A Level Statistics

AQA Past Exam Questions

TOPIC: The Binomial Distribution Solutions

Candidates may use any calculator allowed by Pearson regulations. Calculators must not have retrievable mathematical formulae stored in them.

Instructions

• Use **black** ink or ball-point pen.

• If pencil is used for diagrams/sketches/graphs it must be dark (HB or B). Coloured pencils and highlighter pens must not be used.

• **Fill in the boxes** at the top of this page with your name, centre number and candidate number.

• Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.

• Answer the questions ***on paper***

• You should show sufficient working to make your methods clear. Answers without working may not gain full credit.

• Unless otherwise stated, statistical tests should be carried out at the 5% significance level.

• When a calculator is used, the answer should be given to three significant figures unless otherwise stated.

Information

• ***You may use the*** booklet 'Statistical Formulae and Tables'

• There are **13** questions in this question paper. The total mark for this paper is ***146***

• The marks for **each** question are shown in brackets – use this as a guide as to how much time to spend on each question.

Advice

• Read each question carefully before you start to answer it.

• Try to answer every question.

• Check your answers if you have time at the end.

• If you change your mind about an answer, cross it out and put your new answer and any working underneath.

• Check your answers if you have time at the end.

AQA_JAN_2012_4

Q	Solution	Marks	Total	Comments
4(a)	$U \sim B(40, 0.15)$	M1		Used somewhere in (a)
(i)	$P(U = 6) = 0.6067 - 0.4325$ or			Accept 3 dp rounding or truncation
	$= \binom{40}{6}(0.15)^6(0.85)^{34}$	M1		Can be implied by a correct answer
	$= 0.174$	A1	3	AWRT (0.1742)
(ii)	$P(U \leq 5) = 0.432$ to 0.433	B1	1	AWFW (0.4325)
(iii)	**See supplementary sheet for individual probabilities**			
	$P(5 < U < 10) = 0.9328$ or 0.9701 (p_1)	M1		Accept 3 dp rounding or truncation but allow 0.97 $p_2 - p_1 \Rightarrow$ M0 M0 A0 $(1-p_2) - p_1 \Rightarrow$ M0 M0 A0 $p_1 - (1-p_2) \Rightarrow$ M1 M0 A0 $(1-p_2) - (1-p_1) \Rightarrow$ M1 M1 (A1) only providing result > 0
	MINUS 0.4325 or 0.2633 (p_2)	M1		Accept 3 dp rounding or truncation
	$= 0.5(00)$ to 0.501	A1	3	AWFW (0.5003)
(b)	Mean or $\mu = 32 \times 0.15 = 4.8$	B1		CAO
	(V or σ^2 =) $32 \times 0.15 \times 0.85$ or (SD or σ =) $\sqrt{32 \times 0.15 \times 0.85}$	M1		Either numerical expression; ignore terminology May be implied by 4.08 CAO seen or 2.02 AWRT seen
	(SD or σ) = 2.02	A1	3	AWRT (2.0199) Do not award if labelled V or σ^2
(c)	Mean = 7.7	B1		CAO $(\sum x = 77)$
	SD = 1.26 to 1.34	B1		AWFW $(\sum x^2 = 609)$
	(Sample) mean is bigger / greater / different or 7.7/32 = 0.24 > 0.15 and (Sample) SD is smaller / less / different	Bdep1		Both; dependent on all previous 5 marks of B1 M1 A1 B1 B1 Can be scored for incorrect (b) re-done correctly in (c) Means & SDs different $\Rightarrow$ Bdep0
	So model appears unsuitable	Bdep1	4	OE; dependent on Bdep1
		Total	**14**	

