Surname	StemUp Model Solution	Centre Number	Candidate Number
First name(s)			2

GCE A LEVEL

S25-1300U40-1

1300U40-1

THURSDAY, 12 JUNE 2025 – AFTERNOON

MATHEMATICS – A2 unit 4
APPLIED MATHEMATICS B

1 hour 45 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1	**4**	
2	**12**	
3	**8**	
4	**16**	
5	**7**	
6	**9**	
7	**8**	
8	**7**	
9	**9**	
Total	**80**	

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ADDITIONAL MATERIALS

In addition to this examination paper, you will need:

- a Formula Booklet;
- a calculator;
- statistical tables (RND/WJEC Publications).

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Take g as $9{\cdot}8\,\text{ms}^{-2}$.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The maximum mark for this paper is 80.

The number of marks is given in brackets at the end of each question or part-question.

Sufficient working must be shown to demonstrate the **mathematical** method employed.

Answers without working may not gain full credit.

Unless the degree of accuracy is stated in the question, answers should be rounded appropriately.

You are reminded of the necessity for good English and orderly presentation in your answers.

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Reminder: Sufficient working must be shown to demonstrate the **mathematical** method employed.

Section A: Statistics

1. A continuous random variable X is uniformly distributed over the interval $[c, d]$. The mean and variance of X are 7·5 and 3 respectively. Find the values of c and d. [4]

$E(X) = \frac{c+d}{2} = 7.5 \Rightarrow c + d = 15$

$Var(X) = \frac{(d-c)^2}{12} = 3 \Rightarrow (d-c)^2 = 36$

$d - c = 6$ (since $d > c$)

Adding: $2d = 21 \Rightarrow d = 10.5$

$c = 15 - 10.5 = 4.5$

$\therefore c = 4.5, \quad d = 10.5$

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2. Selina is sitting two multiple-choice tests.

(a) For each question in the first test, she classifies herself as 'very confident', 'confident' or 'not confident' with probabilities 0·2, 0·5 and 0·3 respectively.

If she is 'very confident', the probability of getting a correct answer is 0·9.

If she is 'confident', the probability of getting a correct answer is 0·7.

If she is 'not confident', the probability of getting a correct answer is 0·25.

(i) Calculate the probability that she will get the correct answer to a randomly selected question. [3]

(ii) Given that Selina gets a correct answer to a randomly selected question, calculate the probability that she was 'not confident'. [2]

(i) $P(\text{correct}) = 0.2 \times 0.9 + 0.5 \times 0.7 + 0.3 \times 0.25$

$= 0.18 + 0.35 + 0.075$

$= 0.605$

(ii) $P(N \mid C) = \frac{P(N \cap C)}{P(C)} = \frac{0.3 \times 0.25}{0.605}$

$= \frac{0.075}{0.605} = \frac{15}{121} = 0.12396\ldots$

$= 0.124$ (3 s.f.)

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(b) The second test has 10 questions, each with 4 choices from which to select the answer. The probability that Selina knows the answer to a question is p, independently of any other question. If she knows the answer, she will select it. Otherwise, she will select one of the four choices at random, with equal probability for each.

(i) Calculate the smallest value of p that will give a probability of at least 0·7 of Selina getting the correct answer to a randomly selected question. [4]

(ii) At least 8 out of the 10 questions must be answered correctly to pass the test. Assuming that the probability of Selina getting the correct answer to a randomly selected question is 0·7, calculate the probability that she will pass the test. [3]

(i) $P(\text{correct}) = p \times 1 + (1 - p) \times \frac{1}{4}$

$= p + \frac{1}{4} - \frac{p}{4} = \frac{1 + 3p}{4}$

Need $\frac{1 + 3p}{4} \geq 0.7$

$1 + 3p \geq 2.8 \quad \Rightarrow \quad 3p \geq 1.8 \quad \Rightarrow \quad p \geq 0.6$

Smallest value of $p = 0.6$

(ii) Let X be the number of correct answers.

$X \sim B(10, 0.7)$

$P(\text{pass}) = P(X \geq 8) = 1 - P(X \leq 7)$

$= 1 - 0.6172172...$

$= 0.3828$ (4 d.p.)

