

**OXFORD CAMBRIDGE AND RSA EXAMINATIONS**

**Advanced Subsidiary General Certificate of Education  
Advanced General Certificate of Education**

**MEI STRUCTURED MATHEMATICS**

**4766**

Statistics 1

**Advanced Subsidiary General Certificate of Education**

**MEI STATISTICS**

**G241**

Statistics 1 (Z1)

Wednesday

**24 MAY 2006**

Afternoon

1 hour 30 minutes

Additional materials:

8 page answer booklet

Graph paper

MEI Examination Formulae and Tables (MF2)

**TIME** 1 hour 30 minutes

**INSTRUCTIONS TO CANDIDATES**

- Write your name, centre number and candidate number in the spaces provided on the answer booklet.
- Answer **all** the questions.
- You are permitted to use a graphical calculator in this paper.
- Final answers should be given to a degree of accuracy appropriate to the context.

**INFORMATION FOR CANDIDATES**

- The number of marks is given in brackets [ ] at the end of each question or part question.
- You are advised that an answer may receive **no marks** unless you show sufficient detail of the working to indicate that a correct method is being used.
- The total number of marks for this paper is 72.

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**This question paper consists of 5 printed pages and 3 blank pages.**

## Section A (36 marks)

- 1 Every day, George attempts the quiz in a national newspaper. The quiz always consists of 7 questions. In the first 25 days of January, the numbers of questions George answers correctly each day are summarised in the table below.

Number correct	1	2	3	4	5	6	7
Frequency	1	2	3	3	4	7	5

- (i) Draw a vertical line chart to illustrate the data. [2]
- (ii) State the type of skewness shown by your diagram. [1]
- (iii) Calculate the mean and the mean squared deviation of the data. [3]
- (iv) How many correct answers would George need to average over the next 6 days if he is to achieve an average of 5 correct answers for all 31 days of January? [2]
- 2 Isobel plays football for a local team. Sometimes her parents attend matches to watch her play.
- $A$  is the event that Isobel's parents watch a match.
  - $B$  is the event that Isobel scores in a match.

You are given that  $P(B | A) = \frac{3}{7}$  and  $P(A) = \frac{7}{10}$ .

- (i) Calculate  $P(A \cap B)$ . [2]

The probability that Isobel does not score and her parents do not attend is 0.1.

- (ii) Draw a Venn diagram showing the events  $A$  and  $B$ , and mark in the probability corresponding to each of the regions of your diagram. [2]
- (iii) Are events  $A$  and  $B$  independent? Give a reason for your answer. [2]
- (iv) By comparing  $P(B | A)$  with  $P(B)$ , explain why Isobel should ask her parents not to attend. [2]

- 3 The score,  $X$ , obtained on a given throw of a biased, four-faced die is given by the probability distribution

$$P(X = r) = kr(8 - r) \text{ for } r = 1, 2, 3, 4.$$

- (i) Show that  $k = \frac{1}{50}$ . [2]
- (ii) Calculate  $E(X)$  and  $\text{Var}(X)$ . [5]

4 Peter and Esther visit a restaurant for a three-course meal. On the menu there are 4 starters, 5 main courses and 3 sweets. Peter and Esther each order a starter, a main course and a sweet.

(i) Calculate the number of ways in which Peter may choose his three-course meal. [2]

(ii) Suppose that Peter and Esther choose different dishes from each other.

(A) Show that the number of possible combinations of starters is 6. [1]

(B) Calculate the number of possible combinations of 6 dishes for both meals. [1]

(iii) Suppose instead that Peter and Esther choose their dishes independently.

(A) Write down the probability that they choose the same main course. [1]

(B) Find the probability that they choose different dishes from each other for every course. [2]

5 Douglas plays darts, and the probability that he hits the number he is aiming at is 0.87 for any particular dart.

Douglas aims a set of three darts at the number 20; the number of times he is successful can be modelled by  $B(3, 0.87)$ .

