



GuideMyGrades

— YOUR GOALS. OUR EXPERTISE. —

EDEXCEL INTERNATIONAL A LEVEL MATHS: QUESTIONS BY TOPIC

Combinations of Random Variables (S3.2)

International A Level Mathematics · S3: Statistics 3 (WST03)

13 questions · 187 marks · Mark schemes included

Past papers October 2020 - June 2025 · 1 sub-topic

 guidemygrades.com

 @Guidemygrades

 @Guidemygrades

 @Guidemygrades

 info@guidemygrades.com

 Piccadilly Business Centre, Unit C, Aldow Enterprise Park
Blackett Street, Manchester, M12 6AE

HOW TO USE THIS BOOKLET

Questions are grouped by sub-topic and run from the lowest to the highest mark tariff, then oldest paper first.

Click any row below to jump straight to that sub-topic or question.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme; < QUESTION brings you back.

A gold bar in the left margin marks exactly where the question sits on the original page.

Diagrams, graphs, grids and tables are printed exactly as they appear in the original papers.

Each question is filed under its main topic; longer questions may also test skills from other topics.

QUESTION	SOURCE	MARKS	PAGE
S3.2a	LINEAR COMBINATIONS OF NORMAL VARIABLES	13 Qs · 187 marks	2
1. Q7	IAL S3 (WST03) January 2023	8	3
2. Q6	IAL S3 (WST03) June 2022	10	6
3. Q7	IAL S3 (WST03) June 2023	10	10
4. Q7	IAL S3 (WST03) (unused paper) January 2022	14	13
5. Q7	IAL S3 (WST03) January 2024	14	18
6. Q7	IAL S3 (WST03) January 2025	15	21
7. Q8	IAL S3 (WST03) June 2025	15	24
8. Q7	IAL S3 (WST03) October 2020	16	29
9. Q6	IAL S3 (WST03) June 2024	16	32
10. Q6	IAL S3 (WST03) June 2021	17	36
11. Q7	IAL S3 (WST03) October 2021	17	41
12. Q5	IAL S3 (WST03) January 2022	17	46
13. Q6	IAL S3 (WST03) January 2021	18	50



QUESTIONS

13 questions · 187 marks · 1 sub-topic

SUB-TOPIC S3.2a

LINEAR COMBINATIONS OF NORMAL VARIABLES

Sub-topic S3.2a · 13 questions · 187 marks · lowest tariff first



- 7 At a particular supermarket, the times taken to serve each customer in a queue at a standard checkout may be modelled by a normal distribution with mean 240 seconds and standard deviation 20 seconds.

There is a queue of 3 customers at a standard checkout.

Making a reasonable assumption about the times taken to serve these customers,

- (a) find the probability that the total time taken to serve the 3 customers will be less than 11 minutes.

(3)

- (b) State the assumption you have made in part (a)

(1)

In the supermarket there is also an express checkout, which is reserved for customers buying 10 or fewer items. The time taken to serve a customer at this express checkout may be modelled by a normal distribution with mean 100 seconds and standard deviation 8 seconds.

On a particular day Jiang has 8 items to pay for and has to choose whether to join a queue of 3 customers waiting at a standard checkout or a queue of 7 customers waiting at the express checkout.

Using a similar assumption to that made in part (a),

- (c) find the probability that the total time taken to serve the 3 customers at the standard checkout will exceed the total time taken to serve the 7 customers at the express checkout.

(4)



Question 7 continued

Lined area for writing the answer to Question 7 continued.



Question 7 continued

Lined area for writing the answer to Question 7.

(Total for Question 7 is 8 marks)

TOTAL FOR PAPER IS 75 MARKS

- 6** A particular lift has a maximum load capacity of 700 kg.

The weights of men are normally distributed with mean 80 kg and standard deviation 10 kg.

The weights of women are normally distributed with mean 69 kg and standard deviation 5 kg.

You may assume that weights of people are independent.

- (a) Find the probability that when 6 men and 3 women are in the lift, the load exceeds 700 kg.

(4)

A sign in the lift states: “Maximum number of people in the lift is c ”

- (b) Find the value of c such that the probability of the load exceeding 700kg is less than 2.5% no matter the gender of the occupants.

(6)



Question 6 continued

Lined area for writing the answer to Question 6 continued.

Question 6 continued

Lined area for writing the answer to Question 6 continued.

Question 6 continued

Lined area for writing the answer to Question 6.

(Total for Question 6 is 10 marks)



Question 7 continued

Lined area for writing the answer to Question 7 continued.



Question 7 continued

Lined area for writing the answer to Question 7.

(Total for Question 7 is 10 marks)

TOTAL FOR PAPER IS 75 MARKS



Question 7 continued

Leave
blank

Handwriting practice area with horizontal lines.



Question 7 continued

Leave
blank

Lined area for writing the answer to Question 7 continued.



Leave
blank

Leave
blank

Q7

TOTAL FOR PAPER: 75 MARKS



TOTAL FOR PAPER IS 75 MARKS





TOTAL FOR PAPER IS 75 MARKS





Question 8 continued

Lined area for writing the answer to Question 8 continued.





Question 8 continued

Lined area for writing the answer to Question 8.

(Total for Question 8 is 15 marks)

TOTAL FOR PAPER IS 75 MARKS



Leave
blank



Question 6 continued

Lined area for writing the answer to Question 6 continued.



Question 6 continued

Lined area for writing the answer to Question 6 continued.



Question 6 continued

Lined area for writing the answer to Question 6.

(Total for Question 6 is 16 marks)



Question 6 continued

Lined area for writing the answer to Question 6 continued.



Question 6 continued

Lined area for writing the answer to Question 6.