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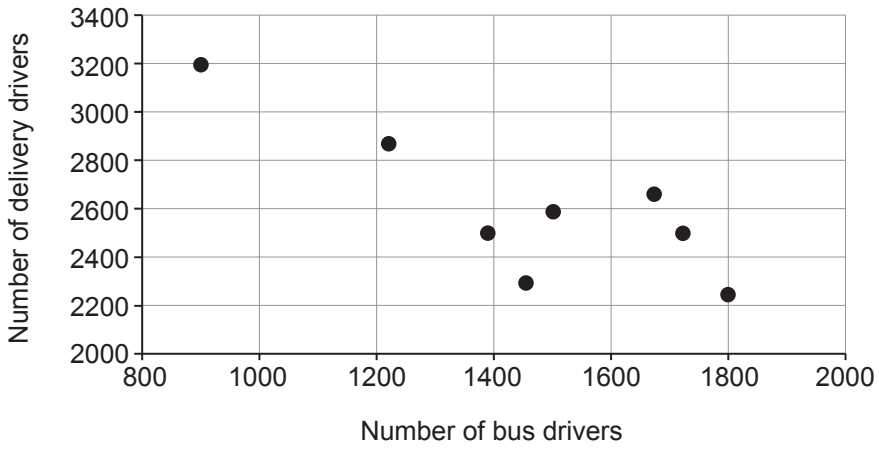
3. A city councillor is investigating the decline in the number of bus drivers in the city. During her research, she finds an article claiming that delivery companies are actively recruiting bus drivers to work for them.

She collects data on the number of bus drivers and the number of delivery drivers from 8 randomly selected cities of a similar size to her city. She calculates the correlation coefficient in order to carry out a hypothesis test.

(a) Explain why a one-tailed test could be appropriate. [1]

She expects that as the number of delivery drivers increases, the number of bus drivers decreases (delivery companies are recruiting bus drivers), so she is specifically looking for negative correlation, not just any correlation.

Number of delivery drivers versus Number of bus drivers



The product moment correlation coefficient for the data is –0·8206.

(b) Carry out a one-tailed significance test at the 5% significance level. [5]

H_0: $\rho = 0$ H_1: $\rho < 0$

(ρ = population correlation coefficient)

Test statistic: $r = -0.8206$

Critical value ($n = 8$, 5%, one-tailed) = -0.6215

Since $-0.8206 < -0.6215$ ($|-0.8206| > 0.6215$),

the result is significant, so there is sufficient evidence to reject H_0.

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There is evidence at the 5% level to suggest that there is negative correlation between the number of delivery drivers and the number of bus drivers in such cities.

(c) (i) Suggest a reason why the city councillor might conclude that there is a causal link between the number of delivery drivers and the number of bus drivers.

(ii) What can the city councillor conclude about the recruitment of bus drivers by delivery companies over time? [2]

(i) Being a delivery driver may offer better pay, hours or working conditions than being a bus driver, so bus drivers may leave to become delivery drivers, causing the number of bus drivers to fall.

(ii) She cannot conclude anything about recruitment over time. Her data are only a snapshot of 8 cities at one point in time, so she has no data showing changes over time.

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4. Collectable football cards come in packs. The masses, in grams, of the packs are normally distributed with mean 28·3 and standard deviation 0·3.

(a) Calculate the probability that a randomly selected pack will have a mass less than 28 g. [2]

$X \sim N(28.3, 0.3^2)$

$P(X < 28) = P\left(z < \frac{28 - 28.3}{0.3}\right) = P(z < -1)$

$= 0.158655\ldots = 0.1587$

(b) Packs that have a mass more than 28·8 g are classed as 'heavy'. Andrei buys a randomly selected 'heavy' pack of cards.

Calculate the probability that this pack has a mass more than 29·1 g. [6]

$P(\text{heavy}) = P(X > 28.8) = P(z > 1.6667) = 0.0477903\ldots$

$P(X > 29.1) = P(z > 2.6667) = 0.0038304\ldots$

$P(X > 29.1 \mid \text{heavy}) = \frac{P(X > 29.1 \cap X > 28.8)}{P(X > 28.8)}$

$= \frac{P(X > 29.1)}{P(X > 28.8)}$

$= \frac{0.0038304\ldots}{0.0477903\ldots}$

$= 0.080149\ldots$

$= 0.0801$ (3 s.f.)