Q	Solution	Marks	Total	Comments
3 (a) (i)	$E \sim B(40, 0.30)$	M1		Used anywhere in (a) even only by implication from a **correct** value
	$P(E \leq 10) =$ **0.308 to 0.309**	A1	(2)	AWFW (0.3087)
SC	For calc^n of individual terms: award B2 for answer within above range; award B1 for answer within range 0.3 to 0.32			
(ii)	$P(E \geq 15) =$ **1 – (0.8074 or 0.8849)**	M1		Requires '1 –' Accept 3 dp rounding or truncation Can be implied by 0.192 to 0.193 but **not** by 0.115 to 0.116
	= **0.192 to 0.193**	A1	(2)	AWFW (0.1926)
SC	For calc^n of individual terms: award B2 for answer within above range; award B1 for answer within range 0.18 to 0.2			
(iii)	$P(E \leq 12) =$ **0.5772 – 0.4406** **or** $P(E \leq 12) = \binom{40}{12}0.3^{12}0.7^{28}$	M1		Accept 3 dp rounding or truncation Correct expression; may be implied by a **correct** answer
	= **0.136 to 0.138**	A1	(2)	AWFW (0.1366)
			6	
(b)	Means = **3.2 and 2**	B1		CAO both **values**; ignore notation *If not labelled, assume order in question*
	Variances = **2.56 and 1.75**	B1 B1	3	CAO each **value**; ignore notation ISW all subsequent working
(c)(i)	Mean = **2**	B1		CAO **value**; ignore notation
	Variance = **2.54 to 2.55 or 2.33 to 2.34** (SD = 1.59 to 1.6 or 1.52 to 1.53)	B1	2	Any **value** within either range; ignore notation ISW all subsequent working
(ii)	B(16, 0.20) **or** eg "One dist^n" **Different/larger** mean **Similar/same** variance or standard deviation	Bdep1		Identification of distribution **not** required Both; dep on 3.2, 2.56 /1.6 & (c)(i)
	B(16, 0.125) **or** eg "Other dist^n" **Equal/same** mean **Different/smaller** variance or standard deviation	Bdep1		Identification of distribution **not** required Both; dep on 2, 1.75/1.3 & (c)(i)
	Neither likely to provide satisfactory model	Bdep1	3	Dep on Bdep1 and on Bdep1
SC	Award Bdep1 Bdep0 Bdep0 for comparison of 3 correct means only **or** for comparison of 3 correct variances/SDs only Award up to Bdep1 Bdep1 Bdep1 for comparison of 3 correct means **and** for comparison of 3 correct variances/SDs			
		Total	**14**	

AQA_JUNE_2012_6

Q	Solution	Marks	Total	Comments
6 (a)(i)	$U \sim$ B(30, 0.13, 0.35 or 0.20)	M1		Used correctly anywhere in (a)
	$P(P = 2) = \binom{30}{2}(0.13)^2(0.87)^{28}$	A1		Can be implied by a **correct** answer
	$= \underline{\mathbf{0.148 \text{ to } 0.15}}$	A1	3	AWFW (0.1489)
(ii)	$p = \underline{\mathbf{0.35}}$	B1		CAO
	$P(R \cup P > 10) = \underline{\mathbf{1 - (0.5078 \text{ or } 0.3575)}}$	M1		Requires '1 –' Accept 3 dp rounding or truncation Can be implied by 0.49 to 0.493 but **not** by 0.642 to 0.643
	$= \underline{\mathbf{0.49 \text{ to } 0.493}}$	A1	3	AWFW (0.4922)
(iii)	$P(5 \leq G \leq 10) =$ **0.9744 or 0.9389** (p_1)	M1		Accept 3 dp rounding or truncation
	MINUS 0.2552 or 0.4275 (p_2)	M1		Accept 3 dp rounding or truncation
	$= \underline{\mathbf{0.719 \text{ to } 0.72}}$ (p_3)	A1	3	AWFW (0.7192)
Notes	**1** $p_3 \leq 0$ or $p_3 \geq 1 \Rightarrow$ M0 M0 A0 **2** $p_2 - p_1 \Rightarrow$ M0 M0 A0 **3** $(1 - p_2) - p_1 \Rightarrow$ M0 M0 A0			**4** $p_1 - (1 - p_2) \Rightarrow$ M1 M0 A0 **5** $p_1 \times p_2 \Rightarrow$ M1 M0 A0 **6** $(1 - p_2) - (1 - p_1) \Rightarrow$ M1 M1 (A1)
(b)(i)	Mean or $\mu = 100 \times 0.22 = \underline{\mathbf{22}}$	B1		CAO
	Variance or $\sigma^2 = 100 \times 0.22 \times 0.78$ $= \underline{\mathbf{17.1 \text{ to } 17.2}}$	B1	2	AWFW (ignore notation) (17.16) ISW all subsequent working
(ii)	22.1 ≈/= 22 or means similar/equal **or** 0.221 ≈/= 0.22 or proportions similar/equal so **reject claim** (that $p > 0.22$) **or** **accept that $p = 0.22$**	B1		Dependent on 22 seen in (b)(i) or (ii) Accept diff = 0.1 CAO **Correct** (numerical) comparison with **correct** conclusion (even if at end and stated as 'reject (both) claims')
	$\sqrt{17.1 \text{ to } 17.2} = \underline{\mathbf{4.13 \text{ to } 4.15 \approx/= 4.17}}$			Comparison using two values **or** one value + diff (0.02 to 0.04 AWFW)
	or	B1		
	$\underline{\mathbf{17.1 \text{ to } 17.2 \approx/= 17.3 \text{ to } 17.4}}$			Comparison using two values **or** one value + diff (0.1 to 0.3 AWFW)
	so **reject claim that not random samples** **or** **accept that are random samples**	Bdep1	3	Dependent on previous B1 **Correct** conclusion regarding randomness of sample
	Total		**14**	