(Total for Question 6 is 17 marks)

TOTAL FOR PAPER: 75 MARKS



Leave
blank

7. A company produces bricks.

The weight of a brick, B kg, is such that $B \sim N(1.96, \sqrt{0.003}^2)$

Two bricks are chosen at random.

- (a) Find the probability that the difference in weight of the 2 bricks is greater than 0.1 kg **(5)**

A random sample of n bricks is to be taken.

- (b) Find the minimum sample size such that the probability of the sample mean being greater than 2 is less than 1%
- (5)**

The bricks are randomly selected and stacked on pallets.

The weight of an empty pallet, E kg, is such that $E \sim N(21.8, \sqrt{0.6}^2)$

The random variable M represents the total weight of a pallet stacked with 500 bricks.

The random variable T represents the total weight of a container of cement.

Given that T is independent of M and that $T \sim N(774, \sqrt{1.8}^2)$

- (c) calculate $P(4T > 100 + 3M)$



Leave
blank

Question 7 continued

Leave
blank

Lined area for writing the answer to Question 7 continued.



Leave
blank

Leave
blank

Q7

END







(Total for Question 5 is 17 marks)



Leave
blank

6. A potter makes decorative tiles in two colours, red and yellow. The length, R cm, of the red tiles has a normal distribution with mean 15 cm and standard deviation 1.5 cm. The length, Y cm, of the yellow tiles has the normal distribution $N(12, 0.8^2)$. The random variables R and Y are independent.

A red tile and a yellow tile are chosen at random.

- (a) Find the probability that the yellow tile is longer than the red tile. (4)

Taruni buys 3 red tiles and 1 yellow tile.

- (b) Find the probability that the total length of the 3 red tiles is less than 4 times the length of the yellow tile.

Stefan defines the random variable $X = aR + bY$, where a and b are constants. He wants to use values of a and b such that X has a mean of 780 and minimum variance.

- (c) Find the value of a and the value of b that Stefan should use. (7)



Leave
blank

Leave
blank

Q6

TOTAL FOR PAPER: 75 MARKS

MARK SCHEMES

official mark schemes, in the same order as the questions



Question	Scheme		Marks
7 (a)	Let P = time to serve a customer at a standard checkout		
	$Q = P_1 + P_2 + P_3$ $[Q \sim]N(720, 1200)$		B1
	$P(Q < 660) = P\left(Z < \pm \frac{660 - "720"}{"\sqrt{1200}}\right) [= P(Z < -1.732...)]$		M1
	$= 0.0418$ (Calculator gives 0.04163...) awrt 0.041 / 0.042		A1
ALT	for the B1 M1		(3)
	B1 for $[Q \sim]N\left(12, \frac{1}{3}\right)$		
	M1 for $P(Q < 11) = P\left(Z < \pm \frac{11 - "12"}{\sqrt{"1/3"}}\right) [= P(Z < -1.732...)]$		
(b)	Assume the time taken to serve customers is independent		B1
			(1)
(c)	R = time to serve a customer at an express checkout		
	$S = (P_1 + P_2 + P_3) - (R_1 + ... + R_7)$ $[S \sim]N(20, 1648)$		M1 A1
	$P(S > 0) = P\left(Z > \pm \frac{0 - 20}{\sqrt{1648}}\right) [= P(Z > -0.492...)]$		M1
	$= 0.6879$ (Calculator gives 0.6888...) awrt 0.688 / 0.689		A1
ALT	For the M1A1M1		(4)
	M1 for $N\left(\frac{1}{3}, ... \right)$		
	A1 for $N\left(\frac{1}{3}, \frac{103}{225}\right)$		
	M1 for $\pm \frac{0 - \frac{1}{3}}{\sqrt{103/225}}$		
			(4)
	Notes		Total 8
(a)	B1	For $N(720, 1200)$ or $N\left(12, \frac{1}{3}\right)$ Maybe awarded if used in standardisation	
	M1	For standardising using 660, their mean $\neq 240$ or 4 and their standard deviation $\neq 20$ or $\frac{1}{3}$. If no distribution given the mean and sd must be correct in the standardisation. Allow $\pm$ stand	
	A1	awrt 0.041 or awrt 0.042	
(b)	B1	A correct assumption. Must have context of customers or time and independence(allow random)	
(c)	M1	For $N(\pm 20, ...)$ or $N\left(\frac{1}{3}, ... \right)$ maybe awarded in standardisation	
	A1	For $N(\pm 20, 1648)$ or $N\left(\frac{1}{3}, \frac{103}{225}\right)$ maybe awarded if used in standardisation	
	M1	For standardising using 0 and mean of ± 20 or $\pm 1/3$ and their standard deviation. The 0 may be implied by having just the mean on the numerator Allow $\pm$ stand	
	A1	awrt 0.688 to 0.689	

Question Number	Scheme		Marks
6 (a)	$M \sim N(80, 100)$ $W \sim N(69, 25)$ $X = M_1 + M_2 + M_3 + M_4 + M_5 + M_6 + W_1 + W_2 + W_3$		
	$X \sim N(687, 675)$		M1 A1
	$P(X > 700) = P\left(Z > \frac{700 - 687}{\sqrt{675}}\right) = P(Z > 0.500\dots)$		M1
	$(= 1 - 0.6915) = 0.3085$ (Calculator gives 0.3084)		A1
			(4)
(b)	Let Y = Number of men in the lift		
	$Y \sim N(80x, 100x)$		M1
	$P(Y > 700) = P\left(Z > \frac{700 - 80x}{10\sqrt{x}}\right) < 0.025$		M1
	$\frac{700 - 80x}{10\sqrt{x}} > 1.96$		B1
	$80x + 19.6\sqrt{x} - 700 \leq 0$	$6400x^2 - 112384.16x + 490000 \geq 0$	M1
	Solving leading to $\sqrt{x} < 2.838\dots$	Solving leading to $x < 8.05\dots$	M1
	So $c = 8$ (people)		A1
			(6)
	Notes		Total 10
(a)	B1	for setting up normal distribution with mean 687	
	B1	for a correct variance (675) or for standard deviation ($15\sqrt{3}$)	
	M1	for standardising with 700, 687 and their standard deviation	
	A1	for answer between 0.308 – 0.309	
(b)	M1	for setting up normal distribution with mean $80x$ and variance $100x$ (may be implied by use of $sd = 10\sqrt{x}$) Allow any letter	
	M1	for standardising with 700, their mean and their standard deviation (if not stated then these must be correct)	
	B1	for an equation or inequality set = to 1.96 (Allow – 1.96)	
	M1	for a correct 3TQ fit their mean and standard deviation	
	M1	for an attempt to solve their 3TQ with either $\sqrt{x} < \dots$ or $x < \dots$ Allow = instead of < Condone > or $\geq$ If the answer is incorrect then we must see use of the quadratic formula/completing the square (Allow one error)	
	A1	cao	