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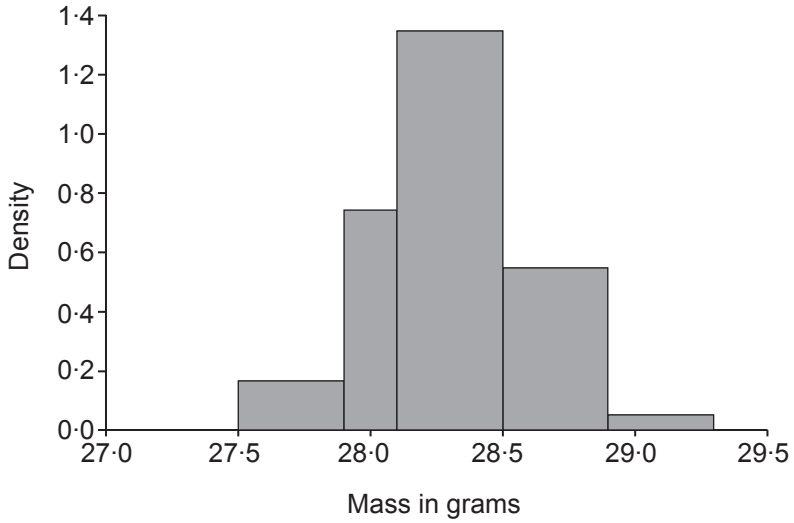
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(c) Graham has a large number of packs of cards and wants to sell some to Andrei. Graham claims that the packs that he has to sell are, on average, heavier than 28·3 g.

Graham draws a histogram of the masses of his packs of cards, shown below.

Mass of packs of cards



Andrei randomly selects 10 packs from Graham to test Graham's claim. He finds that the total mass is 285 g.

(i) What feature of the histogram supports conducting a significance test on the sample mean using Andrei's data? [1]

(ii) Given that the population standard deviation of the masses of Graham's packs is 0·32 g, test Graham's claim at the 3% level of significance. [7]

(i) The histogram is roughly symmetrical and bell-shaped, so the masses can be modelled by a normal distribution.

(ii) Let μ be the mean mass, in grams, of Graham's packs.

H_0: $\mu = 28.3$ H_1: $\mu > 28.3$

Under H_0, $\bar{X} \sim N(28.3, \frac{0.32^2}{10})$

$\bar{x} = \frac{285}{10} = 28.5$

p-value $= P(\bar{X} > 28.5) = P(z > \frac{28.5 - 28.3}{0.32 \div \sqrt{10}})$

$= P(z > 1.9764...)$

$= 0.024053...$

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Since 0.02405 < 0.03, the result is significant at the 3% level,

so there is sufficient evidence to reject H_0.

There is sufficient evidence to suggest that the packs Graham has to sell are, on average, heavier than 28.3 g.

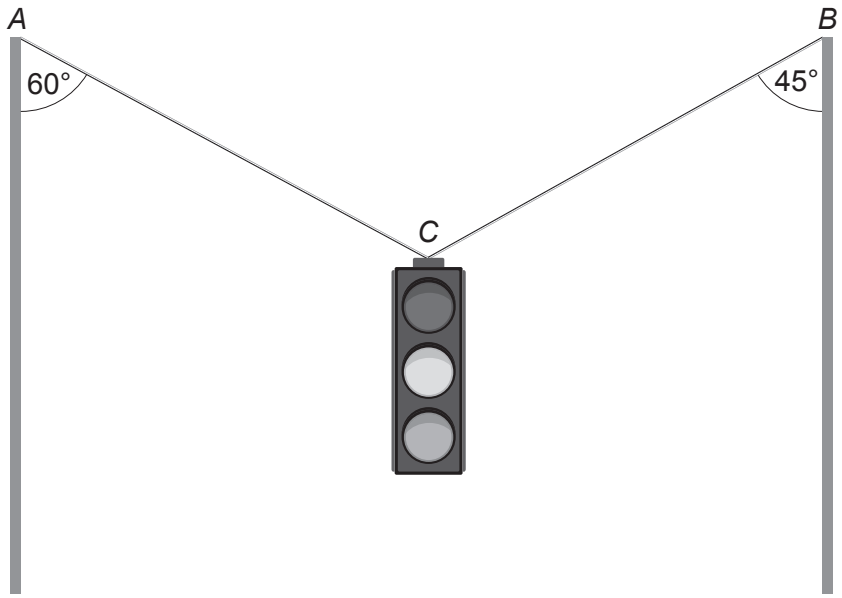
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Section B: Differential Equations and Mechanics

5. The diagram below shows a set of traffic lights suspended in equilibrium by means of two cables *AC* and *BC*, inclined at angles of 60° and 45° to the vertical respectively. The set of traffic lights has a mass of 25 kg and may be modelled as a single particle attached at *C*.



(a) Show that the tension in *AC* is approximately 179 N, and calculate the tension in *BC*. [6]

Let T_1 N = tension in AC and T_2 N = tension in BC.

