Teacher Support Materials
2008

Maths GCE

Paper Reference MS03

Question 1

1 The best performances of a random sample of 20 junior athletes in the long jump, x metres, and in the high jump, y metres, were recorded. The following statistics were calculated from the results.

$$S_{xx} = 7.0036 \quad S_{yy} = 0.8464 \quad S_{xy} = 1.3781$$

(a) Calculate the value of the product moment correlation coefficient between x and y. *(2 marks)*

(b) Assuming that these data come from a bivariate normal distribution, investigate, at the 1% level of significance, the claim that for junior athletes there is a positive correlation between x and y. *(4 marks)*

(c) Interpret your conclusion in the context of this question. *(1 mark)*

Student Response

Question number | Leave blank

1a.

$r = \frac{S_{xy}}{\sqrt{S_{xx} \times S_{yy}}} = \frac{1.3781}{\sqrt{7.0036 \times 0.8464}} = 0.566$ ✓ 2

b. $H_0 : \rho = 0$ ✓ B1

$H_1 : \rho > 0$ $\alpha = 0.01$ one tailed test ✓

$r = 0.566$ ~~Based~~ $n = 20$ B1

From tables, cv = 0.5155 ✓

0.566 > 0.5155 M1

∴ sufficient evidence at 1% level to reject Ho and conclude that there is a positive correlation between x and y. A1

c. significant evidence to conclude that there is a positive correlation between ~~x and y~~ test performances in long jump and high jump. ✓ B1

7

Commentary

A typical fully-correct response to this first question. A correct calculation of r in part (a) is followed, in part (b), by hypotheses (in terms of ρ), critical value, comparison and conclusion. In part (c), this latter conclusion is expressed in context.

Mark scheme

Q	Solution	Marks	Total	Comments
1 (a)	$r = \dfrac{1.3781}{\sqrt{7.0036 \times 0.8464}} =$	M1		Used
	0.56 to 0.57	A1	2	AWFW (0.56602)
(b)	H_0: $\rho = 0$ H_1: $\rho > 0$	B1		Both
	SL α = 0.01 (1%) CV r = **0.515 to 0.516**	B1		AWFW (0.5155)
	Calculated r > Tabulated r	M1		Comparison
	Evidence, at 1% level, of a positive correlation between x and y	A1√	4	ft on r and CV
	Special Case for part (b)			
	CV $t_{n-2}(0.99)$ 2.552	(B1)		
	$r\sqrt{\dfrac{n-2}{1-r^2}} = 2.913$	(B1)		
(c)	(Strong) evidence of a positive correlation between best performances of junior athletes in the long jump and in the high jump	B1√	1	ft on **(b)**; or equivalent
	Total		7	

Question 2

2 A survey of a random sample of 200 passengers on UK internal flights revealed that 132 of them were on business trips.

(a) Construct an approximate 98% confidence interval for the proportion of passengers on UK internal flights that are on business trips. *(6 marks)*

(b) Hence comment on the claim that more than 60 per cent of passengers on UK internal flights are on business trips. *(2 marks)*

Student Response

2. ~~200~~ $\frac{132}{200}$ ⇒ Business trip

a) 98% CI ⇒ 2.3263

$$\frac{132}{200} \pm 2.3263 \times \sqrt{\frac{\left(\frac{132}{200}\right)\left(\frac{68}{200}\right)}{200}}$$

$$0.66 \pm 2.3263 \sqrt{\frac{0.66 \times 0.34}{200}}$$ ✓

$$= (0.582, 0.738)$$ ✓ 6

b) 60% of passengers on UK internal flights are on business trips as the claim falls in the ~~inter~~ confidence interval, ✓ hence claim is supported and true. ✗

B1 B0

7

Commentary

A common correct answer to part (a) that uses the correct values for the <u>sample</u> proportion (0.66) and for *z* (2.3263) in a correct formula for the confidence interval for a <u>population</u> proportion. In part (b), it is correctly stated that 60% (0.6) falls within this interval but this does **not** support the claim of ‘more than 60%’; an error made by many candidates.