(i) Calculate the probability that Douglas hits 20 twice. [3]

(ii) Douglas aims fifty sets of 3 darts at the number 20. Find the expected number of sets for which Douglas hits 20 twice. [1]

(iii) Douglas aims four sets of 3 darts at the number 20. Calculate the probability that he hits 20 twice for two sets out of the four. [2]

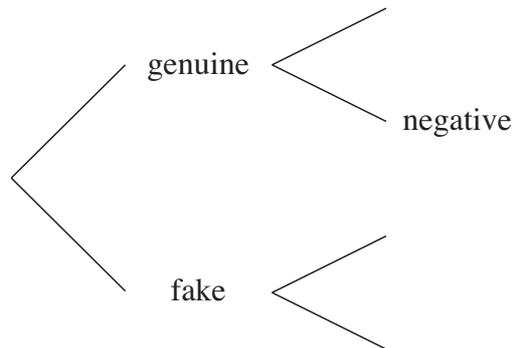
**Section B** (36 marks)

- 6** It has been estimated that 90% of paintings offered for sale at a particular auction house are genuine, and that the other 10% are fakes. The auction house has a test to determine whether or not a given painting is genuine. If this test gives a positive result, it suggests that the painting is genuine. A negative result suggests that the painting is a fake.

If a painting is genuine, the probability that the test result is positive is 0.95.

If a painting is a fake, the probability that the test result is positive is 0.2.

- (i) Copy and complete the probability tree diagram below, to illustrate the information above. [2]



Calculate the probabilities of the following events.

- (ii) The test gives a positive result. [2]
- (iii) The test gives a correct result. [2]
- (iv) The painting is genuine, given a positive result. [3]
- (v) The painting is a fake, given a negative result. [3]

A second test is more accurate, but very expensive. The auction house has a policy of only using this second test on those paintings with a negative result on the original test.

- (vi) Using your answers to parts (iv) and (v), explain why the auction house has this policy. [2]

The probability that the second test gives a correct result is 0.96 whether the painting is genuine or a fake.

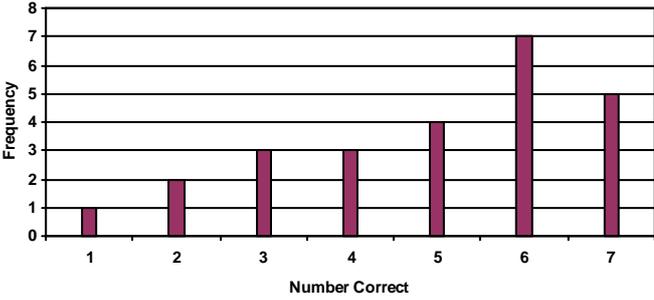
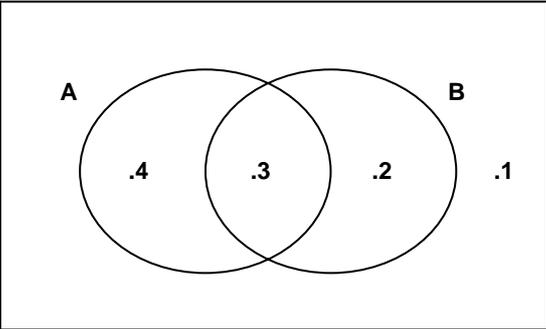
- (vii) Three paintings are independently offered for sale at the auction house. Calculate the probability that all three paintings are genuine, are judged to be fakes in the first test, but are judged to be genuine in the second test. [4]

- 7 A geologist splits rocks to look for fossils. On average 10% of the rocks selected from a particular area do in fact contain fossils.

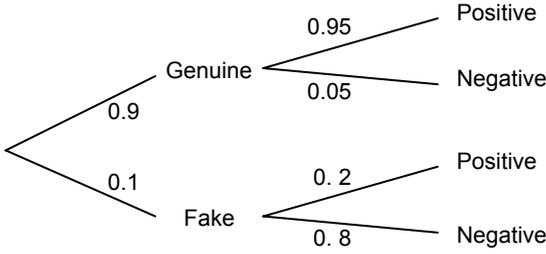
The geologist selects a random sample of 20 rocks from this area.