Question Number	Scheme		Marks
7 (a)	$E(X) = 4 \times 15 - 3 \times 10 [= 30]$		M1
	$\text{Var}(X) = 4^2 \times 5^2 + 3^2 \times 4^2 [= 544]$		M1
	So $X \sim N(30, 544)$		
	$P(X < 40) = P\left(Z < \frac{40 - '30'}{\sqrt{544}}\right) [= P(Z < 0.428...)]$		M1
	$= 0.6664$ (Calculator gives 0.6659...) awrt 0.666		A1
			(4)
(b)	$E(A + B + D) = 15 + 10 + 3 \times 20 = [85]$		M1
	$\text{Var}(A + B + D) = 5^2 + 4^2 + 3 \times \sigma^2 = [41 + 3\sigma^2]$		M1
	So $A + B + D \sim N(85, 41 + 3\sigma^2)$		
	$P(A + B + D < 76) = P\left(Z < \frac{76 - 85}{\sqrt{41 + 3\sigma^2}}\right) = 0.242$		
	So $\frac{-9}{\sqrt{41 + 3\sigma^2}} = -0.7$ or $\frac{9}{\sqrt{41 + 3\sigma^2}} = 0.7$ (Calculator gives $-0.69988...$)		M1 A1
	$3\sigma^2 = \left(\frac{-9}{-0.7}\right)^2 - 41$		dM1
	$\sigma = 6.437...$ awrt 6.44		A1
		(6)	
	Notes		Total 10
(a)	M1	For a correct method to find $E(X)$. May be implied by a correct standardisation expression.	
	M1	For a correct method to find $\text{Var}(X)$ Allow $\sqrt{544}$ oe or 23.3^2 or better. May be implied by a correct standardisation expression.	
	M1	For standardising ($\pm$) using their mean and their variance	
	A1	awrt 0.666	
(b)	M1	For a correct method to find $E(A + B + D)$	
	M1	For a correct method to find $\text{Var}(A + B + D)$	
	M1	For standardising ($\pm$) using their mean and their standard deviation which is in terms of σ^2 and setting equal to -0.7 or better. Allow $+0.7$	
	A1	For the correct equation	
	dM1	Dependent on the previous M mark. For squaring and rearranging leading to an equation in σ^2	
	A1	awrt 6.44 (Do not award if previous A mark was not awarded)	

Question Number	Scheme		Marks
7 (a)	Let X represent $B_1 + B_2 - C_1$		
	$X \sim N(0.268, 0.015633)$ awrt 0.0156		M1 A1
	$P(X < 0) = P\left(Z < \frac{0 - 0.268}{\sqrt{0.015633}} (= -2.14)\right)$		M1
	$(= 1 - 0.9838) = 0.0162$		A1
			(4)
(b)	Let Y represent $2.5B_1 + 3C_1 + 3C_2$		
	$Y \sim N(6.918, 0.071478)$ awrt 6.92, 0.0715		M1 A1
	$P(Y > 7) = P\left(Z > \frac{7 - 6.918}{\sqrt{0.071478}} (= 0.31)\right)$		M1
	$(= 1 - 0.6217) = 0.3783$ (Calculator gives 0.3795...) 0.378 – 0.380		A1
			(4)
(c)	Mean = $2.94w$		B1
	Standard deviation = $0.084\sqrt{5} w$ (= 0.188w)		B1
			(2)
(d)	$\frac{6 - 2.94w}{0.084\sqrt{5} w} = -1.2816$		M1;B1
	$-1.2816 \times 0.084\sqrt{5} w + 2.94w \dots 6$		dM1
	$w \dots 2.22\dots$ So $w = 2.23$		A1
			(4)
	Notes		Total 14
7 (a)	M1	for setting up normal distribution with mean 0.268	
	A1	for a correct expression for variance (= 0.015633) or for standard deviation (= 0.125...)	
	M1	for standardising with 0, 0.268 and their standard deviation	
	A1	awrt 0.0162 (Allow awrt 0.0160 as this comes from a calculator)	
(b)	M1	for setting up normal distribution with mean awrt 6.92	
	A1	for a correct expression for variance (= 0.071478) or for standard deviation (= 0.267...)	
	M1	for standardising with 7, 0.071478 and their standard deviation	
	A1	for answer between 0.378 – 3.80	
(c)	B1	for $2.94w$	
	B1	for $0.084\sqrt{5}w$ or awrt 0.188w	
(d)	M1	for standardising using their mean and their standard deviation = z where $1 < z < 1.5$	
	B1	for -1.28	
	dM1	dependent on M1, for solving their inequality	
	A1	awrt (£)2.23	