Mark Scheme

Q	Solution	Marks	Total	Comments
2 **(a)**	$\hat{p} = \frac{132}{200}$ = **0.66**	B1		CAO; or equivalent
	98% $\Rightarrow$ z = **2.32 to 2.33**	B1		AWFW (2.3263)
	CI for p: $\hat{p} \pm z\sqrt{\frac{\hat{p}(1-\hat{p})}{n}}$	M1 M1		Variance term CI expression used
	ie $0.66 \pm 2.3263 \times \sqrt{\frac{0.66 \times 0.34}{200}}$	A1√		ft on $\hat{p}$ and z
	ie **0.66 ± 0.08** or **(0.58, 0.74)**	A1	6	AWRT; or equivalent
(b)	Value of 0.6 (60%) is **within** CI	B1√		ft on **(a)**
	Reason to **doubt** claim of more than 60%	B1√	2	dependent on previous B1 ft on **(a)**; or equivalent
	Total		**8**	

Question 3

3 Pitted black olives in brine are sold in jars labelled "340 grams net weight". Two machines, A and B, independently fill these jars with olives before the brine is added.

The weight, X grams, of olives delivered by machine A may be modelled by a normal distribution with mean μ_X and standard deviation 4.5.

The weight, Y grams, of olives delivered by machine B may be modelled by a normal distribution with mean μ_Y and standard deviation 5.7.

The mean weight of olives from a random sample of 10 jars filled by machine A is found to be 157 grams, whereas that from a random sample of 15 jars filled by machine B is found to be 162 grams.

Test, at the 1% level of significance, the hypothesis that $\mu_X = \mu_Y$. *(6 marks)*

Student response

3. $H_0 : \mu_X = \mu_Y$ ✓

$H_1 : \mu_X \neq \mu_Y$ ✓ $\alpha = 0.01$ two tailed B1

CV $z = \pm 2.5758$ ✓ B1

$\mu_X \sim N\left(157, \frac{4.5^2}{10}\right)$

$\mu_Y \sim N\left(162, \frac{5.7^2}{15}\right)$ M1

$z = \frac{157 - 162}{\sqrt{\frac{4.5^2}{10} + \frac{5.7^2}{15}}} = -2.44$ ✓ M1 A1

$-2.44 > -2.5758$

$\therefore$ insufficient evidence to reject H_0. conclude that $\mu_X = \mu_Y$. ✓ A1

6

Commentary

A correct solution that is set out much better than is generally the case but which contains certain notation errors that are **not** penalised. For example $\mu_x \sim \mathrm{N}\left(157, \frac{4.5^2}{10}\right)$ should be $\bar{x} \sim \mathrm{N}\left(\mu_X, \frac{4.5^2}{10}\right)$. However a correct **negative** value of *z* is compared correctly with the **negative** critical value leading to the correct conclusion.

Mark Scheme

3	$H_0 : \mu_X = \mu_Y$ $H_1 : \mu_X \neq \mu_Y$	B1		Both
	SL α = 0.01(1%) CV z = (±) **2.57 to 2.58**	B1		AWFW (2.5758)
	$z = \dfrac{\lvert 157 - 162 \rvert}{\sqrt{\dfrac{4.5^2}{10} + \dfrac{5.7^2}{15}}} =$	M1 M1		Numerator Denominator
	(±) **2.44 to 2.445**	A1		AWFW (2.4424)
	No evidence, at 1% level, to reject hypothesis that $\mu_X = \mu_Y$	A1√	6	ft on z, CV and signs; or equivalent
	Total		**6**	

Question 4

4 A manufacturer produces three models of washing machine: basic, standard and deluxe. An analysis of warranty records shows that 25% of faults are on basic machines, 60% are on standard machines and 15% are on deluxe machines.

For basic machines, 30% of faults reported during the warranty period are electrical, 50% are mechanical and 20% are water-related.

For standard machines, 40% of faults reported during the warranty period are electrical, 45% are mechanical and 15% are water-related.

For deluxe machines, 55% of faults reported during the warranty period are electrical, 35% are mechanical and 10% are water-related.

