PROBABILITY AND STATISTICS-2

9709

(March, June and November series 2020 – 2023 With marking scheme)

LINEAR COMBINATION

EXERCISE -2

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1) SP 2020 9709_6 Q4

The lifetimes, in hours, of Longlive light bulbs and Enerlow light bulbs have the independent distributions $N(1020, 45^2)$ and $N(2800, 52^2)$ respectively.

(a) Find the probability that the total of the lifetimes of five randomly chosen Longlive bulbs is less than 5200 hours. [4]

(b) Find the probability that the lifetime of a randomly chosen Enerlow bulb is at least three times that of a randomly chosen Longlive bulb. [6]

2) March 2020 9709_62 Q6

The volumes, in millilitres, of large and small cups of tea are modelled by the distributions N(200, 30) and N(110, 20) respectively.

(a) Find the probability that the total volume of a randomly chosen large cup of tea and a randomly chosen small cup of tea is less than 300 ml. [4]

(b) Find the probability that the volume of a randomly chosen large cup of tea is more than twice the volume of a randomly chosen small cup of tea. [6]

3) March 2021 9709_62 Q5

The volumes, in litres, of juice in large and small bottles have the distributions N(5.10, 0.0102) and N(2.51, 0.0036) respectively.

(a) Find the probability that the total volume of juice in 3 randomly chosen large bottles and 4 randomly chosen small bottles is less than 25.5 litres. [5]

(b) Find the probability that the volume of juice in a randomly chosen large bottle is at least twice the volume of juice in a randomly chosen small bottle. [5]

4) March 2022 9709_62 Q5

The heights of buildings in a large city are normally distributed with mean 18.3 m and standard deviation 2.5 m.

(a) Find the probability that the total height of 5 randomly chosen buildings in the city is more than 95 m. [4]

(b) Find the probability that the difference between the heights of two randomly chosen buildings in the city is less than 1 m. [5]

5) March 2023 9709_62 Q5

The masses, in grams, of large and small packets of Maxwheat cereal have the independent distributions $N(410.0, 3.6^2)$ and $N(206.0, 3.7^2)$ respectively.

(a) Find the probability that a randomly chosen large packet has a mass that is more than double the mass of a randomly chosen small packet. [5]

The packets are placed in boxes. The boxes are identical in appearance. 60% of the boxes contain exactly 10 randomly chosen large packets. 40% of the boxes contain exactly 20 randomly chosen small packets.

(b) Find the probability that a randomly chosen box contains packets with a total mass of more than 4080 grams. [6]

6) June 2020 9709_61 Q3

The masses, in kilograms, of large sacks of flour and small sacks of flour have the independent distributions $N(40, 1.5^2)$ and $N(12, 0.7^2)$ respectively.

(a) Find the probability that the total mass of 6 randomly chosen large sacks of flour is more than 245 kg. [4]

(b) Find the probability that the mass of a randomly chosen large sack of flour is less than 4 times the mass of a randomly chosen small sack of flour. [6]

7) June 2020 9709_62 Q1

The masses, in grams, of plums of a certain type have the distribution $N(40.4, 5.2^2)$. The plums are packed in bags, with each bag containing 6 randomly chosen plums. If the total weight of the plums in a bag is less than 220 g the bag is rejected.

Find the percentage of bags that are rejected. [4]

8) June 2020 9709_63 Q2

Each day at the gym, Sarah completes three runs. The distances, in metres, that she completes in the three runs have the independent distributions $W \sim N(1520, 450)$, $X \sim N(2250, 720)$ and $Y \sim N(3860, 1050)$.

Find the probability that, on a particular day, Y is less than the total of W and X. [5]

9) June 2020 9709_63 Q4

The random variable A has the distribution $Po(1.5)$. A_1 and A_2 are independent values of A.

(a) Find $P(A_1 + A_2 < 2)$. [3]

(b) Given that $A_1 + A_2 < 2$, find $P(A_1 = 1)$. [4]

(c) Give a reason why $A_1 - A_2$ cannot have a Poisson distribution. [1]

10)June 2021 9709_61 Q1

Accidents at two factories occur randomly and independently. On average, the numbers of accidents per month are 3.1 at factory A and 1.7 at factory B.

Find the probability that the total number of accidents in the two factories during a 2-month period is more than 3. [4]

11)June 2021 9709_61 Q7

The masses, in kilograms, of large and small sacks of flour have the distributions $N(55, 3^2)$ and $N(27, 2.5^2)$ respectively.