Question Number	Scheme	Marks
7. (a)	$a = 2 \times 180 - 330 = 30$ $b = 4.5^2 \times 2 + 6.7^2 = 85.39$	B1 M1 A1 (3)
(b)	$X = L - 1.8S$ $E(X) = 330 - 1.8 \times 180 = 6$ $\text{Var}(X) = 6.7^2 + 1.8^2 \times 4.5^2 = 110.5$ $P(X > 0) = P\left(Z > \frac{0-6}{\sqrt{110.5}}\right)$ $P(Z > -0.57) = 0.7157$	M1 M1 A1 M1 A1 (5)
(c)	$T = S_1 - \frac{S_1 + S_2 + S_3}{3} = \frac{2S_1 - S_2 - S_3}{3}$ $E(T) = 0$ $\text{Var}(T) = \frac{1}{9}(2^2 \times 4.5^2 + 4.5^2 + 4.5^2) = \frac{6}{9}(4.5^2) = 13.5$ $P(T > 5) = P\left(Z > \frac{5-0}{\sqrt{13.5}}\right)$ $P(Z > 1.36) = 1 - 0.9131 = 0.0869$	M1 A1 M1 M1 A1 (6) [14]
Notes		
(a)	B1 30 cao M1 $2 \times \text{Var}(S) + \text{Var}(L)$ A1 85.39 (allow 85.4)	
(b)	1 st M1 Seeing or using $E(X) = 6$ or correct expression for mean 2 nd M1 $\text{Var}(L) + 1.8^2 \text{Var}(S)$ (condone mixing variances for M1) 1 st A1 for 110.5 (allow $65.61 + 6.7^2$) 3 rd M1 standardising with their mean and s.d. leading to a probability $p > 0.5$ 2 nd A1 awrt 0.716 [calc: 0.7159262...]	
(c)	1 st M1 realising the need to write as a single distribution using $\bar{S} = \frac{S_1 + S_2 + S_3}{3}$ 1 st A1 for $\frac{2S_1 - S_2 - S_3}{3}$ 2 nd M1 Using mean = 0 3 rd M1 using $\text{Var}(aS) = a^2 \text{Var}(S)$ 4 th M1 standardising with their mean and sd 2 nd A1 awrt 0.0868 to awrt 0.0869 [calc: 0.08678...] Note: Assuming S_1 and $\bar{S}$ are independent, leads to $E(T) = 0$, $\text{Var}(T) = 27$, $P(T > 5) = 0.167...$ scores M0A0M1M0M1A0	

Question Number	Scheme		Marks
7 (a)	$W = S_1 + S_2 + S_3 + L_1 + L_2 + L_3 + L_4$		
	$W \sim N(3 \times 7.7 + 4 \times 20, 3 \times 0.01^2 + 4 \times 0.02^2)$ So $W \sim N(103.1, 0.0019)$		M1 A1
	$[P(W > 103.15) =] P\left(Z > \frac{103.15 - '103.1'}{\sqrt{0.0019}}\right) [= P(Z > 1.1470...)]$		M1
	$[1 - 0.8749] = 0.1251$ (Calculator gives 0.12567...) awrt 0.13		A1
			(4)
(b)	Let $Y = L_1 - L_2$		
	$Y \sim N(0, 2 \times 0.02^2)$ So $Y \sim N(0, 0.0008)$		M1 A1
	$P\left(Z > \frac{0.01 - '0'}{\sqrt{0.0008}}\right)$ or $P\left(Z < \frac{-0.01 - '0'}{\sqrt{0.0008}}\right)$		M1
	$2 \times (1 - 0.6368) = 0.7264$ (Calculator gives $2 \times 0.36183...$) awrt 0.724 $\square$ 0.726		M1 A1
			(5)
(c)	$T \sim N(\mu, \sigma^2)$		
	$\mu = 7.7n - 7.7n [= 0]$		M1
	$\sigma^2 = 0.0001n^2 + 0.0001n$		M1
	$\frac{2 - '0'}{\sqrt{0.0001n^2 + 0.0001n}} = 1.99$		M1 B1
	$0.0001n^2 + 0.0001n - 1.01[00755...] = 0$		dM1
	$n = 100$		A1
			(6)
Notes			Total 15
(a)	M1	For setting up a normal distribution with a mean 103.1	
	A1	For a correct expression for variance (0.0019) or standard deviation (0.04358...) Implied by a correct variance or a correct standard deviation	
	M1	For standardising using 103.15, their mean and their standard deviation	
	A1	If their mean and/or their standard deviation/variance are incorrect then working must be shown awrt 0.13	
(b)	M1	For $L_1 - L_2$ May be implied by a correct mean or variance	
	A1	For $N(0, 0.0008)$	
	M1	For standardising using 0.01, their mean and their standard deviation (May be implied by awrt 0.6368 or awrt 0.3632 or awrt 0.3618 or awrt 0.6382)	
	M1	For 2 times p where $2p$ is a probability (Calculator gives $2 \times 0.36183...$)	
	A1	For answers in the range awrt 0.724 – awrt 0.726	
(c)	M1	For a correct expression for μ Implied by a mean of 0	
	M1	For a correct expression for σ^2	
	M1	For standardising using 2, their mean and their standard deviation and set = to a z value where $1.95 < z < 2$	
	B1	awrt 1.99 seen or used	
	dM1	Dependent on 2 nd M1. For rearranging to get a correct 3 term quadratic e.g. $n^2 + n - 10101$ or $n^2 + n - 10102$	
	A1	cao (Must reject -101 if found)	