(a) Draw a tree diagram to represent the above information. *(3 marks)*

(b) Hence, or otherwise, determine the probability that a fault reported during the warranty period:

(i) is electrical; *(2 marks)*

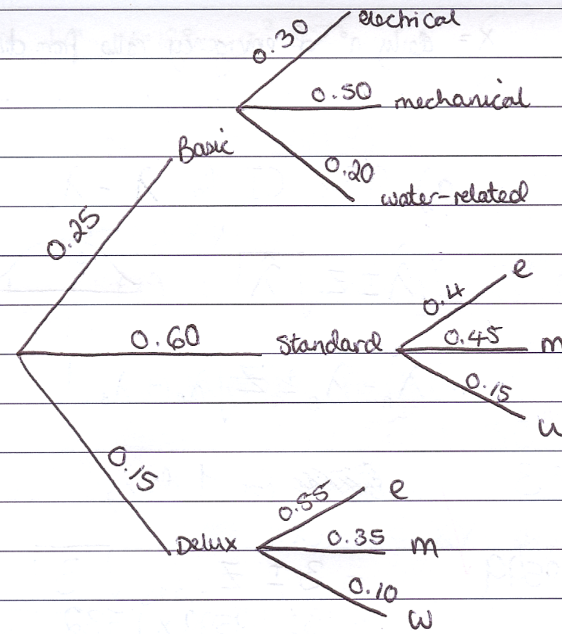
(ii) is on a deluxe machine, given that it is electrical. *(2 marks)*

(c) A random sample of 10 electrical faults reported during the warranty period is selected. Calculate the probability that exactly 4 of them are on deluxe machines. *(3 marks)*

Student Response

Leave blank

4) a.)



✓ 3

b) i) $p(\text{electrical}) = p(B \cap e) + p(S \cap e) + p(D \cap e)$

$= (0.25 \times 0.30) + (0.6 \times 0.4) + (0.15 \times 0.55)$

$= 0.075 + 0.24 + 0.0825$ ✓

$= \boxed{0.3975}$

2.

ii.) $p(D|e) = \dfrac{p(D \cap e)}{p(e)} = \dfrac{(0.15 \times 0.55)}{0.3975} = \dfrac{0.0825}{0.3975}$

$= \boxed{0.208}$ (3sf) ✓

2.

c) $P = 0.3975$, $n = 10$ $\therefore$ $\boxed{np = 3.98}$ (< 10)

~~$\therefore X \sim P_o(3.98)$~~

~~$p(X = 4) = \boxed{0.19535}$~~

0

$X \sim B(10, 0.3975)$

$p(X = 4) = \boxed{0.25078}$ ✗

7

Commentary

A correct tree diagram is drawn in part (a), although it is often helpful to multiply the branch probabilities (eg 0.25×0.3) and list them on the right of the diagram; checking that they add to unity. The answers to part (b) are clearly presented and are correct.
However, in part (c), $P(X = 4)$ was required using B(10, (b)(ii)), **not** B(10, (b)(i)) since it is stated in the question that the 10 faults selected are (known to be) electrical faults.

Mark Scheme

Q	Solution	Marks	Total	Comments
4 **(a)**	B(0.25) — E(0.30) 0.0750; M(0.50) 0.1250; W(0.20) 0.0500	B1		B, S & D with 3 probabilities
	S(0.60) — E(0.40) 0.0240; M(0.45) 0.2700; W(0.15) 0.0900	B2	3	3 × (E, M & W) each with 3 probabilities
	D(0.15) — E(0.55) 0.0825; M(0.35) 0.0525; W(0.10) 0.0150	(B1)		≥ 1 × (E, M & W) (each) with 3 probabilities
(b)(i)	P(E) = $(0.25 \times 0.3) + (0.6 \times 0.4) + (0.15 \times 0.55)$ = 0.075 + 0.24 + 0.0825 =	M1		≥ 1 term correct
	0.397 to 0.398 or 159/400	A1	2	AWFW/CAO (0.3975)
(ii)	$P(D \mid E) = \dfrac{0.0825}{(b)(i)} =$	M1		Or equivalent
	0.207 to 0.208 or 11/53	A1	2	AWFW/CAO (0.2075)
(c)	$X \sim B(10,\ (b)(ii))$	M1		Used
	$P(X=4)=\binom{10}{4}(0.2075)^4(0.7925)^6 =$	A1√		ft on **(b)(ii)**
	0.0955 to 0.0975	A1	3	AWFW (0.09645)
	Total		**10**	

Question 5

5 The daily number of emergency calls received from district A may be modelled by a Poisson distribution with a mean of λ_A.