AQA_JUNE_2013_3

Q	Solution	Marks	Total	Comments
				Accept percentage equivalents except for 27
3(a)(i)	$O \sim \text{B}(40, p)$			
	$\text{P}(NS \leq 10) = \underline{\mathbf{0.97}}$	B1	1	AWRT (0.9701)
(ii)				Requires '1 –'
	$\text{P}(LPE \geq 25) = \underline{\mathbf{1 - (0.9231 \text{ or } 0.9597)}}$	M1		Accept 3 dp rounding Can be implied by (0.0769 to 0.077) but **not** by (0.04 to 0.0403)
	$= \underline{\mathbf{0.077}}$	A1	2	AWRT (0.0769)
(iii)	$\text{P}(UPE = 2) = \binom{40}{2}(0.175)^2(0.825)^{38}$	M1		Correct expression; may be implied by a **correct** answer Ignore extra terms
	$= \underline{\mathbf{0.016}}$	A1	2	AWRT (0.0160)
(iv)				CAO; award on value only May be implied by any of four probabilities below or by a **correct** answer
	$p = 0.85 - 0.50 = \underline{\mathbf{0.35}}$	B1		
	$\text{P}(10 < X < 15) =$ **0.5721 or 0.6946** (p_1)	M1		Accept 3 dp rounding May be implied by a **correct** answer
	MINUS 0.1215 or 0.0644 (p_2)	M1		Accept 3 dp rounding May be implied by a **correct** answer
	$= \underline{\mathbf{0.45 \text{ to } 0.451}}$	A1	4	AWFW (0.4506)
(b)	$p = 0.85 - 0.175 = \underline{\mathbf{0.675}}$ **or** $p' = \underline{\mathbf{0.325}}$	B1		CAO; may be implied by 27 Each can be found in several ways CAO; may be implied by 13 or 27
	Number $= 40 \times 0.675 = \underline{\mathbf{27}}$	B1	2	CAO; can be found in several ways
	Total		**11**	