- (i) Find the probability that
- (A) exactly one of the rocks contains fossils, [3]
  - (B) at least one of the rocks contains fossils. [3]
- (ii) A random sample of  $n$  rocks is selected from this area. The geologist wants to have a probability of 0.8 or greater of finding fossils in at least one of the  $n$  rocks. Find the least possible value of  $n$ . [3]
- (iii) The geologist explores a new area in which it is claimed that less than 10% of rocks contain fossils. In order to investigate the claim, a random sample of 30 rocks from this area is selected, and the number which contain fossils is recorded. A hypothesis test is carried out at the 5% level.
- (A) Write down suitable hypotheses for the test. [3]
  - (B) Show that the critical region consists only of the value 0. [4]
  - (C) In fact, 2 of the 30 rocks in the sample contain fossils. Complete the test, stating your conclusions clearly. [2]

**Mark Scheme 4766**  
**June 2006**

<p><b>Q1</b> <b>(i)</b></p>		<p>G1 Labelled linear scales G1 Height of lines</p>	<p><b>2</b></p>
<p><b>(ii)</b></p>	<p>Negative (skewness)</p>	<p>B1</p>	<p><b>1</b></p>
<p><b>(iii)</b></p>	<p><math>\Sigma fx = 123</math> so mean = <math>123/25 = 4.92</math> o.e. <math>S_{xx} = 681 - \frac{123^2}{25} = 75.84</math> M.s.d = <math>\frac{75.84}{25} = 3.034</math></p>	<p>B1 M1 for <math>S_{xx}</math> attempted A1 FT their 4.92</p>	<p><b>3</b></p>
<p><b>(iv)</b></p>	<p>Total for 25 days is 123 and totals for 31 days is 155. Hence total for next 6 days is 32 and so mean = 5.33</p>	<p>M1 <math>31 \times 5 - 25 \times</math>their 4.92 A1 FT their 123</p>	<p><b>2</b></p>
		<p><b>TOTAL</b></p>	<p><b>8</b></p>
<p><b>Q2</b> <b>(i)</b></p>	<p><math>P(A \cap B) = P(A)P(B A) = \frac{7}{10} \times \frac{3}{7}</math> <math>\rightarrow P(A \cap B) = 0.3</math> o.e.</p>	<p>M1 Product of these fractions A1</p>	<p><b>2</b></p>
<p><b>(ii)</b></p>		<p>B1FT either 0.4 or 0.2 in correct place B1FT all correct and labelled</p>	<p><b>2</b></p>
<p><b>(iii)</b></p>	<p><math>P(B A) \neq P(B)</math>, <math>3/7 \neq 0.5</math> Unequal so not independent</p>	<p>E1 Correct comparison E1dep for 'not independent'</p>	<p><b>2</b></p>
<p><b>(iv)</b></p>	<p><math>3/7 &lt; 0.5</math> so Isobel is less likely to score when her parents attend</p>	<p>E1 for comparison E1dep</p>	<p><b>2</b></p>
		<p><b>TOTAL</b></p>	<p><b>8</b></p>