The daily number of emergency calls received from district B may be modelled by a Poisson distribution with a mean of λ_B.

During a period of 184 days, the number of emergency calls received from district A was 3312, whilst the number received from district B was 2760.

(a) Construct an approximate 95% confidence interval for $\lambda_A - \lambda_B$. *(6 marks)*

(b) State one assumption that is necessary in order to construct the confidence interval in part (a). *(1 mark)*

Student Response

5) $\lambda_a = \frac{3312}{184} = 18$ ✓

$\lambda_b = \frac{2760}{184} = 15$ ✓

C.I. is $\lambda_a - \lambda_b \pm z\sqrt{\lambda_a + \lambda_b}$

$= 3 \pm 1.96\sqrt{18+15} = 3 \pm 11.26 \Rightarrow$

$\Rightarrow -8.26 < \lambda_a - \lambda_b < 14.26$

(b) Samples are independent ✓

6) E(...) = 128

B1 B1 M0 M1 A0 A0 B1 — 4

Commentary

The answer to part (a) starts correctly by finding the mean values of 18 and 15 and of $z = 1.96$. The error, which was common, is the omission of 184 in the denominator of both 18 and 15 in the variance term. This divisor is due to 18 and 15 being mean values for 184 days. The identification of ‘independent’ is the correct answer to part (b); ‘random’ was **not** accepted.

Mark Scheme

Q	Solution	Marks	Total	Comments
5 **(a)**	$\hat{\lambda}_A = \frac{3312}{184} = \mathbf{18}$ $\hat{\lambda}_B = \frac{2760}{184} = \mathbf{15}$	B1		CAO both
	$95\% \Rightarrow z = \mathbf{1.96}$	B1		CAO
	CI for $(\lambda_A - \lambda_B)$:	M1		Variance term
	$(\hat{\lambda}_A - \hat{\lambda}_B) \pm z\sqrt{\frac{\hat{\lambda}_A}{n_A} + \frac{\hat{\lambda}_B}{n_B}}$	M1		CI expression used
	ie $(18-15) \pm 1.96 \times \sqrt{\frac{18}{184} + \frac{15}{184}}$	A1√		ft on $\hat{\lambda}_A$, $\hat{\lambda}_B$ and z
	ie $\mathbf{3 \pm 0.83}$ or **(2.17, 3.83)**	A1	6	AWRT
(b)	Calls from A and B are independent	B1	1	Or equivalent
(a)	*Alternative Solution*			
	$(3312 - 2760) \pm 1.96 \times \sqrt{3312 + 2760} =$ ie 552 ± 152.73	(M2) (B1) (A1)		1.96
	Dividing by 184	(M1)		
	ie $\mathbf{3 \pm 0.83}$ or **(2.17, 3.83)**	(A1)		AWRT
	Total		**7**	

Question 6

6 An aircraft, based at airport A, flies regularly to and from airport B.

The aircraft's flying time, X minutes, from A to B has a mean of 128 and a variance of 50.

The aircraft's flying time, Y minutes, on the return flight from B to A is such that

$$\mathrm{E}(Y) = 112, \quad \mathrm{Var}(Y) = 50 \quad \text{and} \quad \rho_{XY} = -0.4$$

(a) Given that $F = X + Y$:

(i) find the mean of F;

(ii) show that the variance of F is 60. *(4 marks)*

(b) At airport B, the stopover time, S minutes, is independent of F and has a mean of 75 and a variance of 36.