AQA_JAN_2007_2

Q	Solution	Marks	Total	Comments
2(a)	Use of binomial in (a), (b) or (c)	M1		Can be implied
	$P(E=5)=\binom{16}{5}(p)^5(1-p)^{11}$	M1		Allow $p = 0.45, 0.25, 0.30$ or $\frac{1}{3}$
	$= 0.112$	A1	3	AWRT (0.1123)
(b)(i)	B(50, 0.25)	B1		Used; can be implied
	$P(C \leq 12) = 0.511$	B1	2	AWRT (0.5110)
(ii)	$P(10 < B' < 20) = 0.9152$ or 0.9522	M1		Allow 3 dp accuracy
	minus 0.0789 or 0.1390	M1		Allow 3 dp accuracy
	$= 0.836$	A1	3	AWRT (0.8363)
	or			
	B(50, 0.30) expressions stated for **at least 3** terms within $10 \leq B' \leq 20$	(M1)		Or implied by a correct answer
	Answer = 0.836	(A2)		AWRT
(c)	$n = 40,\ p = 0.7$	B1		Both used; can be implied
	Mean $\mu = np = 28$	B1√		CAO; √ on p only
	Variance $\sigma^2 = np(1-p) = 8.4$	M1		Use of $np(1-p)$ even if SD
	Standard deviation $= \sqrt{8.4}$ or $= 2.89$ to 2.9	A1	4	CAO; AWFW
	Total		**12**	

AQA_JAN_2008_7

Q	Solution	Marks	Total	Comments
7(a)	Use of binomial in (a) or (b)	M1		Can be implied by answers
(i)	$P(X \geq x) = 1 - P(X \leq x - 1)$			Identified from an answer / 1 – answer
	OR	M1		Can be implied from a correct answer
	$= 1 - B(\Sigma x, 50, 0.08)$			Identified from an answer/expression
	$= 1 - 0.0827 = 0.915$ to $0.92(0)$	A1		AWFW (0.9173)
				≥ 1 correct $\Rightarrow$ M1 M1
(ii)	$P(X \geq 3)$			
	$= 1 - 0.2260 = 0.77(0)$ to 0.775	A1	4	AWFW (0.7740)
(b)(i)	$P(Y = 0) = (1 - 0.025)^{15} = 0.975^{15}$	M1		Can be implied from correct answer
	$= 0.68(0)$ to 0.685	A1		AWFW (0.6840)
(ii)	$P(Y \geq 1) = 1 -$ (i)	M1		Can be implied from answer if ε (0, 1)
	$= 0.315$ to $0.32(0)$	A1√	4	√ on (i) if ε (0, 1) (0.3160)
(c)	Probability =			
	[(b)(ii) × (a)(i)] or (0.316×0.917)	M1		Ignore additional terms
	[(b)(i) × (a)(ii)] or (0.684×0.774)	M1		
	$= 0.2898 + 0.529$	A1		2 terms added with ≥ 1 correct
	$= 0.81$ to 0.83	A1	4	AWFW (0.8193)
	Total		**12**	

AQA_JAN_2009_7

Q	Solution	Marks	Total	Comments
7 (a)(i)	B(16 or 25 or 40, 0.45)	M1		Used at least once in (a)(i) to (iii)
	$P(S = 3) = \binom{16}{3}(0.45)^3(0.55)^{13}$	A1		May be implied by correct answer Ignore any additional terms
	$= 0.021$ to 0.022	A1	3	AWFW (0.0215)
(ii)	$P(S < 10) = 0.3843$ or 0.2424	B1		Accept 3 dp accuracy from tables or calculation
	$= 0.242$ to 0.243	B1	2	AWFW (0.2424)
(iii)	$P(15 \leq S \leq 20)$	M1		Accept 3 dp accuracy
	$= 0.7870$ or 0.6844 (p_1)			$p_2 - p_1 \Rightarrow$ M0 M0 A0 $p_1 - (1 - p_2) \Rightarrow$ M1 M0 A0
	minus 0.1326 or 0.2142 (p_2)	M1		Accept 3 dp accuracy / truncation
	$= 0.654$ to 0.655	A1		AWFW (0.6544)
	OR			
	B(40, 0.45) expressions stated for at least 3 terms within $14 \leq S \leq 20$ gives probability	(M1)		Or implied by a correct answer
	$= 0.654$ to 0.655	(A2)	3	AWFW
(iv)	Mean, $\mu = np = 50 \times 0.45$	B1		CAO ($22.5 = 22$ or $23 \Rightarrow$ ISW)
	$= 22.5$ or $22\frac{1}{2}$			
	Variance, $\sigma^2 = np(1-p)$			Accept $12\frac{3}{8}$ or $\frac{99}{8}$
	$= 50 \times 0.45 \times 0.55$			
	$= 12.3$ to 12.4	B1	2	AWFW (12.375)
(b)(i)	**Non-independence** of senior citizens travel Senior citizens tend to **travel in pairs/groups**	B1	1	Or equivalent; but must be a clear indication of non-independent events
(ii)	7.15 am is outside 9.30 am to 11.30 am Cannot use SCPs before 9.30 am Cannot use SCPs @ 7.15 am Cannot use SCPs during morning 'rush hour'			
	Value of p likely to be smaller/different/zero	B1		Or equivalent Accept other **sensible** reasons
	Data not available Senior citizens not out at this time Passengers likely to be workers/school children		1	Distribution of **types of** passenger different
		Total	**12**	