Question Number	Scheme		Marks
8(a)	$X = S_1 + S_2 + S_3$		
	$[X \square] N(54, 0.0027)$ or e.g. $[E(X) =] 54, [\text{Var}(X) =] 0.0027$		M1 A1
	$[P(X > 54.1) =] P\left(Z > \pm \frac{54.1 - '54'}{\sqrt{0.0027}}\right) [= P(Z > 1.924...)]$		M1
	$[= 1 - 0.9726] = 0.0274$ (Calc 0.02714...) awrt 0.027		A1
			(4)
(b)	$Y = C_1 - C_2$		
	$[Y \square] N(0, 0.0018)$ or e.g. $[E(Y) =] 0, [\text{Var}(X) =] 0.0018$		M1
	$[P(Y > 0.02) =] P\left(Z > \pm \frac{0.02 - '0'}{\sqrt{0.0018}}\right) [= P(Z > 0.4714...)]$		M1
	$[= 1 - 0.6808] = 0.3192$ (Calc 0.31867...) awrt 0.319		A1
	$2 \times P(Y > 0.02) = 2 \times '0.3192' = 0.6384$ (Calc 0.63735...) awrt 0.637 - awrt 0.638		M1 A1
			(5)
(c)	$T = P_1 + C_1 + \dots + C_5 + S_1 + \dots + S_{28}$		
	Let $R = T - 30P_1 = C_1 + \dots + C_5 + S_1 + \dots + S_{28} - 29P_1$ (or e.g. $Q = T - 30P_1 - 190$)		M1 A1
	$[R \square] N(194, 33.6697)$ or e.g. $[E(R) =] 194, [\text{Var}(R) =] 33.6697$ (or $N(4, 33.6697)$)		M1 A1
	$[P(R < 190) =] P\left(Z < \pm \frac{190 - '194'}{\sqrt{33.6697}}\right) [= P(Z < -0.68935...)]$ (or e.g. $P(Q < 0)$)		M1
	$[= 1 - 0.7549] = 0.2451$ (Calc 0.2453...) awrt 0.245		A1
			(6)
Notes			Total 15
(a)	M1	For $N(54, \dots)$ oe seen or used. May see e.g. $[E(X) =] 3 \times 18$. Implied by awrt 0.027	
	A1	For $N(54, 0.0027)$ oe seen or used (Standard deviation (0.05196...) May be seen in their standardisation. The unevaluated expressions for μ and σ^2 can score	
	M1	For standardising with 54.1, their mean $\neq 18$ or 6 and their standard deviation $\neq 0.03$ or 0.0027 (if their mean/or their sd/var are incorrect then working must be shown. Allow $\pm$ stand	
	A1	awrt 0.027 provided standardisation seen	
(b)	M1	For $N(0, 0.0018)$ oe seen or used e.g. seen in their standardisation. The unevaluated expressions for μ and σ^2 can score. Implied by awrt 0.319 or awrt 0.637– awrt 0.638	
	M1	For standardising with 0.02, their mean and their standard deviation $\neq 0.0018$. Allow $\pm$ stand	
	A1	awrt 0.319 provided standardisation seen . May be implied by their final answer	
	M1	For $2 \times$ their 0.319 provided their probability of “0.319” is < 0.5 Imp by correct prob statement	
	A1	Dep on all previous method marks scored and standardisation seen awrt 0.637– awrt 0.638	
(c)	M1	For sight or use of $T - 30P_1$ may be implied by sight of 194 oe or awrt 33.7 oe. May attempt $T - 30P_1 - 190$ May be implied by sight of 4.	
	A1	for $C_1 + \dots + C_5 + S_1 + \dots + S_{28} - 29P_1$ oe May be implied by sight of awrt 33.7.	
	M1	For $N(194, \dots)$ oe seen or used. May be unsimplified. (or $N(4, \dots)$)	
	A1	For $N(194, 33.6697)$ oe seen or used. The expressions for μ and σ^2 can score. (or $N(4, 33.6697)$)	
	M1	For standardising with 190, their mean and their standard deviation $\neq 33.6697$. Allow $\pm$ stand	
A1	Dependent on all previous marks scored for awrt 0.245 provided standardisation seen		

Question Number	Scheme	Marks
7.		
(a)	$C_1 + C_2 + C_3 \sim N(480, 3 \times 1.25^2)$	M1 A1
	$P(C_1 + C_2 + C_3 > 475.8) = P\left(Z > \frac{475.8 - 480}{\sqrt{3 \times 1.25^2}} (= -1.94)\right)$	M1
	= awrt 0.974	A1
		(4)
(b)	$W = T_1 + T_2 + T_3 + T_4 + T_5 + C_1 + C_2 \sim N(5 \times 60 + 2 \times 160, 5 \times 2^2 + 2 \times 1.25^2)$	M1 A1
	$P(W > 625) = P\left(Z > \frac{625 - 620}{\sqrt{23.125}} (= 1.03975...)\right)$	M1
	= awrt 0.149	A1
		(4)
(c)	$Y = (n-1)T_1 - \sum_{r=2}^n T_r$	
	$Y \sim N(\mu, \sigma^2)$	
	$\mu = (n-1) \times 60 - (n-1) \times 60 [= 0]$	M1 A1
	$\sigma^2 = (n-1)^2 \times 4 + (n-1) \times 4 [= 4n^2 - 4n]$	M1 A1
	$\frac{40 - 0}{\sqrt{4n^2 - 4n}} = 1.38$	M1 B1
	$4n^2 - 4n - 840(.159...) = 0$	dM1
	$n = 15$	A1
		(8)
	Total 16	
	Notes	
(a)	M1 for setting up Normal distribution with mean 480 A1 for correct expression for variance (= 4.6875) or for standard deviation (= 2.165...) M1 standardising with 475.8, 480 and their standard deviation (their standard deviation $\neq$ 3.75) A1 awrt 0.974	
(b)	M1 for setting up Normal distribution with mean 620 A1 for correct expression for variance (= 23.125) or for standard deviation (= 4.8088...) M1 standardising with 625, 620 and their standard deviation A1 awrt 0.149	
(c)	M1 for a single combined normal distribution (may be implied by a single standardisation) A1 correct expression for μ M1 for use of $a^2 \times 4 + a \times 4$ A1 correct expression for σ^2 M1 standardising with their mean and their sd = z where $1 < z < 1.5$ B1 awrt 1.38 dM1 solving their 3TQ (working must be shown if answer is incorrect) (dependent upon 2 nd M1) A1 15 cao (must reject -14 if found). Must come from compatible signs in standardisation.	

