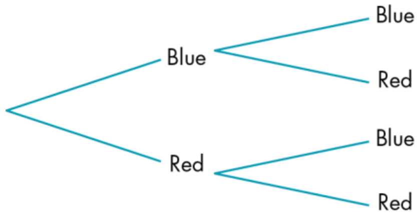
Guidance on the use of codes for this mark scheme	
M	Method mark
A	Accuracy mark
B	Working mark
C	Communication mark
P	Process, proof or justification mark
cao	Correct answer only
oe	Or equivalent
ft	Follow through

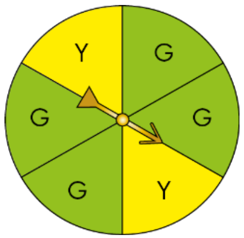
Question	Working	Answer	Mark	AO	Notes	Grade
1 a		False. Experimental probability relies on real life and varies according to the number of trials carried out. You can get a different probability from two different sets of trials.	C1	2	C1 for definition plus explanation oe	M
b		True. The more trials, the closer you get to the theoretical probability.	C1		C1 for explanation oe	
c		False. Relative frequency is $\frac{\text{frequency of desired outcome}}{\text{total number of trials}}$ This is different from the theoretical probability, which is $\frac{\text{number of ways the outcome can happen}}{\text{total number of all possible outcomes}}$ Relative frequency is dependent upon the number of trials.	C1		C1 for definition plus explanation oe	
			3			
2		The frequency is approximately the same for each region of the spinner, suggesting that the spinner is likely to be fair. There are no obvious anomalous results to indicate bias, so there is no strong evidence to suggest it is not fair.	C1	2	C1 for explanation	M
			1			
3	Joy wins: 0.65 × 52 = 33.8 which is approximately 34 wins. Vicky won 10 times. Joy + Vicky = 44 wins		M1	2 3	M1 for multiplication to find the number of Vicky's wins	M
	Max = 52 – 44 = 8 wins	8 times	A1		A1 cao	
			2			

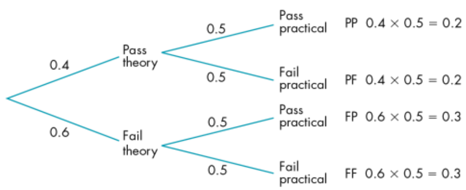
4 a		Anna, Ben Anna, Chloe Anna, Clara Anna, Ciaran Anna, Daniel Ben, Chloe Ben, Clara Ben, Ciaran Ben, Daniel Chloe, Clara Chloe, Ciaran Chloe, Daniel Clara, Ciaran Clara, Daniel Ciaran, Daniel	P1	3	P1 for being methodical	M
b i	P(Anna, Chloe)+ P(Anna, Clara) + P(Chloe, Clara)	$\frac{3}{15} = \frac{1}{5}$	M1 B1		M1 for addition of fractions B1 for simplification	
ii	P(Ben, Ciaran) + P(Ben, Daniel) + P(Ciaran , Daniel)	$\frac{3}{15} = \frac{1}{5}$	M1		M1 for addition of fractions	
iii	P(Chloe, Clara) + P(Chloe, Ciaran) + P(Clara, Ciaran)	$\frac{3}{15} = \frac{1}{5}$	M1		M1 for addition of fractions	
iv	$1 - \frac{3}{15} = \frac{12}{15} = \frac{4}{5}$	$\frac{12}{15} = \frac{4}{5}$ No need to find all the pairs with different initials because it 1 minus the probability that all the pairs have the same initials.	M1 C1		M1 for subtraction from 1 oe C1 for explanation with method	
c i		Mutually exclusive as cannot select the same person twice.	C1		C1 for mutually exclusive with correct explanation oe	
ii		Mutually exclusive as 'two men' cannot include a man and a women, and vice versa.	C1		C1 for mutually exclusive with correct explanation oe	
iii		Mutually exclusive as no two men have the same initial.	C1		C1 for mutually exclusive with correct explanation oe	