AQA_JAN_2010_6

Q	Solution	Marks	Total	Comments
6(a)(i)	$R \sim B(14, 0.35)$ $P(R \leq 7) = 0.924$ to 0.925	M1 A1	2	Used somewhere in (a); may be implied AWFW (0.92466)
(ii)	$P(R \geq 11) = 1 - P(R \leq 10)$ $= 1 - (0.9989$ or $0.9999)$	M1		Requires '1 –' and ≥ 4 dp accuracy
	$= 0.0011$	A1	2	AWRT (0.001106)
(iii)	$P(5 < R < 10) = 0.9940$ or 0.9989 (p_1)	M1		Accept 3 dp accuracy $p_2 - p_1 \Rightarrow$ M0 M0 A0 $(1 - p_2) - p_1 \Rightarrow$ M0 M0 A0 $p_1 - (1 - p_2) \Rightarrow$ M1 M0 A0 only providing result > 0
	minus 0.6405 or 0.4227 (p_2)	M1		Accept 3 dp accuracy
	$= 0.353$ to 0.354	A1	3	AWFW (0.35346)
	or B(14, 0.35) expressions stated for **at least 3** terms within $4 \leq R \leq 11$ gives probability	(M1)		Can be implied by correct answer
	$= 0.353$ to 0.354	(A2)		AWFW (0.35346)
(b)	$R \sim B(21, 0.35)$	M1		Implied from correct stated formula; do not accept misreads
	$P(R = 4) = \binom{21}{4}(0.35)^4(0.65)^{17}$	A1		Can be implied by a correct answer Ignore any additional terms
	$= 0.059$ to 0.0595	A1	3	AWFW (0.059274)
(c)(i)	$S \sim B(7, 5/7)$ Mean $= np = 7 \times 5/7 = 5$ If not identified, assume order is μ then σ^2	B1		CAO
	Variance $= np(1-p)$ $= 7 \times 5/7 \times 2/7 = 10/7$ or 1.42 to 1.43	B1	2	Must clearly state variance value if standard deviation (also) stated CAO / AWFW
(ii)	**Means** are the **same** **and (both comparisons clearly stated)** **Variances**/standard deviations are **similar** Do not accept statements involving correct/incorrect/exact/etc	B1dep		Must have scored B1 B1 in (i) or B1 B0 plus $10/7$ v 1.5 or $\sqrt{10/7}$ v $\sqrt{1.5}$ **stated**
	Barry's claim appears/is **sound/valid/correct/likely**	B1dep	2	Must have scored previous B1dep
		Total	**14**	

