether the road commonly used by the school van was safe enough for regular transport activities.

The marks obtained by learners in a mock examination were grouped below;

Marks interval	Number of students
$0 < x \leq 15$	6
$15 < x \leq 30$	8
$30 < x \leq 35$	15
$35 < x \leq 40$	20
$40 < x \leq 55$	10
$55 < x \leq 65$	7
$65 < x \leq 75$	4

The committee wished the director of studies to estimate the median mark using a suitable statistical graph and also use a computational method to determine the mean mark and standard deviation. The committee will maintain the current teaching plan if the mean mark is at least 50; otherwise, weekly tests will be introduced.

The committee also studied the punctuality of a staff member who travels by either route A or route B. The chance that he uses route A is 0.25. If route A is used, the chance that he arrives late is 0.6, while for route B it is 0.3. The committee will keep the current staff travel arrangement if the chance that the staff member used route B, after arriving late, is less than 0.7; otherwise, a stricter punctuality plan will be introduced.

In addition, accident records on a road used by the school van showed that the monthly number of accidents is a rectangular distribution from 5 to 12 accidents. The committee wished to determine the expected number of accidents in a month and the chance of having more than 7 accidents. The school will continue using the

route for regular transport if this chance is less than 0.4; otherwise, an alternative route will be chosen.

Task:

On behalf of the committee interpret the information, help it to make justified decisions about academic support, staff punctuality and safety school transport route.

Item 3.

A beverage company Namanve is testing the reliability of some production and recruitment decisions before introducing a new factory line. The life time X , in years of a machine component is modeled by the density function below

$$f(x) = \begin{cases} \beta & ; 2 \leq x \leq 3 \\ \beta(x-2) & ; 3 \leq x \leq 4 \\ 0 & ; \text{otherwise} \end{cases}$$

Management only will buy a new component if both mean and the median time exceed 3 years but the standard deviation is less than 1.2. Otherwise, another make of the machine will be considered.

The marketing department is studying two independent customer choices; buying mango juice and buying passion fruit juice. The chances of buying both is $2/15$, while those of buying at least one type of juice are $3/5$. A flavor will be retained on the production line if its individual buying probability is at least 0.3, if not, it will be removed.

During recruitment exercise, each of the trainees performs 7 independent machine trials. From past records a correct start is twice as likely as an incorrect start. A trainee will proceed for further training if he/she makes exactly 5 correct starts.

Task:

Help the management to make informed decisions about the process of purchasing a new machine, flavor retention and to determine the qualification chances of a trainee to the next level.

Item 4.

A school workshop is being prepared for a science exhibition. A heavy demonstration machine of mass 18kg with a square base ABCD has to be moved from the store to the display area without damaging the tiled floor. The side AB of the square base is taken as the x-axis while the side BC is taken as the y-axis.

To test whether the machine can be moved safely by pushing along the sides of its square base, four students apply forces of 18N, 22N, 10N and 14N along AB, BC,

CD and DA respectively. The single force equivalent to the four forces will be approved as efficient only if its magnitude exceeds 10N.

The machine is then loaded onto a trolley of mass 8kg. To reduce the risk of the trolley front wheels jamming, the loaded trolley is pulled by a handle using a force of 120N inclined at 35° above the horizontal. On the rough workshop floor, its speed increases from rest to 4.8ms^{-1} in 4s. This method will be allowed only if the coefficient of friction is not greater than 0.5, since higher values would indicate too much rubbing and possible damage to the floor.

For better control, the teacher considers another method. The 18kg machine is placed on a trolley of mass 12kg, while another trolley of 8kg carries 10kg box of display material. The two loaded trolleys are connected by a light inextensible rope and move along a smooth corridor floor. The trolley carrying the machine is placed in front and is pulled by a horizontal force of 75N. As it moves forward, it pulls the rear trolley carrying the box of display material through the connecting rope. This method can be considered efficient if the accelerations does not exceed 2.8ms^{-2} , to avoid sudden movement of the machine.

Task:

As a student of mathematics, interpret the situation, choose suitable methods and use your results to judge the safer approach of moving the loaded machine.