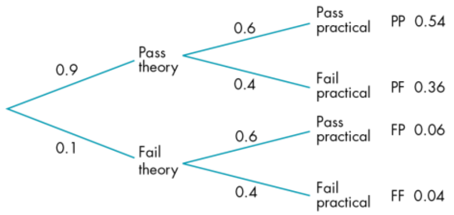
iv		**Not** mutually exclusive as there are possible combinations where two women have the same initial, such as Chloe and Clara.	C1		C1 for mutually exclusive with correct explanation oe	
d	P(exhaustive outcomes) = 1 P(same sex) + P (not the same sex) = P(F, F) + P(M, M) + P(M, F) = 1 **OR** P(two women) = P(A, Ch) + P(A, Cl) +P(Ch, Cl) = $\frac{3}{15}$ P(two men)= P(B, Ci) + P(C, D) + P(Ci, D) = $\frac{3}{15}$ P(opposite sex) = P(A, B) + P(A, Ci) + P(A, D) + P(B, Ch)+ P(B, Cl) + P(Ch, Ci) + P(Ch, D) + P(Cl, Ci) + P(Cl, D) = $\frac{9}{15}$ $\frac{3}{15}+\frac{3}{15}+\frac{9}{15}=\frac{15}{15}$	Picking two people of the same sex and picking two people of opposite sex. This is mutually exclusive **and** mutually exhaustive because the total probabilities add up to 1.	C1 M1 **13**		C1 for mutually exclusive with correct explanation oe M1 for full demonstration of exhaustive outcomes to support argument oe	

5 a		Probabilities on all the branches at each split must sum to 1 because they are mutually exhaustive and exclusive (an outcome happens or another outcome happens until all possible outcomes are accounted for). The probabilities at each stage may have the same denominator if they are independent (with replacement) or the denominator may change if they are dependent (without replacement). Final probabilities must sum to 1 because all possible outcomes have been considered.	C3	2 3	C1 for explanation that includes mutually exclusive events C1 for explanation that includes independent events C1 for clear, complete explanation	M
b		The probabilities on all the branches at each split must sum to 1 because they are exhaustive and must describe all possible outcomes for that event.	C1		C1 for clear explanation of exhaustive events	
c		Denominators for the same event at different stages will be different if the question specifies 'without replacement', for example, when choosing counters without replacement, there are fewer counters to choose from after each choice.	C1		C1 for clear explanation of dependent events	
d		Check each set of branches sum to 1. Check whether choices are made with or without replacement. Make sure you know when to add P(A) and P(B) and when to multiply. Check that sum of the final probabilities after multiplication along the branches is 1.	C1 **6**		C1 for at least three checks that include final probabilities sum to 1 oe	
6	P(rain, not rain) + P(not rain, rain) = 0.25 × 0.52 + 0.75 × 0.48 = 0.49	0.49	M1 A1 **2**	3	M1 for multiplication of rain and complement A1	M

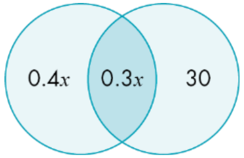
<table>
<tr><td>7 a</td><td><table><tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td></tr><tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td></tr><tr><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td></tr><tr><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr><tr><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td></tr><tr><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td></tr><tr><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td></tr></table></td><td>P(1, 1) = $\frac{1}{36}$</td><td>M1
C1</td><td>3</td><td>M1 for correct calculation cao
C1 for good use of diagram such as two-way table to support explanations</td><td>M</td></tr>
<tr><td>b</td><td></td><td>He can expect to win one in 36 times so should expect to have 36 goes to win at least once.</td><td>C1</td><td></td><td>C1 for correct interpretation of 36 outcomes, of which only one wins</td><td></td></tr>
<tr><td>c</td><td>100 ÷ 36 = 2.7</td><td>If he has 100 goes, then he can expect 3 wins.</td><td>P1
4</td><td></td><td>P1 for division, rounding and correct interpretation in context</td><td></td></tr>
<tr><td>8 a</td><td></td><td>P(B, B) = $\frac{2}{3} \times \frac{2}{3} = \frac{4}{9}$
P(R, B) = 1 – (P(B, B) + P(R, R))
$= 1 - (\frac{4}{9} + \frac{1}{9})$
$= \frac{4}{9}$ as required.
</td><td>M1
P1</td><td></td><td>M1 for multiplication of $\frac{2}{3} \times \frac{2}{3}$ and subtraction from 1
P1 for use of technical notation and possible use of tree diagram to aid explanation</td><td>M</td></tr>
</table>