Resolve horizontally (↔): $T_1 \sin 60° = T_2 \sin 45°$

$\Rightarrow T_2 = \frac{\sin 60°}{\sin 45°} T_1 = \frac{\sqrt{6}}{2} T_1$

Resolve vertically (↕): $T_1 \cos 60° + T_2 \cos 45° = 25g = 245$

$\frac{1}{2} T_1 + \frac{\sqrt{2}}{2} \times \frac{\sqrt{6}}{2} T_1 = 245$

$\frac{1}{2} T_1 + \frac{\sqrt{3}}{2} T_1 = 245$

$T_1 = \frac{490}{1+\sqrt{3}} = 245(\sqrt{3} - 1)$

$T_1 = 179.352... \approx 179$ N (as required)

$T_2 = \frac{\sqrt{6}}{2} \times 179.352... = 219.660...$

Tension in BC ≈ 220 N

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(b) State a modelling assumption that you have made in your solution. [1]

The cables are modelled as light strings (they have negligible mass).

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6. The diagram below shows a uniform rod AB, of length 3·8 m and weight 180 N. The rod is resting horizontally in equilibrium on two smooth supports at the points C and D, where $DB = 0{\cdot}8$ m and $CD = 1{\cdot}8$ m.



An object of weight W N is placed at A.

(a) Given that $W = 69$, find the magnitudes of the reaction at C and the reaction at D. [6]

$AC = 3.8 - 1.8 - 0.8 = 1.2$ m. Centre G is 1.9 m from A, so $CG = 0.7$ m

Moments about C:

$R_D \times 1.8 + 69 \times 1.2 = 180 \times 0.7$

$1.8R_D + 82.8 = 126$

$R_D = 24$ N

Resolve vertically: $R_C + R_D = 180 + 69 = 249$

$R_C = 249 - 24 = 225$ N

Reaction at C = 225 N, reaction at D = 24 N

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(b) Determine the greatest value of W for which the rod remains in equilibrium. [3]

For greatest W the rod is on the point of turning about C, so $R_D = 0$.

Moments about C: $W \times 1.2 = 180 \times 0.7$

$1.2W = 126$

Greatest $W = 105$

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7. A particle of mass 1·2 kg is moving in a straight line under the action of a variable force FN, where

$$F = \frac{30}{(t+2)^2}.$$

The speed of the particle at time t seconds is v ms^{-1}.
When $t = 0{\cdot}5$, the speed of the particle is 20 ms^{-1}.

(a) Find an expression for v in terms of t and hence write down the limiting value of v as t increases. [6]

N2L: $1.2a = \frac{30}{(t+2)^2} \Rightarrow \frac{dv}{dt} = \frac{25}{(t+2)^2}$

$\int dv = \int 25(t+2)^{-2}\,dt$

$v = -25(t+2)^{-1} + C = C - \frac{25}{t+2}$

When $t = 0.5$, $v = 20$: $20 = C - \frac{25}{2.5} = C - 10 \Rightarrow C = 30$

$v = 30 - \frac{25}{t+2}$

As $t \to \infty$, $\frac{25}{t+2} \to 0$, so $v \to 30$

Limiting value of v is 30 ms^{-1}

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(b) Calculate the time taken for the particle to reach a speed of $29\,ms^{-1}$. [2]

$29 = 30 - \frac{25}{t+2}$

$\frac{25}{t+2} = 1 \Rightarrow t + 2 = 25$

$t = 23\ s$

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8. An object, of mass 5 kg, is projected up the line of greatest slope of a rough plane inclined at an angle of 30° to the horizontal.

(a) Given that the deceleration of the object up the plane is $6{\cdot}3\,\text{ms}^{-2}$, show that the coefficient of friction between the plane and the object is $\frac{2\sqrt{3}}{21}$. [5]

Perpendicular to plane: $R = 5g\cos 30° = \frac{49\sqrt{3}}{2} = 42.435\ldots$ N

N2L up the plane ($a = -6.3$): $-5g\sin 30° - F = 5 \times (-6.3)$

$-24.5 - F = -31.5$

$F = 7$ N

Object is moving, so friction is limiting: $F = \mu R$

$7 = \mu \times 5g\cos 30°$

$\mu = \frac{7}{5g\cos 30°} = \frac{7}{49\sqrt{3} \div 2} = \frac{2}{7\sqrt{3}}$

$\mu = \frac{2\sqrt{3}}{21}$ (as required)

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(b) Determine whether the object will remain stationary on the plane immediately after it comes to rest. [2]

Maximum friction = $\mu R = \frac{2\sqrt{3}}{21} \times 5g \cos 30° = 7$ N (up the slope)

Component of weight down the slope = $5g \sin 30° = 24.5$ N

Since $24.5 > 7$, the weight component exceeds the maximum friction,

so the object will not remain stationary: it will slide back down.