(a) Some sacks are loaded onto a boat. The maximum load of flour that the boat can carry safely is 340 kg.

Find the probability that the boat can carry safely 3 randomly chosen large sacks of flour and 6 randomly chosen small sacks of flour. [5]

(b) Find the probability that the mass of a randomly chosen large sack of flour is greater than the total mass of two randomly chosen small sacks of flour. [5]

12)June 2021 9709_62 Q2

The random variable X has the distribution $B(400, 0.01)$.

(a) Find $\text{Var}(4X + 2)$. [3]

(b) **(i)** State an appropriate approximating distribution for X, giving the values of any parameters. Justify your choice of approximating distribution. [2]

(ii) Use your approximating distribution to find $P(2 \leqslant X \leqslant 5)$. [2]

13)June 2021 9709_62 Q4

Wendy's journey to work consists of three parts: walking to the train station, riding on the train and then walking to the office. The times, in minutes, for the three parts of her journey are independent and have the distributions $N(15.0, 1.1^2)$, $N(32.0, 3.5^2)$ and $N(8.6, 1.2^2)$ respectively.

(a) Find the mean and variance of the total time for Wendy's journey. [2]

If Wendy's journey takes more than 60 minutes, she is late for work.

(b) Find the probability that, on a randomly chosen day, Wendy will be late for work. [3]

(c) Find the probability that the mean of Wendy's journey times over 15 randomly chosen days will be less than 54.5 minutes. [3]

14)June 2021 9709_63 Q1

The number of goals scored by a team in a match is independent of other matches, and is denoted by the random variable X, which has a Poisson distribution with mean 1.36. A supporter offers to make a donation of \$5 to the team for each goal that they score in the next 10 matches.

Find the expectation and standard deviation of the amount that the supporter will pay. [5]

15)June 2022 9709_61 Q3

The lengths, in centimetres, of two types of insect, A and B, are modelled by the random variables $X \sim N(6.2, 0.36)$ and $Y \sim N(2.4, 0.25)$ respectively.

Find the probability that the length of a randomly chosen type A insect is greater than the sum of the lengths of 3 randomly chosen type B insects. [5]

16)June 2022 9709_61 Q4

The independent random variables X and Y have distributions Po(2) and $B(20, \frac{1}{4})$ respectively.

(a) Find the mean and standard deviation of $X - 3Y$. [5]

(b) Find $P(Y = 15X)$. [3]

17)June 2022 9709_62 Q6

The masses, in kilograms, of large and small sacks of grain have the distributions N(53, 11) and N(14, 3) respectively.

(a) Find the probability that the mass of a randomly chosen large sack is greater than four times the mass of a randomly chosen small sack. [5]

(b) A lift can safely carry a maximum mass of 1000 kg.

Find the probability that the lift can safely carry 12 randomly chosen large sacks and 25 randomly chosen small sacks. [5]

18)June 2022 9709_63 Q4

Each box of Seeds & Raisins contains S grams of seeds and R grams of raisins. The weight of a box, when empty, is B grams. S, R and B are independent random variables, where $S \sim N(300, 45)$, $R \sim N(200, 25)$ and $B \sim N(15, 4)$. A full box of Seeds & Raisins is chosen at random.

(a) Find the probability that the total weight of the box and its contents is more than 500 grams. [5]

(b) Find the probability that the weight of seeds in the box is less than 1.4 times the weight of raisins in the box. [5]

19)June 2023 9709_61 Q5

Large packets of rice are packed in cartons, each containing 20 randomly chosen packets. The masses of these packets are normally distributed with mean 1010 g and standard deviation 3.4 g. The masses of the cartons, when empty, are independently normally distributed with mean 50 g and standard deviation 2.0 g.

(a) Find the variance of the masses of full cartons. [2]

Small packets of rice are packed in boxes. The total masses of full boxes are normally distributed with mean 6730 g and standard deviation 15.0 g. The masses of the boxes and cartons are distributed independently of each other.

(b) Find the probability that the mass of a randomly chosen full carton is more than three times the mass of a randomly chosen full box. [5]

20)June 2023 9709_62 Q5

(a) Two random variables X and Y have the independent distributions N(7, 3) and N(6, 2) respectively. A random value of each variable is taken.