Question Number	Scheme	Marks
6(a)	$E(C + C + C) = 3.6$ oe	B1
	$\text{Var}(C + C + C) = 0.03^2 + 0.03^2 + 0.03^2 [= 0.0027]$	M1
	$P(C + C + C > 3.5) = P\left(Z > \left(\pm \frac{3.5 - "3.6"}{\sqrt{"0.0027"}}\right) [= -1.9245...]\right)$	M1
	$= 0.9726$ (calc 0.97285...) awrt 0.973	A1
		(4)
(b)	$E(R - R) = 0$	M1
	$\text{Var}(R - R) = 0.03^2 + 0.03^2 [= 0.0018]$	M1
	$P((R - R) > 0.05) = P\left(Z > \left(\frac{0.05 - "0"}{\sqrt{"0.0018"}}\right) [= 1.1785...]\right)$ [= 0.119 (calc 0.119296...)]	M1
	$2 \times P((R - R) > 0.05) = 2 \times "0.119"$	M1
	$= 0.238$ table or 0.23859...calc awrt 0.238/0.239	A1cso
		(5)
(c)	$\mu_G = 2.5 + 10 \times 2.3 [= 25.5]$	M1
	$\sigma_G^2 = 0.1 + 10 \times 0.03^2 [= 0.109]$	M1
	Let $X = G - 2T$	M1
	$\mu_X = "25.5" - 2 \times 2.5 [= 20.5]$	M1
	$\sigma_X^2 = "0.109" + 4 \times 0.1 [= 0.509]$	M1
	$P(G - 2T < 20) = P\left(Z < \frac{20 - "20.5"}{\sqrt{"0.509"}} [= -0.7008...]\right)$	M1
	$= 0.242$ (table) or 0.2417... (calc) awrt 0.242	A1
		(7)
	Notes	Total 16
(a)	B1 Correct value for $E(C + C + C)$ may be seen e.g. $\frac{18}{5}$ or implied by later calculation	
	M1 Correct method to find the variance. Condone 0.03^4 instead of 0.03^2 may be implied by calculation or awrt 0.973	
	M1 Correct standardisation using their mean and sd. Allow $\pm \frac{3.5 - "3.6"}{\sqrt{"0.0027"}}$ may be implied by $P(Z > \text{awrt } -1.92)$ or $P(Z < \text{awrt } 1.92)$ or awrt 0.973	
	A1 awrt 0.973 do not isw	
(b)	M1 for 0 may be seen or implied by later calculation	
	M1 correct method to find $\text{Var}(R - R)$ may be implied by 0.0018 or $\frac{9}{5000}$ or a later calculation. Must be a numerical value or expression.	
	M1 Correct standardisation using their mean and Var Allow $\pm$	
	M1 $2 \times$ "their 0.119"	
	A1 awrt 0.238	
(c)	M1 Correct method for finding the mean of G may be implied by 25.5 or later work or sight of 20.5 (or may subtract 20 so 0.5)	
	M1 Correct method for finding the var of G may be implied by sight of 0.109 provided this is not to find the variance of $10R - T$. May be implied by 0.509	

	M1 Realising they need to find $\pm (G - 2T)$. Allow $\pm (G - 2T - 20)$ may be seen as part of a probability expression or implied by their calculation
	M1 Correct method for finding the mean of X which may be from using their mean of G (which must be correct if no method or value is seen) Allow 0.5
	M1 Correct method for finding the var of X which may be from using their variance of G (which must be correct if no method or value is seen) may be implied by $10 \times 0.03^2 + 0.5$ or 0.509
	M1 Correct standardisation using their mean and standardisation for $G - 2T$ (condone $G - T$) leading to a probability < 0.5 Allow 0 – “0.5” for numerator for correct use of 20 with their “20.5” and their “0.509”
	A1 awrt 0.242 from a correct distribution
	Note candidates who attempt $10R + T < 2T + 20 \Rightarrow 10R - T < 20$ can score maximum M1M0M0M1M0M1A0 (the first method mark is implied by the fourth method mark)