b		No, the probabilities are not the same because: $P(Y, Y) = \frac{1}{4} \times \frac{1}{4} = \frac{1}{16}$ $P(G, G) = \frac{3}{4} \times \frac{3}{4} = \frac{9}{16}$ $P(Y, G) = 1 - (P(Y, Y) + P(G, G))$ $= 1 - \frac{10}{16} = \frac{6}{16} = \frac{3}{8}$ So the probability of scoring green twice is not the same as the probability of scoring yellow and green in this case.	A1 C1 P1		A1 for multiplication leading to correct probabilities cao C1 for use of correct probabilities to compare and justify 'no' answer P1 for use of technical notation and possible use of tree diagram to aid explanation.	
c	P(G) = g P(Y) = y We want $g^2 = gy \times gy$ If you assume any value where $g = 2y$ then $g^2 = (2y)^2 = 4y^2$ $gy \times gy = 2y^2 \times 2y^2 = 4y^2$ So the probabilities will be the same, as required.	Any spinner with twice as many greens as yellows, such as one divided into six equal sections, with two yellow and four greens in any position. $P(Y) = \frac{2}{6}$; $P(Y, Y) = \frac{4}{36}$ $P(G) = \frac{4}{6}$; $P(G, G) = \frac{16}{36}$ $P(Y, G) = 1 - P(Y, Y) + P(G, G)$ $= 1 - \frac{20}{36} = \frac{16}{36}$ So $P(G, G) = P(Y, G)$ 	M1 B1 C1		M1 for spinner as described. Can be any shape provided sections are equal and it will spin around a central axis (eg, circle, regular hexagon) B1 for example C1 for general explanation	
			8			

9 a	P(P, P) = 0.4 × 0.5 = 0.2	 0.2	M1 C1 A1 **3**	3	M1 for correct construction of probability tree diagram C1 for probabilities and events identified clearly A1 cao	M
10	P(6, 7 or 8) = $\frac{12}{52} \times \frac{11}{51}$ $= \frac{11}{221} = 0.049\,77\ldots$	0.050	M1 A1 **2**	2	M1 for multiplication showing probabilities for two draws without replacement A1 cao	M
11		P(land on 1) = P(1, 2, 3 or 4) $= \frac{4}{6} = \frac{2}{3}$ P(land on –1) = P(5 or 6) $= \frac{2}{6} = \frac{1}{3}$ Since $\frac{2}{3} = 2 \times \frac{1}{3}$, the counter is twice as likely to land on 1 as –1. OR There are twice as many possibilities for the dice to land on 1, 2, 3 or 4 than on 5 or 6 with a fair die.	M1 C1 **2**	2 3	M1 for multiplications to calculate P(1) and P(–1) C1 for explanation that there are twice as many chances oe OR C1 for communicating that one probability is twice the other oe	M

12	P(A and B) = P(A) × P(B) NOT P(A) + P(B) or P(A) × P(B) means P(A) and P(B) P(A) + P(B) means P(A) or P(B)	$P(5) = \frac{1}{6}$ $P(H) = \frac{1}{2}$ $P(5 \text{ and } H) = \frac{1}{6} \times \frac{1}{2} = \frac{1}{12}$ $P(5 \text{ or } H) = \frac{1}{6} + \frac{1}{2} = \frac{2}{12} + \frac{6}{12}$ $= \frac{8}{12}$ $\frac{1}{12} \neq \frac{8}{12}$	M1 C1 C1 **3**		M1 for use of probability notation C1 for explanation that shows an understanding of the difference between 'and' and 'or' C1 for further explanation, example oe	M
13	P(pass, pass) = 0.9 × 0.6 = 0.54	 The probability that she passes both parts on the first attempt is 0.54.	M1 C1 A1 **3**	2	M1 for correct construction of probability tree diagram C1 for probabilities and events identified clearly A1 cao	M