Find values for the mean and the variance of:

(i) $T = F + S$; *(2 marks)*

(ii) $M = F - 3S$. *(3 marks)*

(c) Hence, assuming that T and M are normally distributed, determine the probability that, on a particular round trip of the aircraft from A to B and back to A:

(i) the time from leaving A to returning to A exceeds 300 minutes; *(3 marks)*

(ii) the stopover time is greater than one third of the total flying time. *(6 marks)*

Student Response

Question number

Leave blank

6.) X_{A-B} = $\mu = 128$, $\sigma^2 = 50$

X_{B-A} $E(Y) = 112$, $Var(Y) = 50$ & $\rho_{xy} = -0.4$

a.) $F = X + Y$

i.) $E(F) = E(X) + E(Y) = 128 + 112 = 240$ B1

ii.) $Var(F) = Var(X) + Var(Y) - 2Cov(X,Y)$ M0

$= 50 + 50 - (E((X-\mu_x)(Y-\mu_y)))$

$= 100 - E(XY - \mu_x\mu_y)$

$\rho = \frac{Cov(X,Y)}{\sigma_x\sigma_y}$ $\therefore Cov(X,Y) = \rho \times \sigma_x\sigma_y = 0.4 \times (\sqrt{50} \times \sqrt{50})$ M1

$= 0.4 \times 50$

$= 20$

$\therefore Var(F) = Var(X) + Var(Y) - 2Cov(X,Y)$ Fiddle AC

$= 50 + 50 - 2(20)$

$= 100 - 40 = 60$

b.) i.) $T = F + S$ $\therefore E(T) = E(F) + E(S)$

$\Rightarrow E(T) = 240 + 75 = 315$ 2

$Var(T) = Var(F) + Var(S)$

$= 60 + 36 = 96$

ii.) $M = F - 3S \Rightarrow E(M) = E(F) - 3[E(S)]$ B1

$= 240 - 3(75) = 15$

$Var(M) = Var(F) + 3[Var(S)] = 60 + 3(36) = 168$ 0

Question number

Leave blank

6 c.) $T \sim N(315, 96)$ (np, np(1-p))

$M \sim N(15, 168)$ (np, np(1-p))

i.) $(F + S) = T$ Use continuity correction M1

$\therefore p(T > 300) = p(T > 299.5)$ M1

$p(T > 300.5)$

$= 0.94317$

$= 0.93055$ A0

ii.) $p(S > \frac{1}{3}F)$ M1

$\therefore p(3S > F)$ M1 A1

Commentary

In part (a)(ii), the answer has been contrived to match that given; a loss of 2 marks. When answers are given, examiners are always on the lookout for 'fiddles'. In part (b)(ii), the candidate changed minus to plus in finding variance but did not square the multiplier of 3; again a loss of 2 marks. In part (c)(i), somewhat generous method marks were gained for realising that >300(.5) was needed and that it necessitated an area change. Candidates should be aware that as time is a continuous random variable, corrections of ±0.5 are strictly invalid. In part (c)(ii), the 3 marks awarded are for realising that P(M < 0) is needed but here, as no evidence is provided, the remaining 3 marks are lost.

Mark Scheme

Q	Solution	Marks	Total	Comments
6 (a)(i)	$E(F) = 128 + 112 = \mathbf{240}$	B1		CAO
(ii)	$\text{Cov}(X, Y) = -0.4 \times \sqrt{50 \times 50} = \mathbf{-20}$	M1		Used; or equivalent
	$\text{Var}(F) = 50 + 50 + (2 \times -20) = \mathbf{60}$	M1 A1	4	$V(X) + V(Y) + 2\text{Cov}(X,Y)$ used CAO; **AG**
(b)(i)	$E(T) = 240 + 75 = \mathbf{315}$	B1√		ft on (a)(i)
	$\text{Var}(T) = 60 + 36 = \mathbf{96}$	B1	2	CAO
(ii)	$E(M) = 240 - (3 \times 75) = \mathbf{15}$	B1√		ft on (a)(i)
	$\text{Var}(M) = 60 + \{(-3^2) \times 36\}$ $= 60 + 324 = \mathbf{384}$	M1 A1	3	$V(F) + 3^2V(S)$ used CAO
(c)(i)	$P(T > 300) = P\left(Z > \frac{300 - 315}{\sqrt{96}}\right)$	M1		Standardising 300 or 300.5 using (b)(i)
	$= P(Z > -1.53) = P(Z < 1.53)$	m1		Area change
	$= \mathbf{0.936 \text{ to } 0.938}$	A1	3	AWFW
(ii)	$P\left(S > \frac{X + Y}{3}\right) =$	M1		Used; or equivalent
	$P(3S > X + Y) = P(3S > F) =$	M1		Attempt to change to M
	$P(F - 3S < 0) = P(M < 0)$	A1		Or equivalent
	$= P\left(Z < \frac{0 - 15}{\sqrt{384}}\right)$	M1		Standardising 0 using (b)(ii)
	$= P(Z < -0.765) = 1 - P(Z < 0.765)$	m1		Area change
	$= \mathbf{0.22(0) \text{ to } 0.225}$	A1	6	
	Total		**18**	