Item 5.

At 12 noon, a traffic officer was monitoring two vehicles near a busy junction. The police post was taken as the origin. Vehicle A was a school van and vehicle B was a delivery truck. Their positions and velocities were recorded as at 12 noon. The position vectors and velocities of the vehicles were recorded as follows.

Vehicle	Position vector	Velocity
A	$(5\mathbf{i} + 2\mathbf{j}) \text{ km}$	$(15\mathbf{i} + 10\mathbf{j}) \text{ kmh}^{-1}$
B	$(7\mathbf{i} + 7\mathbf{j}) \text{ km}$	$(9\mathbf{i} - 5\mathbf{j}) \text{ kmh}^{-1}$

The officer wanted to know whether the two vehicles would reach the same point if they continued moving with their velocities. The officer wanted to know the time and possible meeting point so that he could direct the help group to the correct place.

Later, vehicle broke down near the junction and had to be towed away from the road. A police vehicle of mass 1800kg towed the damaged vehicle which was of 1200kg. The police vehicle used an extensible rope along a rough horizontal road. The police vehicle applied a driving force of 6000N. The damaged vehicle experienced friction of coefficient 0.2, while the police vehicle experienced a resistance of 800N.

The towing method would work if the motion remained controlled and the rope not over strained. This would be achieved only if the acceleration was less than 2ms^{-2} , and the tension did not exceed 3500N. Otherwise the police officer had to call a break down.

Task:

As a student of mathematics, analyze the situation and advise on where help is needed and before what time. Also advise on whether to call a break down or not.

UGANDA TEACHERS

Item 1

A certain distribution company uses trucks to carry its luggage from Kampala to Busia. The company introduced a module to monitor the charges in relation to weights, speed and distance covered and fuel consumption by the vehicle.

The cost of fuel (y in shillings) for distances (x in kilometers) is as shown in the table below.

Distance, $x(\text{km})$	10	20	30	40
Cost, $y(\text{shs})$	2800	3600	4400	5200

The manager will hire another driver if the cost of covering 45km exceeds shs. 6000 but if the driver spent shs. 4000, on fuel then the minimum distance to be covered should be at most 30km or else he/she will lose the job.

The route taken by the truck is described by the function $f(x) = x^3 - 5x + 1$, and at every check point, $f(x) = 0$. Unfortunately, the company did not insert this module into their system, yet the only tool left is graph and the driver is confused where exactly the vehicle will stop for police checkpoint, and failure to stop at the right spot, the vehicle will be impounded. The driver is required to be careful only in the first 4 kilometers of the journey since it contains the deadliest checkpoints. His friend is a police man who works at one of the checkpoints between 2km and 3km from the company premises and told the driver to consult their technicians at the main station to iterate the graphical value until appropriate numerical distance is obtained, if not the company should be ready to suffer the loss.

Task.

As a student of mathematics;

- Guide the manager on the values he will use in order to hire or maintain the driver.
- Help the company on how they can dodge the loss.

Item 2

One of the prominent Schools in Uganda has organized a visitation day, but for the previous years, parents always complain of traffic jam along the way to the school, since many parents will be moving on that day. The school is planning to meet the parents of candidates but it requires the modal, average and median time such that majority of the parents can attend the meeting.

The table below shows the time taken by parents to travel to school during visitation day

Time (minutes)	<5	<10	<15	<20	<25	<30	<35	<40	<45
Number of parents	28	45	78	143	280	340	375	395	400

The meeting will be delayed if the interquartile range is less than 10 minutes.

The school is willing to give T-shirts to parents who will arrive in less than 18 minutes, on condition that majority arrive in less than 23 minutes.

On this very day, some parents used personal car (C) while others used buses (B) and taxis (T), with the proportions 40%, 50% and 10% respectively. For those who used personal car, 9% arrived late, and those who used buses, 6% came late and 20% of those who boarded taxi arrived at school late.

Task

As a student of mathematics,

- Help the school in planning such that they can have a wonderful visitation day.
- Determine the proportion that the vehicle used is a bus given that it arrives late.