<b>Q3</b> <b>(i)</b>	$P(X = 1) = 7k, P(X = 2) = 12k, P(X = 3) = 15k, P(X = 4) = 16k$ $50k = 1$ so $k = 1/50$	M1 for addition of four multiples of $k$ A1 <b>ANSWER GIVEN</b>	<b>2</b>
<b>(ii)</b>	$E(X) = 1 \times 7k + 2 \times 12k + 3 \times 15k + 4 \times 16k = 140k = 2.8$ OR $E(X) = 1 \times 7/50 + 2 \times 12/50 + 3 \times 15/50 + 4 \times 16/50 = 140/50 = 2.8$ oe  $\text{Var}(X) = 1 \times 7k + 4 \times 12k + 9 \times 15k + 16 \times 16k - 7.84 = 1.08$ OR $\text{Var}(X) = 1 \times 7/50 + 4 \times 12/50 + 9 \times 15/50 + 16 \times 16/50 - 7.84 = 8.92 - 7.84 = 1.08$	M1 for $\sum xp$ (at least 3 terms correct) A1 CAO  M1 $\sum x^2p$ (at least 3 terms correct) M1 <i>dep</i> for – their $E(X)^2$ NB provided $\text{Var}(X) > 0$ A1 FT their $E(X)$	<b>5</b>
		<b>TOTAL</b>	<b>7</b>
<b>Q4</b> <b>(i)</b>	$4 \times 5 \times 3 = 60$	M1 for $4 \times 5 \times 3$ A1 CAO	<b>2</b>
<b>(ii)</b>	<b>(A)</b> $\binom{4}{2} = 6$  <b>(B)</b> $\binom{4}{2} \binom{5}{2} \binom{3}{2} = 180$	B1 <b>ANSWER GIVEN</b>  B1 CAO	<b>2</b>
<b>(iii)</b>	<b>(A)</b> $1/5$  <b>(B)</b> $\frac{3}{4} \times \frac{4}{5} \times \frac{2}{3} = \frac{2}{5}$	B1 CAO  M1 for $\frac{3}{4} \times \frac{4}{5} \times \frac{2}{3}$  A1	<b>3</b>
		<b>TOTAL</b>	<b>7</b>
<b>Q5</b> <b>(i)</b>	$P(X = 2) = \binom{3}{2} \times 0.87^2 \times 0.13 = 0.2952$	M1 $0.87^2 \times 0.13$ M1 $\binom{3}{2} \times p^2q$ with $p+q=1$ A1 CAO	<b>3</b>
<b>(ii)</b>	In 50 throws expect 50 $(0.2952) = 14.76$ times	B1 FT	<b>1</b>
<b>(iii)</b>	$P(\text{two } 20\text{'s twice}) = \binom{4}{2} \times 0.2952^2 \times 0.7048^2 = 0.2597$	M1 $0.2952^2 \times 0.7048^2$ A1 FT their $0.2952$	<b>2</b>
		<b>TOTAL</b>	<b>6</b>

<b>Q6</b>  <b>(i)</b>		G1 for left hand set of branches fully correct including labels and probabilities G1 for right hand set of branches fully correct	<b>2</b>
<b>(ii)</b>	$P(\text{test is positive}) = (0.9)(0.95) + (0.1)(0.2) = 0.875$	M1 Two correct pairs added A1 CAO	<b>2</b>
<b>(iii)</b>	$P(\text{test is correct}) = (0.9)(0.95) + (0.1)(0.8) = 0.935$	M1 Two correct pairs added A1 CAO	<b>2</b>
<b>(iv)</b>	$P(\text{Genuine} \text{Positive})$ $= 0.855/0.875$ $= 0.977$	M1 Numerator M1 Denominator A1 CAO	<b>3</b>
<b>(v)</b>	$P(\text{Fake} \text{Negative}) = 0.08/0.125 = 0.64$	M1 Numerator M1 Denominator A1 CAO	<b>3</b>
<b>(vi)</b>	<p>EITHER: A positive test means that the painting is almost certain to be genuine so no need for a further test.</p> <p>However, more than a third of those paintings with a negative result are genuine so a further test is needed.</p> <p>NOTE: Allow sensible alternative answers</p>	E1FT  E1FT	<b>2</b>
<b>(vii)</b>	$P(\text{all 3 genuine}) = (0.9 \times 0.05 \times 0.96)^3$ $= (0.045 \times 0.96)^3$ $= (0.0432)^3$ $= 0.0000806$	M1 for $0.9 \times 0.05$ (=0.045) M1 for complete correct triple product M1 <i>indep</i> for cubing A1 CAO	<b>4</b>
		<b>TOTAL</b>	<b>18</b>