Find the probability that the two values differ by more than 2. [5]

(b) Each candidate's overall score in a science test is calculated as follows. The mark for theory is denoted by T, the mark for practical is denoted by P, and the overall score is given by $T + 1.5P$. The variables T and P are assumed to be independent with distributions $N(62, 158)$ and $N(42, 108)$ respectively. You should assume that no continuity corrections are needed when using these distributions.

(i) A pass is awarded to candidates whose overall score is at least 90.

Find the proportion of candidates who pass. [5]

(ii) Comment on the assumption that the variables T and P are independent. [1]

21)June 2023 9709_63 Q4

The mass, in tonnes, of steel produced per day at a factory is normally distributed with mean 65.2 and standard deviation 3.6. It can be assumed that the mass of steel produced each day is independent of other days. The factory makes $50 profit on each tonne of steel produced.

Find the probability that the total profit made in a randomly chosen 7-day week is less than $22 000. [6]

22)Oct 2020 9709_61 Q3

The masses, in kilograms, of female and male animals of a certain species have the distributions $N(102, 27^2)$ and $N(170, 55^2)$ respectively.

Find the probability that a randomly chosen female has a mass that is less than half the mass of a randomly chosen male. [6]

23)Oct 2020 9709_62 Q7

Before a certain type of book is published it is checked for errors, which are then corrected. For costing purposes each error is classified as either minor or major. The numbers of minor and major errors in a book are modelled by the independent distributions $N(380, 140)$ and $N(210, 80)$ respectively. You should assume that no continuity corrections are needed when using these models.

A book of this type is chosen at random.

(a) Find the probability that the number of minor errors is at least 200 more than the number of major errors. [5]

The costs of correcting a minor error and a major error are 20 cents and 50 cents respectively.

(b) Find the probability that the total cost of correcting the errors in the book is less than $190. [5]

24)Oct 2021 9709_62 Q1

The mass, in kilograms, of a block of cheese sold in a supermarket is denoted by the random variable M. The masses of a random sample of 40 blocks are summarised as follows.

$$n = 40 \qquad \Sigma m = 20.50 \qquad \Sigma m^2 = 10.7280$$

(a) Calculate unbiased estimates of the population mean and variance of M. [3]

(b) The price, $\$P$, of a block of cheese of mass M kg is found using the formula $P = 11M + 0.50$.

Find estimates of the population mean and variance of P. [3]

25)Oct 2022 9709_61 Q4

Each month a company sells X kg of brown sugar and Y kg of white sugar, where X and Y have the independent distributions $N(2500, 120^2)$ and $N(3700, 130^2)$ respectively.

(a) Find the mean and standard deviation of the total amount of sugar that the company sells in 3 randomly chosen months. [3]

The company makes a profit of \$1.50 per kilogram of brown sugar sold and makes a loss of \$0.20 per kilogram of white sugar sold.

(b) Find the probability that, in a randomly chosen month, the total profit is less than \$3000. [5]

26)Oct 2022 9709_62 Q6

The masses, in grams, of small and large bags of flour have the distributions $N(510, 100)$ and $N(1015, 324)$ respectively. André selects 4 small bags of flour and 2 large bags of flour at random.

(a) Find the probability that the total mass of these 6 bags of flour is less than 4130 g. [5]

(b) Find the probability that the total mass of the 4 small bags is more than the total mass of the 2 large bags. [5]

Marking scheme

1) .

(a)	N(5100, 5×45^2) or N(5100, 10 125)	1	**B1**
	$\frac{5200 - \text{'5100'}}{\sqrt{\text{'10 125'}}}$ (= 0.994)	1	**M1**
	Φ('0.994')	1	**M1**
	= 0.840 (3 sf)	1	**A1**
		4	
(b)	Use of $E - 3L$ or similar	1	**M1**
	$\text{E}(E - 3L) = -260$	1	**B1**
	$\text{Var}(E - 3L) = 52^2 + 9 \times 45^2$ or 20 929	1	**B1**
	$\frac{0 - (\text{'}-260\text{'})}{\sqrt{\text{'20 929'}}}$ (= 1.797)	1	**M1**
	1 – Φ('1.797')	1	**M1**
	= 0.0361 (3 sf) or 0.0362	1	**A1**
		6	

2) .