Item 3

The director of studies (DOS) in a certain school is complaining why students are performing well in chemistry than in mathematics. He was trying to compare marks of students in both subjects and the table below shows the marks obtained by 10 students.

Mathematics (x)	10	15	20	15	30	35	40	45	50	60
Chemistry (y)	15	20	35	40	35	50	55	40	55	60

More teachers will be recruited if there is negative correlation between the performance in the above subjects. And extra lessons shall be created if the correlation is insignificant at 5%. The DOS is wondering what could be the marks obtained in chemistry if a student scores 25 in mathematics.

During printing of report cards, the secretary occasionally makes mistakes. In a batch of 20 cards, 5 are found to have mistake. A sample of 3 batches were at random and examined, the DOS wishes to know the expected number of mistakes and standard deviation made by the secretary.

Task

As a student of mathematics;

Help the Director of Studies clarify on the disparities of marks in the two subjects and the mistakes in order to make an informed decision.

Item 4

Peter is a very concerned parent, one day, he bought two toy cars, one of mass 1kg and the other of mass 4kg. To his surprise, he found his 5-year-old boy trying to combine the two toys but the strings keep breaking and sometimes the heavier toy would fall on his feet. This always makes the little boy to cry a lot while playing.

Peter decided to get for him a rough plane and tried to arrange the set up as follows;

For safety of the child, he placed the 1kg mass toy on a 4m long rough plane which has a coefficient of friction 0.25, a smooth fixed pulley was placed at the edge of the plane, light inextensible string was connected to the 1kg mass and allowed to pass over the pulley and a 4kg mass which hangs freely at 2.5m above the horizontal ground. Since he wanted the boy to enjoy the movement of the toys, he tilted the plane such that the angle of inclination θ with the horizontal is $\sin^{-1}(3/5)$.

And the system is to be released from rest. In order for peter's son not to cry again, the following conditions must be met,

Condition 1: Acceleration of the system must be less than 7ms^{-2}

Condition 2: The tension in the string must not exceed 15N

Condition 3: The maximum kinetic energy with which the 4kg mass hits the ground must be less than 70J.

Task

As a mathematics student,

Determine whether the setup peter made will stop his son from crying and justify your responses.

Item 5

Pirates always smuggle people's goods in Oceans and seas. Due to that, shipmen and fishermen always try to avoid the paths which they like.

One business man always imports his products from India to Mombasa via Indian Ocean. He uses a global positioning system (GPS) to track the path, speed and position of the ships carrying his goods. One day, when he was checking the progress of his goods, he observed that, at 11:30am a pirate ship is at a place with

position vectors $(-6\mathbf{i} + 12\mathbf{j})$ km and is moving with velocity vector $(16\mathbf{i} - 4\mathbf{j})$ km/h. At 12:00 noon the ship carrying his goods is at a place with position vectors $(12\mathbf{i} - 15\mathbf{j})$ km and is moving with velocity vector $(8\mathbf{i} + 16\mathbf{j})$ km/h.

Both ships' velocities are constant and the business man is worried that the pirate might destroy his goods if they meet. However, he sent a rescue team which must reach their ship before 1pm.

When the rescue team saw the pirates' ship, one of the soldiers in the rescue ship fired a bullet with velocity of 320ms^{-1} at an angle of 30° to the horizontal. But the bullet must pass over a vertical cliff in order to hit the right target and the bullet must be shot when the ships are less than 10000m from each other.

Task

As a student of mathematics;

Determine whether the business man's goods will reach Mombasa safely or not.

Justify your response.

PEA**ITEM. 1**

In the process of construction of a water reservoir, a team of surveyors measured the depth profile of land at equal intervals of 10 meters across the proposed site and obtained the following systematic measurements in meters; 2.4, 3.1, 3.8, 4.2, 4.0, 3.5 and 2.8. Engineers want to estimate the cross-sectional area of the land before excavation begins.

The engineer further explains that the amount of water expected to be pumped into the reservoir depends on solving the equation $x^3 - 4x - 10 = 0$, where x represents the operating efficiency factor of the pump. A preliminary estimate suggests that the value of x lies between 2 and 3.