Question Number	Scheme	Notes	Marks
6(a)	$W = B - 1.1R$	May be implied by correct mean or variance	M1
	$W \sim N(55 - 1.1 \times 51, 1.3^2 + 1.1^2 \times 1.2^2)$ or $W \sim N(-1.1, 3.4324)$	($\pm$)1.1, awrt 3.43 (may be seen in standardisation)	A1, A1
	$P(W < 0) = P\left(Z < \frac{0+1.1}{\sqrt{3.4324}}\right)$	Standardising with their mean and their sd. leading to a probability > 0.5	M1
	$= P(Z < 0.5937...)$		
	$= 0.7224$ or 0.7237	awrt 0.72	A1
			(5)
6(b)	$X = B_1 - B_2$	May be implied by correct mean or variance	M1
	$X \sim N(55 - 55, 2 \times 1.3^2)$ or $X \sim N(0, 3.38)$	0, 3.38	A1, A1
	$P\left(Z > \frac{1-0}{\sqrt{3.38}}\right)$ or $P\left(Z < \frac{-1-0}{\sqrt{3.38}}\right)$	dep on 1 st M1 for standardising with their mean and their sd.	dM1
	$P(X > 1) = 2 \times P(X > 1)$	For 2 $\times$ seen or implied	M1
	$= 2 \times P(Z > 0.5439...)$ $= 2 \times (1 - 0.7054)$	2×0.2946 or 2×0.2932 (calc)	
	$= 0.5892$	awrt 0.59	A1
			(6)
6(c)	$V = B_1 + B_2 + B_3 + B_4 + B_5 + B_6 + B_7 + B_8 + B_9 + B_{10} + S$ $Y = R_1 + R_2 + R_3 + R_4 + R_5 + R_6 + R_7 + R_8 + R_9 + R_{10} + R_{11} + S$	May be implied by either correct distribution	M1
	$V \sim N(553, 16.94)$ and $Y \sim N(564, 15.88)$	Both correct	A1
	$D = Y - V$ so $D \sim N(11 \times 51 - 10 \times 55, 11 \times 1.2^2 + 10 \times 1.3^2 + 2 \times 0.2^2)$ or $D \sim N(11, 32.82)$	Attempt at their difference for the mean, and their sum for the variance.	M1
		($\pm$)11 and awrt 32.8	A1
	$P(D > 0) = P\left(Z > \frac{0-11}{\sqrt{32.82}}\right)$	dep on 1 st M1 for standardising using their mean and their standard deviation leading to a probability > 0.5	dM1
	$= P(Z > -1.920...)$		
	$= 0.9726$	awrt 0.973	A1
			(6)
			Total 17

Question Number	Scheme	Marks
7(a)	$E(B_1 - B_2) = 0$	B1
	$\text{Var}(B_1 - B_2) = 0.006$	B1
	$P(B_1 - B_2 > 0.1) = 2P(B_1 - B_2 > 0.1)$	M1
	$= 2 \times P\left(Z > \frac{0.1}{\sqrt{0.006}}\right) [= 2 \times P(Z > 1.2909...)]$	M1
	$= 0.1967...$ awrt 0.197	A1
		(5)
(b)	$\bar{B} \sim N\left(1.96, \frac{0.003}{n}\right)$	B1
	$P(\bar{B} > 2) = P\left(Z > \frac{2 - 1.96}{\sqrt{0.003/n}}\right) [< 0.01]$	M1
	$\frac{2 - 1.96}{\sqrt{\frac{0.003}{n}}} > 2.3263$	B1 dM1
	$n = 11$	A1
		(5)
(c)	$\mu_M = 21.8 + 500 \times 1.96 [= 1001.8] ; \sigma_M^2 = 0.6 + 500 \times 0.003 [= 2.1]$	M1 ; M1
	Let $X = 4T - 3M$	M1
	$\mu_X = 4 \times 774 - 3 \times 1001.8 [= 90.6] ; \sigma_X^2 = 16 \times 1.8 + 9 \times 2.1 [= 47.7]$	M1 ; M1
	$P(4T - 3M > 100) = P\left(Z > \frac{100 - 90.6}{\sqrt{47.7}}\right) [= P(Z > 1.361...)]$	M1
	$= 0.0869$ (table) or $0.08675...$ (calc)	A1
		(7)
		Total 17
(a)	B1 For expected value being 0 written or used B1 For 0.006 being written or used for Variance M1 Realising they need to consider both M1 Correct standardisation using their 0.1 and 0.006 If the expected value and/or standard deviation not stated then they must be correct A1 awrt 0.197	
(b)	B1 The correct distribution written or used M1 Correct standardisation. Allow using their distribution if stated but must contain $\sqrt{n}$ for sd B1 Using awrt 2.3263 dM1 Dep on previous M being awarded using a z value, $2 < z < 3$ A1 11	
(c)	M1 Correct method for finding the mean of M M1 Correct method for finding the var of M M1 Realising the need to find $4T - 3M$ or $4T - 3M - 100$ or $100 + 3M - 4T$ M1 Correct method for finding the mean of X (using $4T - 3M - 100 = -9.4$ or $100 + 3M - 4T = 9.4$) M1 Correct method for finding the var of X M1 Correct standardisation using their mean of X and their standard deviation of X If these are not stated then they must be correct A1 awrt 0.0869 or 0.0868	