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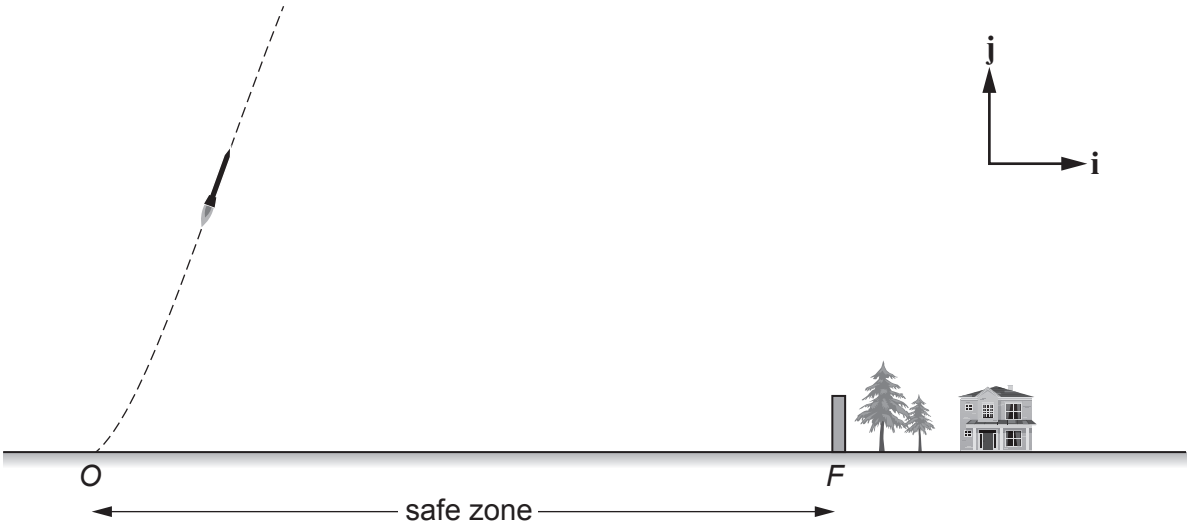
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9. A small rocket *R* is launched from a point *O* on horizontal ground so that it is moving in a vertical plane, where the unit vectors **i** and **j** are horizontal and vertical respectively.

The diagram below shows the path of *R* for the first 4 seconds of its motion.

The rocket *R* is required to land in a 'safe zone' which consists of the horizontal line from *O* to *F*.



At time t seconds, the position vector $\mathbf{r}$ m of *R*, relative to *O*, is modelled by

$$\mathbf{r} = 4t^2\mathbf{i} + \left(\frac{1}{4}t^4 + 6t^{\frac{3}{2}}\right)\mathbf{j} \qquad \text{for} \qquad 0 \leqslant t \leqslant 4.$$

(a) Find an expression for the velocity vector of *R* at time t s, valid for $0 \leqslant t \leqslant 4$. Hence find the velocity vector of *R* when $t = 4$. [3]

$v = \frac{dr}{dt} = 8t\,i + (t^3 + 9t^{1/2})\,j$

At $t = 4$: $v = 8(4)\,i + (4^3 + 9 \times 2)\,j$

$v = 32i + 82j \quad (ms^{-1})$

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(b) At $t = 4$, R runs out of fuel. For $t > 4$, the motion of R can be modelled as a projectile.

(i) Show that R takes approximately 18 seconds to reach the ground after the fuel runs out. [4]

(ii) Hence, determine whether R lands within the 'safe zone', given that $OF = 600$ m. [2]

(i) At $t = 4$: $r = 4(16)i + (\frac{1}{4}(256) + 6(8))j = 64i + 112j$

Vertically (↑ positive), from $t = 4$:

$s = ut + \frac{1}{2}at^2$, $s = -112$, $u = 82$, $a = -9.8$

$-112 = 82t - 4.9t^2$

$4.9t^2 - 82t - 112 = 0$

$t = \frac{82 \pm \sqrt{(82^2 + 4 \times 4.9 \times 112)}}{9.8}$

$t = 18.0042...$ ($t = -1.2695...$ rejected)

R takes approximately 18 seconds to reach the ground.

(ii) Horizontally: constant velocity 32 ms^{-1}

Distance $= 32 \times 18.0042... = 576.135...$ m

Total horizontal distance $= 64 + 576.135... = 640.1$ m

$640 > 600$, so R lands outside the safe zone

(it does not land in the safe zone).

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