Since no exact algebraic solution is readily available.

Before final construction begins, the supervisor had to measure the planned rectangular concrete base of the reservoir and record the length as $30\text{m} \pm 0.1\text{m}$ and width as $30\text{m} \pm 0.1\text{m}$. The project committee was worried that inaccurate measurements may affect the construction budget and amount of materials required.

Tasks:

As a mathematics student, if given a chance to analytically advise on the above situation, how would you come up with;

- The appropriate numerical method to find the approximate area of the land available for excavation.
- A suitable iterative method to obtain the solution to 3 decimal places
- The range within which the exact area lies and the percentage error in approximating the area

ITEM. 2

In a secondary school, the issuance of school uniforms for senior ones depends on their heights. As they proceed in the successive classes their uniform sizes keep changing and new uniforms need to be issued again. It is the school policy that only when the initial mean height is at least 125cm and the inter-quartile range of the heights not exceeding 16cm is when new uniforms will be issued. The heights are as follows;

Height(cm)	< 100	< 110	< 120	< 130	< 140	< 150	< 160	< 170
Cumulative frequency	0	27	85	215	320	370	395	400

Sometimes the head teacher prefers storing the heights of new senior one students in a graphical format to easily establish the most common height initially on admission to guide on the amount of material to purchase as students progress in the next classes. Unfortunately he is not a mathematician.

On the other hand, when a student completes S.4 and joins S.5 at the same school, free school uniform sets will be given as a reward under a condition that the relationship between the first 7 best performed subjects in MOCK and UCE is at least high. A student obtained the following grades;

MOCK	A	B	A	D	E	D	B	E
UCE	C	B	C	E	E	C	A	D

Tasks;

As a mathematics student, if consulted, advise the school to establish;

- Whether new uniforms will or will not be issued.
- How the head teacher will store the data and also highlight for him the most likely height to enable the change uniform.
- In your own view, do you think a set of new uniforms will be given to that student joining S.5 with the scores provided? (Justify your responses backed by calculations)

ITEM. 3

In Uganda, the cases of road accidents are increasing because of wreck less crossing and over speeding of pedestrians and drivers respectively. Because of this, traffic lights have been mounted on most busy roads. A case in point is the Kampala northern bypass whereby at a given point the speeds of the cars are normally distributed. Police found out that 95% cars travelled at a speed less than 85kmh^{-1} and 10% travelled at a speed less than 55kmh^{-1} .

On a certain day, an operation by police was carried out on 5 cars to find out how often these accidents occur. They came to realize that the chance of an accident to occur at this point was twice that of an accident not to occur. The O.C traffic instructed that if the chance that at least 3 accidents occurring in a week exceed 0.49, new road humps will be constructed unless otherwise.

In the process, many cars were impounded and each car had its issues depending on the

mechanical conditions found on it. These conditions followed a continuous random variable that was uniformly distributed in the interval a to b. the mechanical conditions for car A had a lower quartile of 5 and an upper quartile of 9. It is a policy by the police to imprison a driver if the mechanical issues of the car lie in the interval between 2 and 12.

Tasks

As a senior six student if consulted, come up with a clear report on the following backed by calculations;

- The average speed and proportion of cars that exceeded 50kmh^{-1}
- Whether new road humps will be constructed or not.
- Whether it was possible for the driver of car A to be imprisoned or not.

ITEM. 4

A trader in Kasese who runs a dairy farm find challenges in delivering the milk uphill to where his dairy shop is located. Since the farm is located down at the foothill of Rwenzori Mountain, he was advised to buy a container and fasten 4 ropes on it to enable 4 men to lift it to the dairy uphill. The ropes were fastened in such a way that each was in the direction $N60^\circ E$, 320° , $S20^\circ E$ and 210° . The men could provide forces in the ropes equivalent to 30N, 20N, 70N and 60N each respectively.