<p><b>Q7</b> <b>(i)</b></p>	<p><math>X \sim B(20, 0.1)</math></p> <p>(A) <math>P(X = 1) = \binom{20}{1} \times 0.1 \times 0.9^{19} = 0.2702</math></p> <p>OR from tables <math>0.3917 - 0.1216 = 0.2701</math></p> <p>(B) <math>P(X \geq 1) = 1 - 0.1216 = 0.8784</math></p>	<p>M1 <math>0.1 \times 0.9^{19}</math></p> <p>M1 <math>\binom{20}{1} \times pq^{19}</math></p> <p>A1 CAO</p> <p>OR: M2 for <math>0.3917 - 0.1216</math> A1 CAO</p> <p>M1 <math>P(X=0)</math> provided that <math>P(X \geq 1) = 1 - P(X \leq 1)</math> not seen</p> <p>M1 <math>1 - P(X=0)</math></p> <p>A1 CAO</p>	<p><b>3</b></p> <p><b>3</b></p>
<p><b>(ii)</b></p>	<p>EITHER: <math>1 - 0.9^n \geq 0.8</math>  <math>0.9^n \leq 0.2</math>  Minimum <math>n = 16</math></p> <p>OR (using trial and improvement):  Trial with <math>0.9^{15}</math> or <math>0.9^{16}</math> or <math>0.9^{17}</math>  <math>1 - 0.9^{15} = 0.7941 &lt; 0.8</math> and <math>1 - 0.9^{16} = 0.8147 &gt; 0.8</math>  Minimum <math>n = 16</math></p> <p>NOTE: <math>n = 16</math> unsupported scores SC1 only</p>	<p>M1 for <math>0.9^n</math></p> <p>M1 for inequality</p> <p>A1 CAO</p> <p>M1</p> <p>M1</p> <p>A1 CAO</p>	<p><b>3</b></p>
<p><b>(iii)</b></p>	<p>(A) Let <math>p</math> = probability of a randomly selected rock containing a fossil (for population)  <math>H_0: p = 0.1</math>  <math>H_1: p &lt; 0.1</math></p> <p>(B) Let <math>X \sim B(30, 0.1)</math>  <math>P(X \leq 0) = 0.0424 &lt; 5\%</math>  <math>P(X \leq 1) = 0.0424 + 0.1413 = 0.1837 &gt; 5\%</math></p> <p>So critical region consists only of 0.</p> <p>(C)  2 does not lie in the critical region.</p> <p>So there is insufficient evidence to reject the null hypothesis and we conclude that it seems that 10% of rocks in this area contain fossils.</p>	<p>B1 for definition of <math>p</math></p> <p>B1 for <math>H_0</math></p> <p>B1 for <math>H_1</math></p> <p>M1 for attempt to find <math>P(X \leq 0)</math> or <math>P(X \leq 1)</math> using binomial</p> <p>M1 for both attempted</p> <p>M1 for comparison of either of the above with 5%</p> <p>A1 for critical region dep on both comparisons <b>(NB Answer given)</b></p> <p>M1 for comparison</p> <p>A1 for conclusion <b>in context</b></p>	<p><b>3</b></p> <p><b>4</b></p> <p><b>2</b></p>
		<p><b>TOTAL</b></p>	<p><b>18</b></p>

## 4766 - Statistics 1

### General Comments

The paper attracted a wide range of responses, from those who were able to produce good answers to almost all questions to those who appeared to be unfamiliar with much of the basic content of the Statistics 1 material. On the whole, candidates seemed to have sufficient time to attempt all questions. Answers were usually well presented with methods and working clear. However, many candidates do not appreciate the implications of using rounded answers in subsequent calculations; nor do they seem to have a good understanding of the use of significant figures.