14 a	P(late) = 0.08 P(not late) = 0.92 P(early) = 0.02 P(not early) = 0.98 P(raining) = 0.3 P(not raining) = 0.7 P(on time) = 1 – P(late) – P(early) = 1 –0.08 – 0.02 = 0.9 P(on time, not raining) = 0.9 × 0.7 = 0.63	P(on time, not raining) = 0.63	M1	2	M1 for correct multiplication for three different events oe	M
b	P(raining, raining, raining) = 0.3^3 =0.027	P(raining, raining, raining) = 0.027	M1		M1 for correct multiplication for three same events oe	
c	P(not late five days in a row) = 0.92^5 = 0.6591	P(not late five days in a row) = 0.659	M1		M1 for correct multiplication for five same complement events oe	
			3			
15	Let the number of students in the class be x. Number who solve problem 1 = $0.5x$ Number who solve problem 2 = $0.8x$ So x is the two added together less 12 as this has been counted twice $x = 0.8x + 0.5x – 12$ $x= 1.3x – 12$ $12 = 0.3x$ $x= 40$ or 80% + 50% = 130% so 12 represents the overcount by 30%. $\frac{30x}{100} = 12$ $x = 40$	The number of students who took the exam is 40.	P1 C1 A1	2	P1 for either solving the linear equation or calculating, using the percentages from the Venn diagram C1 for explanation as to why 12 is subtracted (or we have 30% too much) A1 cao	H
			3			

16 a **b**	$x = 0.7x + 30 - 0.3x$ $x - 0.7x + 0.3x = 30$ $0.6x = 30$ $x = 50$	 $x = 50$ Own problem	P1 A1 C1 C1 **4**	3	P1 for equation set up A1 cao C1 for clear, organised problem C1 for relevant mark scheme	H
17		You cannot use a sample space diagram because it is a is a two-way diagram, it is two-dimensional (horizontal and vertical) and it is impossible to draw the third and fourth dimensions. Also a probability tree diagram would be very complex.	C1 C1 **1**	3	C1 for explanation of the fact that a two-way table describes two events only oe C1 for comment on the complexity or impracticality of a tree diagram	H

18 a		Example of a problem that can be solved by adding probabilities.	P1	3	P1 for clearly structured question, for example: E.g. A bag contains 3 red, 2 yellow and 4 blue counters. One is drawn and replaced. A second is drawn. What is the probability of a red first or a blue first? P(R first) + P (B first) = $\frac{3}{9} + \frac{4}{9} = \frac{7}{9}$	H
b		Example of a problem that can be solved by multiplying probabilities.	P1		P1 for clearly structured question, for example: What is the probability of drawing two yellows, replacing the counter each time? P(YY) = P(Y) × P(Y) = $\frac{2}{9} \times \frac{2}{9} = \frac{4}{81}$	
c		Example of a problem that involves both adding and multiplying probabilities.	B1 **3**		B1 for clearly structured question, for example: What is the probability of drawing two counters the same colour, replacing the counter each time? P(Y, Y) + P(B, B) + P(R, R) $= (\frac{2}{9} \times \frac{2}{9}) + (\frac{4}{9} \times \frac{4}{9}) + (\frac{3}{9} \times \frac{3}{9})$ $= \frac{29}{81}$	