In the long run, this seemed costly and time wasting. He was advised to instead use a pulley placed at the top of the hill driven by an engine. This made him buy a larger tank of mass 20kg to carry milk weighing 100kg and a cable that would pass over the smooth fixed pulley that would connect the tank to another mass of 10kg

that could act as a counter weight. The tank containing milk will be moving up the slope of 3 in 5 that is rough with the coefficient of friction 0.4. The counter weight will hang freely vertically downwards on the other side of the hill to control downward motion for refill.

The pulley should be strong enough to withstand the force imposed on it by the cable for the combined masses uphill and also wishes that when the engine is switched off, the empty tank should be made to slide down with an acceleration of 1.896ms^{-2} under influence of a force PN acting downwards parallel to the plane.

Task;

As a mechanics student if consulted, use clear calculations to come up with proper advise on;

- A single force and its direction that is equivalent to the system of forces imposed on the container by the four men.
- Whether buying a pulley that could withstand a total net force of 180N for the combined mass uphill would work well for him.
- The magnitude of force P required in achieving the required acceleration. How safe can this system be kept working efficiently? (Give scientific ways).

ITEM. 5

A game ranger at Murchison falls national park spots a buffalo running along a straight line towards river Nile. The ranger observes it at post A, at the moment of observation ($t = 0$), the buffalo is at point B, 120m east of post A and it is running due north at a constant speed of 20ms^{-1} relative to the ground.

Simultaneously, a rescue drone is launched from the post A to move as close as possible to the buffalo's path. The drone flies at a constant speed of 10ms^{-1} relative to the ground maintaining a fixed direction.

At the instant when the drone is $60\sqrt{3}\text{m}$ horizontally away from the buffalo, it projects a tranquilizer dart horizontally towards the buffalo. The dart is released from a height 80m above the ground with an initial speed ums^{-1} . To avoid injuring the buffalo, the speed with which the dart hits the buffalo should not exceed 47ms^{-1} . When the buffalo was hit, it got shocked and it jumped upwards a distance of 0.45m high. The game ranger wishes to get analysis of the above information mathematically for better reporting.

Tasks:

As a dynamics student, come up with necessary calculation to help the ranger establish;

- The closest distance reached by the drone and the time it took to be achieved.

b. If the buffalo was injured or not.

c. The initial velocity with which the buffalo jumped.

NAMIREMBE

Item 1

A group of Senior Six students at a renewable energy innovation camp in Kampala are designing a solar-powered water purification system for a rural community.

During calibration of the electronic controller, the students discover that one of the sensor equations governing the voltage output of the controller is represented by: $3x^3 - x - 5 = 0$. The engineering software indicates that instability occurs within a narrow operating interval between $x = -1.4$ and $x = -1.2$. To prevent damage to the purifier, the students are required to investigate the behaviour of the controller within this interval and predict the critical operating point as accurately as possible before testing the device. After obtaining an initial estimate from the digital simulator by interpolation, they refine the value using an iterative correction model based on Newton Raphson embedded in the controller's software until a critical operating value is achieved, correct to two decimal places.

As part of the same project, the students are also studying the energy variation in the filtration unit. The accumulated energy transfer over the interval $1 \leq x \leq 2$ is modelled by: $\int_1^2 (x - 1) \ln x \, dx$

Because the school computer laboratory has limited computational power, the students first estimate the quantity numerically using six equal sections, then later compare their estimate with the exact theoretical value obtained analytically. Finally, they evaluate how reliable their approximation method was by determining the greatest possible discrepancy between the two results. Their approximation is considered reliable only if the magnitude of the discrepancy between the two results is less than or equal to 0.003.

Task

- Determine the critical operating value of the purifier.
- Determine whether the students' approximation of the accumulated energy transfer is reliable. State how the reliability of the approximation can be improved.

Item 2

The administration of a large girls' secondary school is concerned about the nutritional wellbeing of finalists preparing for national examinations. A health

survey is conducted to study the distribution of body masses among the candidates.