(a)	N(310, 50)	**B1**
	$\frac{300-\text{'310'}}{\sqrt{\text{'50'}}}$ (= –1.414)	**M1**
	Φ('–1.414') = 1 – ϕ('1.414')	**M1**
	= 0.0786 or 0.0787 (3 sf)	**A1**
		4

(b)	$P(L - 2S > 0)$	M1
	$E(X) = 200\text{-}2\text{x}110$ or $= -20$	B1
	$\text{Var} = 30 + 2^2 \times 20$ or $= 110$	B1
	$N(-20, 110)$ $\frac{0-('-20')}{\sqrt{'110'}}$ $(= 1.907)$	M1
	$1 - \Phi(\text{'}1.907\text{'})$	M1
	$= 0.0283$ (3 sf)	A1
		6

3) .

(a)	$E(L_1+L_2+L_3+S_1+S_2+S_3+S_4) = 3\times 5.10 + 4\times 2.51$ [= 25.34]	B1
	$\text{Var}(L_1+L_2+L_3+S_1+S_2+S_3+S_4) = 3\times 0.0102 + 4\times 0.0036$ [= 0.045]	B1
	$\frac{25.5-'25.34'}{\sqrt{'0.045'}}$ [= 0.754]	M1
	$\Phi(\text{'}0.754\text{'})$	M1
	0.775 (3 sf)	A1
		5
(b)	$E(L - 2S) = 5.10 - 2\times 2.51$ [= 0.08]	B1
	$\text{Var}(L - 2S) = 0.0102 + 2^2 \times 0.0036$ [= 0.0246]	B1
	$\frac{0-'0.08'}{\sqrt{'0.0246'}}$ [= –0.510]	M1
	$P(Z > '-0.510') = \phi(\text{'}0.510\text{'})$	M1
	0.695 (3 sf)	A1
		5

4) .

(a)	Mean = 5×18.3 and Variance = 5×2.5^2 [= N(91.5, 31.25)]	**B1**
	$\frac{95-'91.5}{\sqrt{'31.25'}}$ [= 0.626]	**M1**
	1 – Φ('0.626')	**M1**
	0.266 (3 sf)	**A1**
		4
(b)	E(*D*) = 0	**B1**
	Var(*D*) = $2.5^2 \times 2$ [= 12.5]	**B1**
	$\frac{1-0}{\sqrt{'12.5'}}$ [= 0.283] or $\frac{-1-0}{\sqrt{'12.5'}}$ [= –0.283]	**M1**
	Φ('0.283') – (1 – ϕ(0.283)) [= 0.6115 – 0.3885]	**M1**
	0.223 (3 sf)	**A1**
		5

5) .

(a)	D = L – 2S E(D) = 410 – 2(206) = –2	**B1**
	Var(D) = $3.6^2 + 4 \times 3.7^2$ [= 67.72]	**B1**
	$\frac{0-(-2)}{\sqrt{'67.72'}}$ [= 0.243]	**M1**
	1 – ϕ(*their* '0.243')	**M1**
	= 0.404 (3 sf)	**A1**
		5

(b)	$T_L \sim N(4100, 10\times3.6^2)$	$T_S \sim N(4120, 20\times3.7^2)$	B1
	$\frac{4080-4100}{\sqrt{'129.6'}}$ $(=-1.757)$	$\frac{4080-4120}{\sqrt{'273.8'}}$ $(=-2.417)$	M1
	$1-\phi('-1.757') = \phi(1.757)$	$1-\phi('-2.417') = \phi(2.417)$	M1
	$= 0.9605$ **or** 0.961	$= 0.9921$ **or** 0.9922 **or** 0.992	A1
	$0.6 \times$ '*their* 0.9605' $+ 0.4 \times$ '*their* 0.9921'		M1
	$= 0.973$ (3 sf)		A1
			6

6) .

(a)	$N(240, 6\times1.5^2)$ or $N(240, 13.5)$	M1
	$\frac{245-"240"}{\sqrt{"13.5"}}$ $(=1.361)$	M1
	$1-\Phi("1.361")$	M1
	0.0867 (3 sf)	A1
		4
(b)	Use of $L-4S$ or similar	M1
	$E(L-4S) = -8$	B1
	$Var(L-4S) = 1.5^2 + 16\times0.7^2$ or 10.09	B1
	$\frac{0-("-8")}{\sqrt{"10.09"}}$ $(=2.519)$	M1
	$\Phi("2.519")$	M1
	0.994 (3 sf)	A1
		6

7) .