AQA_JAN_2011_4

Q	Solution	Marks	Total	Comments
4(a)	$R \sim B(15, 0.45)$			
(i)	$P(R \leq 5) = 0.26(0)$ to 0.261	B1	1	AWFW (0.2608)
(ii)	$P(R > 10) = 1 - P(R \leq 10)$			Requires '1 –' Accept 3dp rounding or truncation
	$= 1 - (0.9745$ or $0.9231)$	M1		Can be implied by 0.025 to 0.026 but not by 0.0769 to 0.077
	$= 0.025$ to 0.026	A1	2	AWFW (0.0255)
(iii)	$P(R = 6) = 0.4522 - $ (a)(i)			
	or $= \binom{15}{6}(0.45)^6(0.55)^9$	M1		Can be implied by a correct answer
	$= 0.191$ to 0.192	A1	2	AWFW (0.1914)
(iv)	$P(5 \leq R \leq 10) = 0.9745$ or 0.9231 (p_1)	M1		Accept 3dp rounding or truncation $p_2 - p_1 \Rightarrow$ M0 M0 A0 $(1 - p_2) - p_1 \Rightarrow$ M0 M0 A0 $p_1 - (1 - p_2) \Rightarrow$ M1 M0 A0 only providing result > 0
	Minus 0.1204 or 0.2608 (p_2)	M1		Accept 3dp rounding or truncation
	$= 0.853$ to 0.855	A1	3	AWFW (0.8541)
	Or			
	B (15, 0.45) terms stated for at least 3 values within $4 \leq R \leq 11$ gives probability	(M1)		Can be implied by a correct answer
	$= 0.853$ to 0.855	(A2)		AWFW (0.8541)
(b)(i)	$P(S) = 0.85$ plus (0.15×0.80) 1 minus (0.15×0.20)	B1		CAO; requires 'plus' or 'minus'
		B1	2	CAO; not simply 0.12 or 0.03
	$= 0.97$			AG
	NB: $(0.85 \times 0.20) + 0.80 \Rightarrow$ B0 B0			
	$(0.85 \times 0.20) + (0.85 \times 0.80)$			
	$+ (0.15 \times 0.80) \Rightarrow$ B0 B1			
(ii)	$P(S \geq 48) = 0.81$ to 0.82 or 0.5553 or 0.9372	M2		Accept 3dp rounding or truncation M2 for the three correctly expressed terms for B (50, 0.03) or B (50, 0.97) added
	$= 0.81(0)$ to 0.811	A1	3	AWFW (0.8108)
	NB: Answer = 0.4447 or 0.1892 or 0.0628 $\Rightarrow$ M1 only			
(iii)	$p = 1 - 0.85 = 0.15$	B1		CAO; may be implied by correct answer or correct expression for mean
	Mean, $\mu = 80 \times 0.15 = 12$	B1	2	CAO
	SC Mean = 9.6 $\Rightarrow$ B1 only			
	Total		**15**	

AQA_JUNE_2007_6

Q	Solution	Marks	Total	Comments
6(a)	Use of binomial in (a) or (b)(i)	M1		PI
(i)	$P(T_{10} \leq 3) = 0.38$ to 0.383	B1	2	AWFW (0.3823)
(ii)	$P(10 < T_{40} < 20) =$ 0.8702 or 0.9256	M1		Allow 3 dp accuracy
	minus 0.0352 or 0.0156	M1		Allow 3 dp accuracy
	$=$ 0.83 to 0.84	A1		AWFW (0.835)
	OR			
	B(40, 0.40) expressions stated for at least 3 terms within $10 \leq T_{40} \leq 20$	(M1)		Or implied by a correct answer
	Answer = 0.83 to 0.84	(A2)	3	AWFW
(b)(i)	$n = 5 \quad p = 0.4$			
	Mean, $\mu = np = 2$	B1		CAO
	Variance, $\sigma^2 = np(1-p) = 1.2$	M1		Use of $np(1-p)$ even if SD
	Standard deviation $= \sqrt{1.2}$ or $= 1.09$ to 1.1	A1	3	CAO AWFW
(ii)	Mean $(\bar{x}) = 2$	B1		CAO $\sum x = 26$
	Standard Deviation $(s_n,\ s_{n-1})$ $= 1.1$ to 1.16	B2		$\sum x^2 = 68$ AWFW (1.1094 or 1.1547)
	If neither correct but use of mean $(\bar{x}) = \frac{\sum x}{13}$	(M1)	3	
(iii)	Means are same and SDs are similar/same	B1		Must have scored full marks in (b)(i) and (b)(ii)
	Means are same but SDs are different so	↑Dep↑		
	Trina's claims appear valid / invalid	B1	2	
	Total		**13**	