The cumulative results collected by the school nurse are summarized below:

Mass (Kg)	<45	<50	<60	<75	<80	<85	<90	<100	<105	<110
Cumulative frequency	0	9	25	46	63	77	82	89	93	94

The head teacher requests the mathematics department to prepare a statistical report that can guide the school feeding programme for the following academic year. In preparing the report, the learners are expected to organize the information graphically in a form suitable for identifying the most common body mass among the candidates. The school dietician then uses the findings to estimate the average body mass of the students together with a measure showing how widely the masses vary from the average.

The completed report is intended to help the school determine whether the feeding programme is producing balanced nutritional outcomes among the finalists. The feeding programme is considered to be producing balanced nutritional outcomes if the most common body mass among the candidates and the average mass of the finalists lies between 60 Kg – 70 Kg and the standard deviation of mass does not exceed 10Kg.

Task

Make a report to help the school administration determine whether the feeding programme is producing a balanced nutritional outcome among the finalists based on the statistical data.

Item 3

A road safety organization in Uganda conducted a study involving 30 drivers to investigate the relationship between road accidents and the use of corrective glasses. Out of all the drivers interviewed, 9 had previously been involved in road accidents. Among those accident victims, 5 were found to wear glasses. Further investigations revealed that among drivers who had never experienced an accident, the probability of wearing glasses was $\frac{1}{3}$. The researchers intend to use the information to estimate the likelihood that a randomly selected driver from the group wears glasses. He also intends to determine whether wearing glasses appears common among accident victims and if this chance is less than 45%, the researchers conclude that wearing glasses does not appear common among accident victims.

In a related university health study, researchers analyzing student wellness records discover that the heights of students follow a normal distribution. It is known that only 1% of the students are taller than 200 cm, while 76% have heights between 165 cm and 200 cm. The university medical team wishes to establish the average

height and standard deviation of student heights so as to design lecture-room furniture appropriate for most learners. They also need to estimate the percentage of students whose heights fall below 158 cm in order to identify students who may require specially adjusted facilities.

Task

Help the researchers in achieving the objectives of their investigations

Item 4

During a mountain rescue training exercise, engineers design a transport mechanism that moves medical supplies between two rescue stations built on two smooth mountain slopes intersecting at right angles. One slope rises at 30° to the horizontal while the other rises at 60° . A 2 kg emergency package is placed on one slope while a 4 kg package is positioned on the other. The two packages are connected by a light inextensible cable passing over a smooth pulley fixed at the intersection of the slopes. When the system is released from rest, the rescue engineers monitor the motion in order to determine whether the transport system can safely move the supplies without overstretching the cable. To safely move the supplies, the acceleration of the system must be about 4 ms^{-2} and force developed in the connecting cables should not exceed 18N. They therefore investigate both the motion of the packages and the force developed in the connecting cable.

Later, during field testing under rough weather conditions, the slope carrying the 4 kg package develops a small resistive force due to ice accumulation. The engineers repeat the investigation to determine how the additional resistance alters the motion of the system, given that the coefficient of friction between the surface and the 4Kg supply was computed to be 0.25. The system is recommended for use if the change in the motion of the system is less than 1 ms^{-2} as compared to the previous value.

In another stage of the rescue exercise, a 50 kg communication device is suspended between two mountain posts by two light strings of lengths 9 m and 12 m attached to points 15 m apart. The two supporting cables are likely to break if their tensions exceed 400N and 300N respectively.

Task

- Help the engineers to determine whether the transport mechanism safely moves the supplies and also determine whether the system is recommended or not.
- Help the rescue team determine if the supporting cables can withstand the load safely.

Item 5

A transport company operating in Uganda is training pilots and marine navigators to handle motion under varying wind and current conditions. During one simulation, a car fitted with weather sensors travels at 20 ms^{-1} on a bearing of 040° . At the same time, the wind blows from a bearing of 330° at 10 ms^{-1} . The trainee engineers are required to determine how the wind would actually be experienced by the moving driver so that vehicle stability systems can be adjusted correctly.

In a separate navigation exercise beginning at 8:00 a.m., two patrol boats A and B are initially 5.2 km apart, with A due west of B. Boat B travels steadily in the direction $N20^\circ W$ at 13 kmh^{-1} , while boat A moves due north at 12 kmh^{-1} . The marine trainees are expected to analyze the motion of one boat relative to the other in order to predict the navigation path observed from boat A. Using this information, they further determine how far apart the boats will be at 8:30 a.m. so as to avoid collision during the exercise.