$N(242.4, 162.24)$	B1
$\frac{220-'242.4'}{\sqrt{'162.24'}}$ $(=-1.759)$	M1
$\phi('-1.759') = 1-\phi('1.759') = 0.0393$	M1
3.93%	A1
	4

8) .

$Y - W - X \sim N(90, \ldots)$	B1
$\text{Var}(Y - W - X) = 1050 + 450 + 720$ or 2220	B1
$\frac{0-90}{\sqrt{'2220'}}$ $(=-1.910)$	M1
$\Phi('-1.910') = 1 - \Phi('1.910')$	M1
0.0281	A1
	5

9) .

(a)	$\lambda = 3$	B1
	$e^{-3}(1+3)$	M1
	$= 0.199$ (3 sf)	A1
		3
(b)	$P(A_1 = 1 \text{ and } A_1 + A_2 < 2) = P(A_1 = 1) \times P(A_2 = 0)$	M1
	$e^{-1.5} \times 1.5 \times e^{-1.5} = 0.0747$	A1
	$P(A_1 = 1 \mid A_1 + A_2 < 2) = \frac{P(A1 = 1 \text{ and } A1 + A2 < 2)}{P(A1 + A2 < 2)}$ $= \frac{1.5 \times (e^{-1.5})^2}{4e^{-3}} = \frac{'0.0747'}{'0.199'}$	M1
	$\frac{3}{8}$ or 0.375 (3 sf)	A1
		4
(c)	Takes negative values	B1
		1

10).

$\lambda = (3.1 + 1.7) \times 2$	M1
$= 9.6$	A1
$1 - e^{-9.6}\left(1 + 9.6 + \frac{9.6^2}{2} + \frac{9.6^3}{3!}\right)$	M1
$= 0.986$ (3 sf)	A1

11).

(a)	$E(T) = 3 \times 55 + 6 \times 27 [= 327]$	B1
	$\text{Var}(T) = 3 \times 3^2 + 6 \times 2.5^2$ $[= 64.5]$	B1
	$\frac{340 - '327'}{\sqrt{'64.5'}}$ $[= 1.619]$	M1
	$P(z < '1.619') = \Phi('1.619')$	M1
	0.947 (3 sf)	A1

(b)	$E(L-S_1-S_2) = 55 - 2\times 27$ [=1]	B1
	$Var(L-S_1-S_2) = 3^2 + 2\times 2.5^2$ [= 21.5]	B1
	$\frac{0-'1'}{\sqrt{'21.5'}}$ [= –0.216]	M1
	$P(L-S_1-S_2 > 0) = \Phi('0.216')$	M1
	0.586 or 0.585 (3 sf)	A1

12).

(a)	$Var(X) = 400 \times 0.01 \times 0.99$ (= 3.96)	M1
	$Var(4X + 2) = 16 \times Var(X)$	M1
	63.36	A1
(b)(i)	Po(4)	B1
	$n = 400 > 50$ and either $np = 4 < 5$ or $p=0.01 < 0.1$	B1
(b)(ii)	$e^{-4}\left(\frac{4^2}{2!}+\frac{4^3}{3!}+\frac{4^4}{4!}+\frac{4^5}{5!}\right)$	M1
	0.694 (3 sf)	A1

13).

a)	Mean = 15.0+32.0+8.6 [= 55.6]	B1
	Var = $1.1^2+3.5^2+1.2^2$ [= 14.9]	B1
b)	$\frac{60-"55.6"}{\sqrt{"14.9"}}$ [= 1.140]	M1
	$1-\phi("1.140")$	M1
	0.127 (3 sf)	A1
(c)	$\frac{54.5-"55.6"}{\sqrt{\frac{"14.9"}{15}}}$ or $\frac{817.5-834}{\sqrt{223.5}}$ [= –1.104]	**M1**
	$1-\phi("1.104")$	**M1**
	0.135 (3 sf)	**A1**

14).

$\lambda = 10 \times 1.36$ [= 13.6]	**M1**
E(amount) = 5×13.6 = [\$]68	**A1**
Var(amount) = $5^2 \times 13.6$ [= 340]	**M1**
	M1
Standard Deviation = [\$]18.4(4) (3 s.f.)	**A1**

15).

$D = X - (Y_1 + Y_2 + Y_3)$ OE E(D) = 6.2 -2.4 × 3 [= –1] OE	**B1**
Var(D) = 0.36 + 3 × 0.25 [= 1.11]	**B1**
$\frac{0-(-1)}{\sqrt{\text{'1.11'}}}$ [= 0.949]	**M1**
1 – Φ('0.949')	**M1**
= 0.171 (3 s.f.)	**A1**

16).