Qu. No.	Scheme		Marks
5 (a)	Let T = total time taken		
	$T \sim N(41 + 81 + 57, 5.2^2 + 4.2^2 + 6.6^2)$ [So $T \sim N(179, 88.24)$]		M1 A1
	$P(T > 180) = P\left(Z > \frac{180 - 179}{\sqrt{88.24}}\right)$		M1
	$= 1 - 0.5438 = 0.4562$ (calculator gives 0.4576...) awrt 0.456 to 0.458		M1 A1
			(5)
(b)	Let Y = difference between run and swim or Let $D = R - S - 20$		
	$Y \sim N(16, 70.6)$ or $D \sim N(-4, 70.6)$		B1
	$P(Y > 20) = P\left(Z > \frac{20 - 16}{\sqrt{70.6}}\right)$ or $P(D > 0) = P\left(Z > \frac{0 - (-4)}{\sqrt{70.6}}\right)$		M1
	$= 1 - 0.6844 = 0.3156$ (calculator gives 0.3170...) awrt 0.316/0.317		M1 A1
			(4)
(c)	$P(T > t) = 0.95 \Rightarrow P\left(Z > \frac{t - 179}{\sqrt{88.24}}\right) = 0.95 \Rightarrow \frac{t - 179}{\sqrt{88.24}} = -1.6449$		M1 B1
	$t = 163.548...$ awrt 164		A1
			(3)
(d)	Let X = the number of times greater than 3 hours in 6 attempts		
	$X \sim B(6, "0.456")$		B1ft
	$P(X \geq 1) = 1 - P(X = 0) = 1 - "0.5438"^{*6}$ $P(X \geq 1) = 1 - P(X = 0) = 1 - "0.5438"^{*6}$		M1
	$= 0.9741...$ (using the calculator value gives 0.9745...) awrt 0.974/0.975		A1
			(3)
(e)	eg The times for each event are not now likely to be independent		M1
	Jane is correct / calculation is not valid		A1 (2)
	Notes		Total 17
(a)	M1	for setting up a normal distribution with a mean $41 + 81 + 57 (= 179)$	
	A1	for a correct expression of variance implied by (variance =) 88.24 or for s.d. = awrt 9.39	
	M1	for standardising with 180, their mean and their standard deviation	
	M1	use of $1 - p$ with $0.5 < p < 1$	
	A1	awrt 0.456 to 0.458	
(b)	B1	For $N(\pm 16, 70.6)$ or $N(\pm 4, 70.6)$ May be seen in a calculation	
	M1	for standardisation with ± 20 or 0, their mean and their s.d.(their var must be > 0) must be compatible e.g. -20 with -16	
	M1	use of $1 - p$ with $0.5 < p < 1$	
	A1	awrt 0.316/0.317	
(c)	M1	for standardising using their mean and standard deviation = z value $1 < z < 2$	
	B1	for correct z value ± 1.6449 or better. Must have compatible sign with standardisation	
	A1	awrt 164	
(d)	B1ft	for writing or using $B(6, '0.4562')$ ft their answer to part (a) to 3sf	
	M1	use of $P(X \geq 1) = 1 - P(X = 0)$ [$= 1 - (1 - \text{their}(a))^6$] allow $P(X \geq 1) = P(X = 1) + P(X = 2) + ... + P(X = 6)$	
	A1	awrt 0.974/0.975	
(e)	M1	Reference to the events no longer being independent (he might get tired after each event or events now follow consecutively)/ calculation does not include time between events	
	A1	Correct conclusion (Jane is correct) with corresponding reason	

Question Number	Scheme	Marks
6. (a)	Let $D = Y - R$ then $E(D) = -3$; $\text{Var}(D) = 0.8^2 + 1.5^2$ or 1.7^2 or 2.89 $P(D > 0) = P\left(Z > \frac{0 - (-3)}{1.7}\right)$ or $P(Z > 1.7647\dots)$ $= 0.03880655\dots$ or $1 - 0.9608 = 0.0392$ awrt 0.039	B1, M1 M1 A1 (4)
(b)	$(R_1 + R_2 + R_3) \sim N\left(45, \sqrt{3 \times 1.5^2}\right)$; $4Y \sim N\left(48, \sqrt{4^2 \times 0.8^2}\right)$ $L = 4Y - (R_1 + R_2 + R_3) \Rightarrow L \sim N\left(3, \sqrt{16.99}\right)$ $P(L > 0) = P\left(Z > \frac{0 - 3}{\sqrt{16.99}}\right)$ or $P(Z > 0 - 0.7278\dots)$ [use 0 - 0.73 in tables] $=$ awrt 0.767	M1A1A1 M1A1 dM1 A1 (7)
(c)	$E(X) = 780$ gives $15a + 12b = 780$ $[\text{Var}(X) =] 1.5^2 \times a^2 + 0.8^2 \times b^2$ Sub for a : $\text{Var}(X) = 2.25(52 - 0.8b)^2 + 0.64 \times b^2$ or $2.08b^2 - 187.2b + 6084$ $\frac{d}{db}[\text{Var}(X)] = 0 \Rightarrow 4.16b - 187.2 = 0$ $b = 45$ So $a = 52 - 0.8 \times 45 = 52 - 36$ $a = 16$	M1A1 M1 M1 M1 A1 A1 (7)
[18 marks]		
Notes		
(a)	B1 for $E(D) = -3$ (or +3 if using $R - Y$) and 1 st M1 for $\text{Var}(D) = 0.8^2 + 1.5^2$ o.e. 2 nd M1 for attempt at $P(D > 0)$ must standardise with their -3 and their 1.7 and inequality A1 for awrt 0.039	
(b)	1 st M1 for correct mean or variance for either $R_1 + R_2 + R_3$ or $4Y$ 1 st A1 for $(R_1 + R_2 + R_3) \sim N\left(45, \sqrt{6.75^2}\right)$ 2 nd A1 for $4Y \sim N\left(48, \sqrt{10.24^2}\right)$ 2 nd M1 for attempting a suitable L (condone $3R - 4L$ etc) Must have L with mean of ± 3 and $\sigma_L^2 = "6.75" + "10.24" = (4.1218\dots)^2$ 3 rd A1 for a correct mean and variance. Sight of $N(\pm 3, 16.99)$ scores 1st 5 marks 3 rd dM1 (dep on 2 nd M1) for attempting a prob ($\rightarrow$ ans > 0.5) using $\mu_L = \pm 3$ and their σ_L 4 th A1 for awrt 0.767 (Calc: 0.7666384... or tables 0.7673)	
(c)	1 st M1 for an attempt to use $E(X) = 780$ must see a linear equation in a and b using 780 1 st A1 for $15a + 12b = 780$ o.e. e.g. $5a + 4b = 260$ or $a + 0.8b = 52$ etc 2 nd M1 for an attempt to find an expression for $\text{Var}(X)$ (condone a and b wrong way around) 3 rd M1 for forming a quadratic expression for $\text{Var}(X)$ in terms of a or b only (M0 for $= k, k \neq 0$) 4 th M1 suitable method for finding min (e.g. differentiation, or completing square or calc) e.g. $\frac{13}{4}(a^2 - 32a + 832)$ [3 rd M1] then $k[(a - 16)^2 + m]$ would score 4 th M1 2 nd A1 for $b = 45$ or $a = 16$ 3 rd A1 for both $b = 45$ <u>and</u> $a = 16$	Correct answers should be accompanied by evidence for 1 st 4 marks