Question 7

7 (a) The random variable X has a Poisson distribution with $\mathrm{E}(X) = \lambda$.

(i) Prove, from first principles, that $\mathrm{E}(X(X-1)) = \lambda^2$. *(4 marks)*

(ii) Hence deduce that $\mathrm{Var}(X) = \lambda$. *(2 marks)*

(b) The independent Poisson random variables X_1 and X_2 are such that $\mathrm{E}(X_1) = 5$ and $\mathrm{E}(X_2) = 2$.

The random variables D and F are defined by

$$D = X_1 - X_2 \quad \text{and} \quad F = 2X_1 + 10$$

(i) Determine the mean and the variance of D. *(2 marks)*

(ii) Determine the mean and the variance of F. *(3 marks)*

(iii) For **each** of the variables D and F, give a reason why the distribution is **not** Poisson. *(2 marks)*

(c) The daily number of black printer cartridges sold by a shop may be modelled by a Poisson distribution with a mean of 5.

Independently, the daily number of colour printer cartridges sold by the same shop may be modelled by a Poisson distribution with a mean of 2.

Use a distributional approximation to estimate the probability that the total number of black and colour printer cartridges sold by the shop during a 4-week period (24 days) exceeds 175. *(6 marks)*

Student Response

7a i

$$E(X(X-1)) = \sum_0^\infty x(x-1)\ P(X=x)$$

$$= \sum_0^\infty x(x-1)\ \frac{e^{-\lambda}\lambda^x}{x!}$$

(nb $\lambda^2 \times \lambda^{x-2} = \lambda^x$) $= \lambda^2 \sum_0^\infty x(x-1)\ \frac{e^{-\lambda}\lambda^{x-2}}{x!}$

(nb $\frac{x(x-1)}{x!} = \frac{1}{(x-2)!}$) $= \lambda^2 \sum_0^\infty \frac{e^{-\lambda}\lambda^{x-2}}{(x-2)!}$

why

(nb Σ all probs $= 1$) $= \lambda^2 \sum_0^\infty P(X=x)$

$$= \lambda^2 \times 1$$

$$= \lambda^2$$

ii

$$Var(X) = E(X^2) - (E(X))^2$$

$$= E(X^2) - E(X) + E(X) - (E(X))^2$$

$$= E(X(X-1)) + E(X) - (E(X))^2$$

$$= \lambda^2 + \lambda - \lambda^2$$

$$= \lambda$$

18

M3

A0

2

Question number		Leave blank
7b	$X_1 \sim Po(5)$	
	$X_2 \sim Po(2)$	
	i $E(D) = E(X_1) - E(X_2)$	
	$= 5 - 2 = 3$ ✓	
	$Var(D) = Var(X_1) + Var(X_2)$ ✓	2
	$= 5 + 2 = 7$	
	ii $E(F) = 2E(X_1) + 10$	
	$= 2 \times 5 + 10$	
	$= 20$ ✓	B1
	$Var(F) = 2^2 var(X_1) + 10$	
	$= 4 \times 5 + 10$	
	$= 20 + 10$ ✗	0
	$= 30$	
	iii Mean and variance not the same on F ✓	B1
	Mean and variance not the same on D ✗	0
c	$E(X_1) + E(X_2) = 5 + 2 = 7$	
	$A = X_1 + X_2 \sim Po(7)$	
	$24(X_1 + X_2) \sim Po(168)$	B1
	$\sim N(168, \sqrt{168}^2)$ ✓	M1
	$P(A > 175) = 1 - P(A < 175)$	