Most candidates gave good answers to and were able to earn substantial marks from questions 1, 3, 5, 6 and 7i. Question 2 was not well answered; candidates were evidently unclear about how to manipulate probabilities in a Venn diagram and many scored at best 2 out of 8 marks. The performance on question 4 was also variable, and the latter parts of Question 7 were not well answered. As mentioned in the January 2006 report, candidates must define  $p$  in words in the context of any question on hypothesis testing. Many candidates are still not meeting this requirement. In addition in hypothesis testing on the binomial distribution the use of point probabilities rather than tail probabilities was seen in many scripts. This essentially renders any solution invalid and centres are encouraged to emphasise this point to candidates.

A surprising observation was the number of occasions in which a 'probability' of greater than 1 or even a negative 'probability' was allowed to stand unchallenged as a final answer. This was particularly in evidence in question 6 (iv) and (v), with candidates attempting to use these values in their explanations for part (vi).

### Comments on Individual Questions

#### Section A

- 1) **Attempts at a quiz; line graph, skewness, mean and mean squared deviation, calculation of new mean.**
- (i) The line graph was usually drawn clearly and most candidates scored 2 marks. The few who did not, usually lost marks for omitting labels or adding a curve/polygon to the tops of the lines.
  - (ii) A number of candidates wrongly (or randomly) believed the data were positively skewed.
  - (iii) The mean was usually correct. The most common error was the use of divisor  $n = 7$  instead of 25. However only about half of the candidature found the mean squared deviation completely correctly. Many square rooted and/or divided by 24 instead of 25. In addition the usual errors were seen such as the confusion of  $\sum x^2$  with  $(\sum x)^2$ . Those who attempted a solution using  $\sum (x - \bar{x})^2 f$  often omitted the frequencies  $f$ . As indicated in the January report candidates are **strongly recommended** in this type of question to first calculate the sum of squares  $S_{xx}$  and it is pleasing to note that many candidates had been taught to use this approach. A perfectly acceptable alternative method, which was rarely seen, was the use of calculator statistical functions.
  - (iv) Whilst some candidates coped easily, this part proved to be beyond a significant proportion of candidates, who did not even attempt it. Many used the right method but stopped at 32, stating 'he needs to average 32 over the next 6 days'. Some found  $32/5$  rather than  $32/6$ . A common wrong method was to say  $(4.92 + \bar{x}) / 2 = 5, \Rightarrow \bar{x} = 5.08$ . Many believed that the final answer must be a whole number and rounded to 5 or 6, for which they were penalised. Some used trial and improvement but only tried whole numbers – again getting 5 or 6.