Meanwhile, at a nearby sports science laboratory, students investigate projectile motion using a launching device. In one experiment, a particle is projected at an angle of 30° with speed 21 ms^{-1} from a point situated 5 m above horizontal ground. The students analyze the motion to predict how far from the launch point the particle will strike the ground.

In another experiment, a boy throws a ball with speed 40 ms^{-1} at an angle of elevation α . During analysis of the flight data, the researchers discover that the possible times of flight corresponding to a horizontal range of 80 m satisfy the equation: $T^4 - 64T^2 + 256 = 0$. (Hint: Take $g = 10 \text{ ms}^{-2}$)

Task

- Help the pilots and marine trainees to determine the solutions to the tasks
- Help the learners to predict how far from the launch point the particle will strike the ground and to justify mathematically whether the observed flight times satisfy the above relationship.

MUKONO EXAMINATION COUNCIL

ITEM 1.

Kato runs a delivery service business around Kampala city centre. The total cost (c) of delivering a package of weight (w) to a distance (d) is modelled by the formula $c = bw + d/r$, where b is the charge for the package delivered per kilometer and r is the distance adjustment rate.

For one customer, Kato is asked to deliver a package of items from the city centre to a certain destination. The weight of the package and the distance to the destination was estimated as 18.5kg and 24km with possible errors of 0.3kg and 1.5km respectively.

Kato charges UGX.2,500 with a margin of error 4% and uses a distance adjustment rate of 2 which tends to vary by 5% depending on the road conditions.

In order to inform the client of how much is needed to deliver the package, Kato needs to know the range within which the total cost to be incurred by this client is expected to lie.

A certain regular client has used Kato's delivery services on three past occasions. He was charged UGX.32,000 for a distance of 10km, UGX.45,000 for a distance of 16km and UGX.38,000 for a distance of 12km from the city centre. The client now wants Kato to deliver a package to a place 17.5km from the city centre and he has prepared UGX.47,500 for this delivery and he wants to know whether the money will be enough or not.

Basing on his previous experience and expertise in the delivery business, Kato found out that the delivery condition score y for a package can be obtained using the two models $y = 2x$ and $y = 3 \cos \frac{1}{2}x$, where x represents the expected delivery time in hours.

The time at which the two models give exactly the same delivery condition score between 1 and 2 is used as the initial estimate of the expected delivery time for a package and using a suitable iterative formula, the initial estimate can be improved until the maximum possible error in the estimate is 0.0005. Kato promised a certain customer that the package will be delivered within 1.5 hours and he must decide whether to start on the journey immediately or first notify the customer that delivery will delay.

Task

As a mathematician, help Kato find the required range, determine whether the money prepared by the regular client will be enough to cover the total cost for delivering the package and decide whether to start the journey immediately or notify the customer that the delivery will delay.

ITEM 2.

At a certain school, the games master Mr. Kasadha is preparing students for a district athletics and games competition. He measured the weights in kilograms of

40 students that are set to participate in the competitions and their weights were recorded as follows:

Weight (kg)	30 – < 35	35 – < 40	40 – < 55	55 – < 60	60 – < 65
Frequency	8	5	12	9	6

At the same time, Mr. Kasadha records a random sample of 100 race times x in seconds from students who were training for a given race. From the sample results, it was observed that $\Sigma x = 380$ and $\Sigma x^2 = 1840$ where x represents the race times recorded. According to the training standard requirements, all participants whose weight is heavier than the average weight need special fitness attention and the acceptable range of weights for the participants is the middle 70% of the weight distribution of the participants. Mr. Kasadha does not know the specific facts about the participants in line with the training standard requirements.

Mr. Kasadha has to assess whether the sample results recorded on the race times of the students training are precise enough before planning for further training sessions and to judge how precise the recorded results are, the width of the 90.8% confidence interval for the mean race times of all students who were training for the race must be at most 0.5. He wants to plan for extra training sessions to prepare for the district athletics and games competition.