Question number

Leave blank

7c

$1 - P(A < 175)$

$= 1 - P\left(Z < \frac{175 - 168}{\sqrt{168}}\right)$ B0

$= 1 - P(Z < 0.54)$ M1

$= 1 - \Phi(0.54)$ m1

$= 1 - 0.7054$

$= 0.295$ (3sf) A0

(13)

Commentary

The proof required in part (a)(i), is not fully correct as there is a 'fudging' of the limits. However the answer to part (a)(ii) is worthy of full marks. In parts (b)(i) & (ii), the mean and variance of D and the mean of F are correct, but the variance of D should not include the '+ 10'. This error enabled the candidate to give the same reason in (iii) when, in fact, for D both the mean and variance are 10 so a different reason (eg values less than 10 impossible) was needed. The only error in part (c) was to omit the continuity correction (here '+0.5'); something necessary when using the normal approximation to the Poisson (or binomial) distributions.

Q	Solution	Marks	Total	Comments
7(a)(i)	$\mathrm{E}(X(X-1)) = \sum_{x=0}^{\infty} x(x-1)\times\frac{e^{-\lambda}\lambda^x}{x!} =$	M1		$\sum x(x-1)\times \mathrm{P}(X=x)$ used Ignore limits until A1
	$\sum_{x=2}^{\infty}\frac{e^{-\lambda}\lambda^x}{(x-2)!} =$	M1		$\frac{x(x-1)}{x!}=\frac{1}{(x-2)!}$ used
	$\lambda^2 e^{-\lambda}\sum_{x=2}^{\infty}\frac{\lambda^{x-2}}{(x-2)!} =$	M1		Factor of $\lambda^2 e^{-\lambda}$ used
	$(\lambda^2 e^{-\lambda})\times(e^{\lambda}) = \boldsymbol{\lambda^2}$	A1	4	Fully correct derivation; **AG**
(ii)	$\mathrm{Var}(X) = \mathrm{E}(X(X-1)) + \mathrm{E}(X) - (\mathrm{E}(X))^2$	M1		Used
	$= \lambda^2 + \lambda - \lambda^2 = \boldsymbol{\lambda}$	A1	2	Fully correct derivation; **AG**
(b)(i)	$\mathrm{E}(D) = 5 - 2 = \mathbf{3}$ $\mathrm{Var}(D) = 5 + 2 = \mathbf{7}$	B1 B1	2	CAO CAO
(ii)	$\mathrm{E}(F) = (2\times 5) + 10 = \mathbf{20}$ $\mathrm{Var}(F) = 2^2\times 5$ $= \mathbf{20}$	B1 M1 A1	3	CAO $2^2\mathrm{V}(X_1) + 0$ CAO
(iii)	D: Mean $\neq$ Variance	B1		Negative values possible
	F: Values < 10 impossible Odd values impossible	B1	2	$2X_1 = X_1 + X_1$ is not sum of independent Po variables
(c)	$B \sim \mathrm{Po}(5) \quad C \sim \mathrm{Po}(2)$			
	$T = 24 \times (5 + 2) \sim \mathrm{Po}(\mathbf{168})$	B1		CAO
	$T \sim$ approx $\mathrm{N}(168, 168)$	M1		Normal with $\mu = \sigma^2$
	$\mathrm{P}(T_{\mathrm{Po}} > 175) = \mathrm{P}(T_{\mathrm{N}} > 175.5)$	B1		175.5
	$= \mathrm{P}\left(Z > \frac{175.5-168}{\sqrt{168}}\right) = \mathrm{P}(Z > 0.58) =$	M1		Standardising 174.5, 175 or 175.5 with $\mu = \sigma^2$
	$1 - \mathrm{P}(Z < 0.58) =$ **0.28(0) to 0.283**	m1 A1	6	Area change AWFW
	Total		**19**	
	TOTAL		**75**	