(a)	$E(Y) = \frac{20}{4}\left[= 5\right]$, $\text{Var}(Y) = 20 \times \frac{1}{4} \times \frac{3}{4}\left[= \frac{15}{4}\right]$	**B1**
	Var(X) = 2	**B1**
	E(X – 3Y) = –13	**B1**
	Var(X – 3Y) = 2 + 9 × '$\frac{15}{4}$' [= 35.75]	**M1**
	Standard deviation of (X – 3Y) = 5.98 (3 s.f.) or $\frac{1}{2}\sqrt{143}$	**A1**
(b)	(0, 0) and (1, 15)	**M1**
	$e^{-2} \times (\frac{3}{4})^{20} + e^{-2} \times 2 \times {}^{20}C_{15} (\frac{3}{4})^5 (\frac{1}{4})^{15}$	**M1**
	0.000430 (3 sf)	**A1**

17).

(a)	$E(D) = 53 - (4 \times 14) = -3$	**B1**
	$Var(D) = 11 + 4^2 \times 3$ [= 59]	**B1**
	$\frac{0-(-3)}{\sqrt{59}}$ [= 0.391]	**M1**
	$1 - \Phi(\text{'0.391'})$	**M1**
	0.348 (3 s.f.)	**A1**
(b)	$E(T) = 12 \times 53 + 25 \times 14$ [= 986]	**B1**
	$Var(T) = 12 \times 11 + 25 \times 3$ [= 207]	**B1**
	$\frac{1000-986}{\sqrt{207}}$ [= 0.973]	**M1**
	$\Phi(\text{'0.973'})$	**M1**
	0.835 (3 sf)	**A1**

18).

(a)	$\lambda = 6.6$	**B1**
	$e^{-6.6} \times \frac{6.6^6}{6!}$	**M1**
	0.156 (3 s.f.)	**A1**
(b)	$1 - e^{-2.2}(1 + 2.2 + \frac{2.2^2}{2} + \frac{2.2^3}{3!} + \frac{2.2^4}{4!})$	**M1**
	0.0725 (3 s.f.)	**A1**

19).

(a)	$2.0^2 + 20 \times 3.4^2$	**M1**
	= 235.2	**A1**

(b)	$E(C-3B) = 50 + 20\times1010 - 3\times6730$ or 60	B1
	$Var(C-3B) = $ '235.2' $+ 9\times15^2$ or 2260.2	M1
	[$C - 3B \sim N$('60', '2260.2')] $= \frac{0-60}{\sqrt{2260.2}}$ [$= -1.262$]	M1
	$1 - \Phi$('-1.262') $= \Phi$('1.262')	M1
	$= 0.897$ (3 sf)	A1

20).

(a)	$E(X-Y) = 1$ $Var(X-Y) = 5$	B1
	$\frac{2-1}{\sqrt{5}}$ [$= 0.447$] $\frac{-2-1}{\sqrt{5}}$ [$= -1.342$]	M1
	$1 - \Phi$('0.447') Φ('-1.342') $= 1 - \Phi$('1.342')	M1
	$= 0.327$ or 0.328 $= 0.0898$ or 0.0899	A1
	Probability that difference is more than 2 = 0.417 (3 sf) or 0.418	A1

(b)(i)	$E(X) = 62 + 1.5(42)$ [$= 125$]	B1
	$Var(X) = 158 + 1.5^2 \times 108$ [$= 401$]	B1
	$\frac{90-\text{"125"}}{\sqrt{\text{"401"}}}$ [$= -1.748$]	M1
	Φ('1.748')	M1
	$= 0.960$ or 96.0% (3 sf)	A1
(b)(ii)	Unlikely. A candidate who does well in Theory is likely to do well in Practical.	B1

21).

Method 1: Based on mass

Mean = $7 \times 65.2 = 456.4$	**B1**
Var = 7×3.6^2 [= 90.72]	**M1**
22 000/50 = 440 used in standardising equation	**M1**
$\frac{'440' - '456.4'}{\sqrt{'90.72'}}$ [= –1.722] no mixed methods	**M1**
$\phi(-'1.722') = 1 - \phi('1.722')$	**M1**
= 0.0425 or 0.0426	**A1**

Method 2: Based on profit

Mean = $7 \times 65.2 \times 50 = 22820$	**B1**
Var = 7×3.6^2	**M1**
Var = $50^2 \times '90.72'$ [= 226800]	**M1**
$\frac{22000 - '22820'}{\sqrt{'226800'}}$ [= –1.722] no mixed methods	**M1**
$\phi(-'1.722') = 1 - \phi('1.722')$	**M1**
= 0.0425 or 0.0426	**A1**

22).