- 2) **Football scoring; conditional probability, Venn diagram, independence, decision making with conditional probabilities.**
- (i) Most candidates were able to calculate  $P(A \cap B) = \frac{7}{10} \times \frac{3}{7} = \frac{3}{10}$ , but two alternatives were fairly common:  $\frac{3}{7} \div \frac{7}{10} = \frac{30}{49}$  and stating that  $P(B) = \frac{3}{7} \times \frac{7}{10} = 0.3$ , followed by  $P(A \cap B) = P(A) \times P(B) = 0.21$ .
- (ii) The Venn diagram was rarely correct. Occasionally, 0.4 and/or 0.2 were positioned in the correct space, but completely correct diagrams were rare. 0.7 was often placed where 0.4 should have been and 0.5 was placed where 0.2 should have been. To some extent this may have been a result of candidates having become confused in part (i), but it does suggest that centres should place much more emphasis on this topic.
- (iii) Some candidates knew the rule for independence but were reluctant to back it up with numerical values as evidence. Simply quoting the independence rule did not secure any credit. Many candidates used completely erroneous values when trying to determine whether the events were independent.
- (iv) Again, some candidates knew that  $P(B | A) > P(B)$  was required but could not substantiate it with numerical values. Candidates are **strongly advised to give numerical evidence** in questions of this type and not to rely on qualitative arguments or stories.
- 3) **Biased four faced dice modelled a discrete random variable; justifying the value of  $k$ ; calculation of  $E(X)$  and  $\text{Var}(X)$ .**
- This was perhaps the best answered question on the paper. Candidates were comfortable with the underlying concepts and scored highly.
- (i) The majority of candidates established the value of  $k$  convincingly but some candidates who substituted the given value of  $k$  then failed to add up the resulting figures to justify a sum of unity.
- (ii) The calculation of  $E(X)$  and  $\text{Var}(X)$  was very well done with only the occasional case where the candidate subtracted  $\mu$  rather than  $\mu^2$  or alternatively omitted the subtraction altogether.
- 4) **Three course meal; various choices made by Peter and Esther.**
- (i) Many arrived at the correct answer of 60 here, often as  $4 \times 5 \times 3$ . The most common alternative seen was  $4 + 5 + 3 = 12$ . Some used factorials  $5! \times 4! \times 3! = 17280$  although candidates might have been alerted to their error by such a high figure from a choice of just 4 starters, 5 main courses and 3 sweets.
- (ii) (A) Many used  ${}^4C_2$  or equivalent to arrive at the given answer of 6 or simply listed the different combinations but there were many incorrect attempts seen such as  $3!$  or  ${}^3C_1 \times {}^2C_1$ .  
(B) This proved more challenging and few correct responses were seen with two common errors being  ${}^{12}C_6 = 924$  and the addition of the binomial coefficients  ${}^4C_2 + {}^5C_2 + {}^3C_2 = 19$ .
- (iii) In (A) many candidates gave the incorrect response of  $1/5 \times 1/5 = 1/25$  failing to realise that Peter could choose any dish to begin with as long as Esther chose the same dish thus giving a probability of  $1 \times 1/5 = 1/5$ . Part (B) was also poorly answered and relatively few correct solutions were seen, with  $1 - p(\text{same}) = 1 - (1/4)^2 - (1/5)^2 - (1/3)^2 = 0.786$  often wrongly submitted. Equally common was the attempt at  $(24/25) \times (15/16) \times (8/9) = 4/5$ , although special consideration was given to candidates who chose this latter route. It was very rare to see the correct response of  $3/4 \times 4/5 \times 2/3 = 2/5$ .

- 5) **Darts modelled by the binomial distribution, expected value.**  
This question was generally well answered and candidates were able to demonstrate a sound understanding of binomial probabilities. However, in both parts (ii) and (iii), some candidates used rounded values from part (i) to produce inaccurate solutions. As a guiding rule, candidates should be advised to avoid premature approximation and to work with full accuracy, using the storage facility on their calculator if necessary.
- (i) A small number of candidates omitted the binomial coefficient of  ${}^3C_2$  from their answer.
  - (ii) Most candidates correctly multiplied their answer to part (i) by 50, although a few were confused by the concept of expected value and chose to work with a value of 0.87. Some used a multiplier of 150 (darts) instead of 50 (sets of 3 darts). As always, many incorrectly believed that the mean or expected value had to be a whole number.
  - (iii) Many correct solutions were seen but some candidates reverted to 0.87 in place of 0.2952, or used incorrect powers.