AQA_JUNE_2008_6

Q	Solution	Marks	Total	Comments
6	Binomial distribution	M1		Used somewhere in question
(a)(i)	$M \sim B(40, 0.35)$	A1		Used; may be implied
	$P(M \leq 15) = 0.69(0)$ to 0.696	A1	3	AWFW (0.6946)
(ii)	$P(10 < M < 20) =$			
	0.9637 or 0.9827	M1		Accept 3 dp accuracy
	minus 0.1215 or 0.0644	M1		Accept 3 dp accuracy
	$= 0.84(0)$ to 0.843	A1	3	AWFW (0.8422)
	OR			
	B(40, 0.35) expressions stated for **at least 3** terms within $10 \leq M \leq 20$	(M1)		Or implied by a correct answer
	Answer $= 0.84(0)$ to 0.843	(A2)		AWFW
(b)	$W \sim B(10, 0.29)$	B1		Used; may be implied
	$P(W = 3) = \binom{10}{3}(0.29)^3(0.71)^7$	M1		Stated; may be implied
	$= 0.266$ to 0.2665	A1	3	AWFW (0.2662) **Note**: B(10, 0.3) $\Rightarrow$ 0.2668
(c)(i)	$n = 20 \quad p = 0.71$	B1		Stated or used; may be implied by 14.2
	Mean, $\mu = np = 14.2$	B1		CAO
	Variance, $\sigma^2 = np(1-p) = 4.11$ to 4.12	B1	3	AWFW (4.118)
(ii)	Mean of 16.5 is greater/different **or** 16.5/20 = 0.825 is greater/different to 0.71	B1dep		Dependent on $\mu = 14.2$
	Means and variances are different	*(B2,1 dep)*		
	Variance of 2.50 is smaller/different	B1dep		Dependent on $\sigma^2 = 4.11$ to 4.12
	Suggests **claim** that groups are not random samples **is justified**	B1dep	3	Dependent on previous 2 marks Or equivalent
	Total		**15**	

Q	Solution	Marks	Total	Comments
4(a)	$\underline{M \sim B(50,\ 0.15)}$	M1		Used somewhere in (a); may be implied
(i)	$P(M \leq 10) =$ **0.88(0)**	A1	2	AWRT (0.8801)
(ii)	$P(M \geq 5) = 1 - P(M \leq 4)$			
	= **1 – (0.1121 or 0.2194)**	M1		Requires '1 –'; accept 3 dp accuracy Implied by 0.888 but **not** by 0.781
	= **0.888**	A1	2	AWRT (0.8879)
(iii)	$P(6 < R < 12) =$ **0.9372 or 0.9699** (p_1)	M1		Accept 3 dp accuracy rounding or truncation $p_2 - p_1 \Rightarrow$ M0 M0 A0 $(1 - p_2) - p_1 \Rightarrow$ M0 M0 A0 $p_1 - (1 - p_2) \Rightarrow$ M1 M0 A0 only providing result > 0
	minus 0.3613 or 0.2194 (p_2)	M1		Accept 3 dp accuracy
	= **0.576**	A1		AWRT (0.5759)
	OR			
	B(50, 0.15) expressions stated for **at least 3** terms within $5 \leq R \leq 12$ gives probability = **0.576**	(M1) (A2)	3	Can be implied by correct answer AWFW (0.5759)
(b)	$\underline{F \sim B(35,\ 0.11)}$	M1		Implied from correct stated formula; do not accept misreads
	$P(F = 4) = \binom{35}{4}(0.11)^4(0.89)^{31}$	A1		Can be implied by a correct answer Ignore any additional terms
	= **0.206 to 0.208**	A1	3	AWFW (0.20685)
(c)	$P(M \text{ and } LH) = 0.52 \times 0.15 =$ **0.078**)			
	or $N(M) = 2000 \times 0.52 =$ **1040**)	M1		**≥1** of these 2 probabilities or **≥1** of these 2 numbers attempted; may be implied
	$P(F \text{ and } LH) = 0.48 \times 0.1 =$ **0.0528**)			
	or $N(F) = 2000 \times 0.48 =$ **960**)	A1		**2** probabilities or **2** numbers evaluated correctly
	$N(M \text{ and } LH) =$ $2000 \times 0.078 = 1040 \times 0.15 =$ **156**)			
	$N(F \text{ and } LH) =$ $2000 \times 0.0528 = 960 \times 0.11 =$ **105.6**)			Evaluation of **≥1** of these 2 numbers
	or $P(LH) = 0.078 + 0.0528 =$ **0.1308**)	A1		**or** Addition of these 2 probabilities
	$N(LH) = 156 + 105.6 = 2000 \times 0.1308$ = **261 to 262**	A1	4	262/2000 ⇒ A0 AWFW (261.6)
	Total		**14**	