From the past training records, the number of extra training sessions needed by a given student is represented by the random variable Y where $Y = 1, 2, 3$ or 4 and the probability that a student needs y extra training sessions is given by:

$$P(Y = y) = \begin{cases} \frac{1}{60}(ay + b), & y = 1, 2, 3, 4. \\ 0, & \text{otherwise.} \end{cases} \quad \text{where } a \text{ and } b \text{ are constants.}$$

It is also known that $F(3) = \frac{13}{20}$. Mr. Kasadha wishes to know the expected number of extra training sessions needed to prepare the students and the number of students who need more than one extra training session.

Task

Help Mr. Kasadha find the specific facts about the participants in line with the training standard requirements, assess the preciseness of the sample results, determine the expected number of extra training sessions and the number of students who need more than one extra training sessions.

ITEM 4.

A mechanical engineer visited a vocational training workshop to test three mechanics demonstrations about force systems, friction and pulleys.

On a horizontal table, a particle was acted on by forces of magnitudes of 30N, 50N, 60N, 100N and 20N at the same time acting in the directions 060° , 090° , 120° , 210° and 330° respectively. The engineer needed to know the net effect of the forces acting on the particle and its direction.

In another section, a 4kg block was pulled across a rough horizontal plane using a string inclined at an angle of 20° above the horizontal. The tension in the string was 25N and the block accelerated at 4 ms^{-2} . The engineer noticed that the nature of the horizontal surface was affecting motion of the block and wanted to determine the coefficient of friction between the block and the surface.

In the pulley section, a light inextensible string attached to the ceiling, passed under a smooth movable pulley of mass 3kg, then over a smooth light pulley fixed at the top of the inclined plane and was finally attached to a body of mass m kg resting on a rough inclined plane set at 30° to the horizontal. The coefficient of friction between the body and the plane was 0.25 and when the system was released from rest, the m kg mass covered a distance of 2m in 4 seconds along the plane while the movable pulley moved vertically. The engineer wanted to decide whether the unknown mass was light enough to be used in the demonstration if the maximum allowed mass on the inclined plane was supposed to be 8kg.

Task

As a mathematician, use the above information to determine the net effect of the forces acting on the particle and its direction, the frictional force and co-efficient of friction and decide whether the body on the inclined plane is safe for the demonstration.

ITEM 5.

A medical emergency has broken out in Northern Uganda and a humanitarian organization based in Gulu is coordinating the urgent delivery of vaccines and medical supplies to a remote health centre in Kitgum.

At the health centre, a nurse is stationed at a window on the upper floor of the hospital building waiting to receive a small emergency package. A health worker stands on the ground 10 m from the hospital building and throws the package

from a height of 1.0 m above the ground with a speed of 11.5 ms^{-1} at an angle of 60° to the above the horizontal. The lower edge of the window is 3.2 m above the ground while the upper edge of the window is 4.5 m above the ground. The nurse needs to know whether the package will pass through the window or strike the wall of the hospital building.

At the same time, a medical aeroplane takes off from airstrip A in Gulu and must fly directly to airstrip B in Kitgum which is 500 km due south of airstrip A. A steady wind of 100 km/h blows from the east while the aeroplane can fly at 400 km/h in still air. The pilot does not know the right course to set so that aeroplane moves directly to airstrip B.

At exactly 1500hours, while the aeroplane is enroute, air traffic controllers detect a rescue helicopter 80km on a bearing of 290° from the aeroplane. The helicopter immediately flies on a bearing of $N30^\circ E$ at a speed of 15km/h. At the same instant, the aeroplane travels at 12km/h on a bearing of $N300^\circ W$. The control tower operator must report to her supervisor on the possible closest distance between the two aircrafts and the exact time when this occurs.

Task

As a mathematician, help the nurse to know if the package will pass through the window or strike the wall of the hospital building and the its speed when it reaches the building, set the right course the pilot needs to fly the plane directly to airstrip B and determine the facts the control tower operator needs to report to her supervisor about the motion of the two aircrafts.