## Section B

- 6) **Genuine and fake paintings; tree diagram, positive and correct test results, conditional probability calculations; further test to eliminate fakes and associated probability calculation.**  
This question was generally well answered and provided a rich source of marks for all but the weakest candidates. Some excellent responses were seen.
- (i) The tree diagram was almost invariably correct.
  - (ii) Again, very well answered, although a common mistake was to add wrongly the decimals 0.855 and 0.02 to give 0.857 instead of 0.875.
  - (iii) Usually correctly answered but a number of candidates chose to leave this part blank – perhaps unclear as to how to interpret the word ‘correct’ in the context of the question.
  - (iv) Often candidates were able to apply the correct conditional probability formula and many correct answers were seen. A common erroneous method was  $0.875/0.9$ . Another common error was the use of  $P(A \cap B) = P(A) \times P(B)$  in finding the numerator of the conditional probability expression. This of course is almost never valid in a question of this sort, since the probabilities concerned are rarely independent. There were also a number of candidates who seemed content to give probabilities greater than 1 as their answer.
  - (v) Although slightly more difficult than part (iv), since neither element of the fraction had already been calculated, most candidates scored the same number of marks here as in part (iv), making equivalent errors (or none).
  - (vi) The difference between positive given genuine and genuine given positive was not clearly understood. The words ‘positive’ and ‘genuine’ were often wrongly considered to be interchangeable, as were ‘negative’ and ‘fake’. A small number of candidates were able to give excellent responses, ably supported by their correct numerical results.
  - (vii) Most candidates attempted and made some progress with this part but completely correct solutions were often restricted to the best candidates. The most common error was to multiply the correct triple product  $0.9 \times 0.05 \times 0.96$  by three, leading to 0.1296, instead of cubing it.
- 7) **Splitting rocks to find fossils. The binomial distribution,  $P(X \geq 1)$ , least value of  $n$ ; hypothesis test on the binomial distribution.**
- (i) Part (A) was usually correct, most candidates choosing to use the formula to calculate  ${}^{20}C_1 \times 0.1 \times 0.9^{19}$  rather than using tables. Some candidates gave an answer of 0.3917 which was  $P(X \leq 1)$ .  
Part (B) once again was well answered with the most common errors being  $P(X \geq$

- $1) = 1 - P(X \leq 1)$  or  $P(X \geq 1) = 1 - P(X = 1)$  instead of the correct  $P(X \geq 1) = 1 - P(X = 0)$ .
- (ii) Some very good solutions were seen from high scoring candidates who obtained  $n=16$  very efficiently by trial and improvement or by use of logs. Other attempts faltered because of poor manipulation of the inequality or by the use of  $0.8^n$  rather than  $0.9^n$ . Some candidates wrote down  $n = 16$  without working or thought that  $1 - 0.9^{16} = 0.8147$  on its own was sufficient justification. In questions of this type, full justification is required, ie the probabilities associated with the least value of  $n$  which meets the requirement and also of the greatest value of  $n$  which does not meet the requirement must both be explicitly stated.
- (iii) (A) The hypotheses were usually correct although a number of candidates gave the hypotheses in words, which was not penalised on this occasion. Candidates should learn and use the correct symbolic notation, which is  $H_0: p = 0.1$ . They should realise that answers such as  $H_0 = 0.1$  or  $H_0: P(X) = 0.1$  will be penalised. Very few candidates defined the parameter  $p$  in this part. This is now a mandatory requirement, as pointed out in the January 2006 report. Few centres seemed to have taken heed of this as yet.
- (B) Many candidates correctly evaluated  $P(X \leq 0)$  and compared this with 0.05, scoring 2 marks, but unfortunately a large proportion of candidates then mistakenly calculated the point probability  $P(X = 1)$  instead of the tail probability  $P(X \leq 1)$  and so their result for the critical region was invalid. It is worth stressing that many candidates erroneously try to argue that a probability is in the critical region, instead of saying it is less than 5% or whatever the significance level may be, which suggests that their understanding of critical regions is limited.
- (C) Since the critical region had already been established in part B, all that was required in part C was for candidates to state clearly that '2 does not lie in the critical region' and then conclude that there is insufficient evidence to reject the null hypothesis (and as always with a hypothesis test, to express this conclusion in context). However most candidates did not appear to know how to use the critical region since they calculated the point probability  $P(X = 2)$  and then incorrectly compared this to 0.05, thus denying themselves any credit. Those who used the tail probability  $P(X \leq 2)$  were able to gain full credit although they wasted time by unnecessarily calculating this probability. Candidates who did reach a conclusion were sometimes unclear about the appropriate statistical language, with statements such as 'reject the alternative hypothesis' being seen. It is important that candidates realise that  $H_0$  is either accepted (or more properly it is stated that 'there is insufficient evidence to reject  $H_0$ ') or that  $H_0$  is rejected in favour of  $H_1$ .