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Q	Solution	Marks	Total	Comments
6				
(a)	$\underline{X \sim B(10, 0.15)}$			
(i)	$P(X \leq 2) =$ **0.82(0)**	B1	1	AWRT (0.8202)
(ii)	$P(X \geq 2) = 1 - P(X \leq 1)$			
				Requires '1 –'
	= 1 – (0.5443 or 0.8202)	M1		Accept 3/2 dp rounding or truncation Can be implied by 0.455 to 0.456 but **not** by 0.179 to 0.18(0)
	= 0.455 to 0.456	A1	2	AWFW (0.4557)
(iii)	$P(1 < X < 5) =$ **0.9901 or 0.9986** (p_1)	M1		Accept 3 dp rounding or truncation $p_2 - p_1 \Rightarrow$ M0 M0 A0 $(1 - p_2) - p_1 \Rightarrow$ M0 M0 A0 $p_1 - (1 - p_2) \Rightarrow$ M1 M0 A0 only providing result > 0
	minus 0.5443 or 0.1969 (p_2)	M1		Accept 3 dp rounding or truncation
	= 0.445 to 0.446	A1	3	AWFW (0.4458)
	OR			
	B(10, 0.15) expressions stated for **at least 3** terms within $1 \leq X \leq 5$ gives probability	(M1)		Can be implied by a correct answer
	= 0.445 to 0.446	(A2)		AWFW (0.4458)
(b)	$\underline{Y \sim B(50, 0.15)}$			Normal approximation $\Rightarrow$ 0 marks
(i)	$P(Y > 5) = 1 - P(Y \leq 5)$			
				Requires '1 –'
	= 1 – (0.2194 or 0.1121)	M1		Accept 3 dp rounding or truncation Can be implied by 0.78(0) to 0.781 but **not** by 0.888 to 0.89
	= 0.78(0) to 0.781	A1	2	AWFW (0.7806)
(ii)	$P(5 \leq Y \leq 10) =$ **0.8801 or 0.7911** (p_1)	M1		Accept 2/3 dp rounding or truncation $p_2 - p_1 \Rightarrow$ M0 M0 A0 $(1 - p_2) - p_1 \Rightarrow$ M0 M0 A0 $p_1 - (1 - p_2) \Rightarrow$ M1 M0 A0 only providing result > 0
	minus 0.1121 or 0.2194 (p_2)	M1		Accept 3 dp rounding or truncation
	= 0.768	A1	3	AWRT (0.7680)
	OR			
	B(50, 0.15) expressions stated for **at least 3** terms within $4 \leq Y \leq 10$ gives probability	(M1)		Can be implied by a correct answer
	= 0.768	(A2)		AWRT (0.7680)
	Total		**11**	