$F - 0.5M$	**M1**
$\sim N(17, 27^2 + 0.25 \times 55^2)$	**B1**
	B1
$\frac{0 - '17'}{\sqrt{'1485.25'}}$ (= –0.4411)	**M1**
$P(F - 0.5M < 0) = \phi('-0.4411') = 1 - \phi('0.4411')$	**M1**
= 0.330 (3 sf)	**A1**

Alternative method for question 3

2F – M	
$\sim N(34,\ 2^2 \times 27^2 + 55^2)$	B1
	B1
$\dfrac{0-'34'}{\sqrt{'5941'}}$ (= –0.4411)	M1
P(2F – M < 0) = ϕ('-0.4411') = 1 – ϕ('0.4411')	M1
= 0.330 (3 sf)	A1

23).

(a)	P(S > L + 200) = P(S – L > 200) E(S – L) = 380–210 (=170) or E(S–L–200)= 380–210–200 (=–30)	B1
	Var(S – L) = 140+80 (=220) or Var(S–L–200)= 140+80 (=220)	B1
	$\dfrac{200-"170"}{\sqrt{"220"}}$ or $\dfrac{0-"-30"}{\sqrt{"220"}}$ (= 2.023)	M1
	1 – ϕ("2.023")	M1
	= 0.0216 (3sf)	A1

(b)	E(total cost) = 380 × 20 + 210 × 50 (= 18 100)	B1
	Var(total cost) = 140 × 20^2 + 80 × 50^2 (= 256 000)	B1
	$\dfrac{19000-"18100"}{\sqrt{"256000"}}$ or $\dfrac{190-"181"}{\sqrt{"25.6"}}$ (= 1.778)	M1
	ϕ("1.778")	M1
	= 0.962 or 0.963 (3 sf)	A1

24) .

(a)	$\frac{20.5}{40} = 0.5125$	**B1**
	$\frac{40}{39}\left(\frac{10.728}{40} - ('0.5125'^2)\right)$ or $\frac{1}{39}\left(10.728 - \frac{20.50^2}{40}\right)$	**M1**
	0.0056859 or 0.00569 (3 sf) or $\frac{887}{156\,000}$	**A1**
(b)	[11 × '0.5125' + 0.5]) = 6.1375 or $\frac{491}{80}$ or 6.14 (3sf)	**B1 FT**
	11^2 × '0.0056859'	**M1**
	0.688 (3sf)	**A1**

25) .

(a)	Mean = [3 (2500 + 3700)] = 18600 (kg)	**B1**
	Var(Total profit) = $3(120^2 + 130^2)$ or 93900	**M1**
	sd = 306 (kg) (3 sf)	**A1**
(b)	$E(1.5X - 0.2Y)$ = 1.5x2500 – 0.20x3700 = [3010]	**B1**
	$Var(1.5X - 0.2Y) = 1.5^2 \times 120^2 + 0.2^2 \times 130^2$ [= 33076]	**B1**
	$\frac{3000 - 3010}{\sqrt{their\ '33076'}}$ [= –0.055]	**M1**
	Φ(*their* '–0.055') = 1 – Φ(*their* '0.055')	**M1**
	= 0.478 (3 sf)	**A1**

26) .

(a)	$E(T) = 4 \times 510 + 2 \times 1015$ [= 4070]	**B1**
	$Var(T) = 4 \times 100 + 2 \times 324$ [= 1048]	**B1**
	$\frac{4130-4070}{\sqrt{'1048'}}$ [= 1.853]	**M1**
	Φ('1.853')	**M1**
	= 0.968 (3 sf)	**A1**
(b)	$E(D) = 4 \times 510 - 2 \times 1015$ [= 10]	**B1**
	$Var(D) = 4 \times 100 + 2 \times 324$ [= 1048]	**B1**
	$\frac{0-'10'}{\sqrt{'1048'}}$ [= –0.309]	**M1**
	1 – Φ('–0.309') = Φ('0.309')	**M1**
	= 0.621	**A1**