19 a	$\frac{3}{10} \times \frac{2}{9} \times \frac{1}{8} = \frac{1}{120}$	P(win) = $\frac{1}{120}$	M1	2	M1 for multiplication of three probabilities without replacement	H
b	$\frac{3}{10} \times \frac{2}{9} \times \frac{1}{8} = \frac{1}{120}$	He is incorrect; every set of three numbers has the same chance of being chosen.	C1		C1 for explanation that all numbers have the same chance of being drawn	
c	The number of 'plays' in a year is 45 × 50 = 2250. The income is 2250 × 20p = £450. The probability of a win on each play is $\frac{1}{120}$. The expected number of wins is $\frac{1}{120} \times 2250 = 18.75$ = 19 (nearest whole number) The expected pay-out is 19 × £5 = £95 The expected profit in one year is £450 – £95 = £355	£355	M1 M1 M1 M1 A1 **7**	3	M1 for multiplication 45 × 50 oe M1 for multiplication 2250 × 20p oe M1 for $\frac{1}{120} \times 2250$ oe M1 for 19 × 5 oe A1 £450 – £95 (ft)	
20		It will help to show all nine possible outcomes and which ones give two socks of the same colour. Then the probabilities on the branches can be used to work out the chance of each outcome.	C1 P1 **2**	2	P1 for clear explanation that shows awareness of nine possible outcomes (3 possible colours and then a further choice of 3), together with a comment about the diagram finding all possible combinations P1 for use of technical notation and possible use of a probability tree diagram to aid explanation	H
21		He forgot there were now only 49 cards left in the pack. The probability of being dealt the final ace is $\frac{1}{49}$.	C1 **1**	2	C1 for comment that shows understanding that the cards had not been replaced, leaving the final ace to be chosen from 49 cards, not 52	H

22	P(picture card) = $\frac{16}{52}$ P(four in a row) = $\frac{16}{52} \times \frac{15}{51} \times \frac{14}{50} \times \frac{13}{49}$ $= \frac{4}{595}$ = 0.0067…	0.0067	M1 A1 **2**	3	M1 for multiplication $\frac{16}{52} \times \frac{15}{51} \times \frac{14}{50} \times \frac{13}{49}$ A1 cao	H
23		Work out P(Y), P(G) and P(O). Then P(Y) × P(yellow second), remembering both the numerator and denominator will be 1 less. Then P(G) × P(green second), remembering both the numerator and denominator will be 1 less. Then P(O) × P(orange second), remembering both the numerator and denominator will be 1 less. Then add together these three probabilities. She is most likely to forget to reduce the denominator by one for the second jelly baby.	C1 C1 C1 C1 **4**	2 3	C1 for stating the need to find the probabilities of each first oe C1 for reminding about the change in numerator and denominator oe C1 for final addition of probabilities oe C1 for example or relevant diagram	H
24	Work out the probability that no two friends choose the same random number. P(no match) = $\frac{8}{9} \times \frac{7}{9} \times \frac{6}{9} \times \frac{5}{9}$ $= \frac{1680}{6561}$ $= \frac{560}{2187}$ P(match) = 1 – P(no match) So P(match) = $1 - \frac{560}{2187} = \frac{1627}{2187}$ = 0.743 941 472 3	0.74	M1 M1 A1 **3**	3	M1 for multiplication $\frac{8}{9} \times \frac{7}{9} \times \frac{6}{9} \times \frac{5}{9}$ M1 for (1 – probability of no match) A1 for rounding and ft	H

25 a	Probability that they don't have their birthday on the same day is: $\frac{364 \times 363 \times 362...(365-24)}{365^{25}}$ Probability that they do is: $1 - \frac{364 \times 363 \times 362...(365-24)}{365^{25}}$		P1 M1	2	P1 for probability that the 25 people have birthdays on different days oe M1 for probability that they do being 1 – probability that they don't	H
b	Alison is incorrect, a choice of $\frac{25}{365}$ would only give you the probability of choosing 25 days from the year and they would not be the same day.		C1		C1 for clear explanation of the probability defined by $\frac{25}{365}$ oe	
c		In reality birthdays are not evenly distributed through the year. For example more babies are born in Spring.	P1 **6**		P1 for valid assumption that considers an uneven distribution of birthdays	
26 a		Assumptions made in order to start the question: All letters are equally likely to be initial letters. All 10 people are using the same alphabet for naming.	M1	2	M1 for valid assumption oe	H
b	Probability that they don't is: $\frac{25 \times 24 \times 23..........(26-9)}{26^{10}}$ = 0.005 25 Probability that they do is: $1 - \frac{25 \times 24 \times 23..........(17)}{26^{10}}$ = 0.994 75 $1 - \frac{25 \times 24 \times 23..........(17)}{26^{10}} - 0.5$	0.994 75	M1 M1 A1 M1 **5**		M1 for probability that the 10 people have first names starting with the same letter oe M1 for probability that they do being 1 – probability that they don't A1 ft M1 for adaptation of calculation	