OCR
Oxford Cambridge and RSA

GCE

Quantitative Methods (MEI)

Unit **G244**: Introduction to Quantitative Methods (MEI)

Advanced Subsidiary GCE

Mark Scheme for June 2016

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

1. **Annotations and abbreviations**

Annotation in scoris	**Meaning**
✓and ✗	
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working
M0, M1	Method mark awarded 0, 1
A0, A1	Accuracy mark awarded 0, 1
B0, B1	Independent mark awarded 0, 1
SC	Special case
^	Omission sign
MR	Misread
Highlighting	
Other abbreviations in mark scheme	**Meaning**
E1	Mark for explaining
U1	Mark for correct units
G1	Mark for a correct feature on a graph
M1 dep*	Method mark dependent on a previous mark, indicated by *
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working

2. Subject-specific Marking Instructions for GCE Mathematics (MEI) Statistics strand

a Annotations should be used whenever appropriate during your marking.

The A, M and B annotations must be used on your standardisation scripts for responses that are not awarded either 0 or full marks. It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

For subsequent marking you must make it clear how you have arrived at the mark you have awarded.

b An element of professional judgement is required in the marking of any written paper. Remember that the mark scheme is designed to assist in marking incorrect solutions. Correct *solutions* leading to correct answers are awarded full marks but work must not be judged on the answer alone, and answers that are given in the question, especially, must be validly obtained; key steps in the working must always be looked at and anything unfamiliar must be investigated thoroughly.

Correct but unfamiliar or unexpected methods are often signalled by a correct result following an *apparently* incorrect method. Such work must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, award marks according to the spirit of the basic scheme; if you are in any doubt whatsoever (especially if several marks or candidates are involved) you should contact your Team Leader.

c The following types of marks are available.

M
A suitable method has been selected and *applied* in a manner which shows that the method is essentially understood. Method marks are not usually lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, eg by substituting the relevant quantities into the formula. In some cases the nature of the errors allowed for the award of an M mark may be specified.

A
Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated Method mark is earned (or implied). Therefore M0 A1 cannot ever be awarded.

B
Mark for a correct result or statement independent of Method marks.

E
A given result is to be established or a result has to be explained. This usually requires more working or explanation than the establishment of an unknown result.

Unless otherwise indicated, marks once gained cannot subsequently be lost, eg wrong working following a correct form of answer is ignored. Sometimes this is reinforced in the mark scheme by the abbreviation isw. However, this would not apply to a case where a candidate passes through the correct answer as part of a wrong argument.

d When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. (The notation 'dep *' is used to indicate that a particular mark is dependent on an earlier, asterisked, mark in the scheme.) Of course, in practice it may happen that when a candidate has once gone wrong in a part of a question, the work from there on is worthless so that no more marks can sensibly be given. On the other hand, when two or more steps are successfully run together by the candidate, the earlier marks are implied and full credit must be given.

e The abbreviation ft implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A and B marks are given for correct work only — differences in notation are of course permitted. A (accuracy) marks are not given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage of a solution, there may be various alternatives that are equally acceptable. In such cases, exactly what is acceptable will be detailed in the mark scheme rationale. If this is not the case please consult your Team Leader.

Sometimes the answer to one part of a question is used in a later part of the same question. In this case, A marks will often be 'follow through'. In such cases you must ensure that you refer back to the answer of the previous part question even if this is not shown within the image zone. You may find it easier to mark follow through questions candidate-by-candidate rather than question-by-question.

f Wrong or missing units in an answer should not lead to the loss of a mark unless the scheme specifically indicates otherwise.

Candidates are expected to give numerical answers to an appropriate degree of accuracy. 3 significant figures may often be the norm for this, but this always needs to be considered in the context of the problem in hand. For example, in quoting probabilities from Normal tables, we generally expect *some* evidence of interpolation and so

quotation to 4 decimal places will often be appropriate. But even this does not always apply – quotations of the standard critical points for significance tests such as 1.96, 1.645, 2.576 (maybe even 2.58 – but not 2.57) will commonly suffice, especially if the calculated value of a test statistic is nowhere near any of these values. Sensible discretion *must* be exercised in such cases.

Discretion must also be exercised in the case of small variations in the degree of accuracy to which an answer is given. For example, if 3 significant figures are expected (either because of an explicit instruction or because the general context of a problem demands it) but only 2 are given, loss of an accuracy ("A") mark is likely to be appropriate; but if 4 significant figures are given, this should not normally be penalised. Likewise, answers which are slightly deviant from what is expected in a very minor manner (for example a Normal probability given, after an attempt at interpolation, as 0.6418 whereas 0.6417 was expected) should not be penalised. However, answers which are *grossly* over- or under-specified should normally result in the loss of a mark. This includes cases such as, for example, insistence that the value of a test statistic is (say) 2.128888446667 merely because that is the value that happened to come off the candidate's calculator. Note that this applies to answers that are given as final stages of calculations; intermediate working should usually be carried out, and quoted, to a greater degree of accuracy to avoid the danger of premature approximation.

The situation regarding any particular cases where the accuracy of the answer may be a marking issue should be detailed in the mark scheme rationale. If in doubt, contact your Team Leader.

g Rules for replaced work

If a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests.

If there are two or more attempts at a question which have not been crossed out, examiners should mark what appears to be the last (complete) attempt and ignore the others.

NB Follow these maths-specific instructions rather than those in the assessor handbook.

h Genuine misreading (of numbers or symbols, occasionally even of text) occurs. If this results in the object and/or difficulty of the question being considerably changed, it is likely that all the marks for that question, or section of the question, will be lost. However, misreads are often such that the object and/or difficulty remain substantially unaltered; these cases are considered below.

The simple rule is that *all* method ("M") marks [and of course all independent ("B") marks] remain accessible but at least some accuracy ("A") marks do not. It is difficult to legislate in an overall sense beyond this global statement because misreads, even when the object and/or difficulty remains unchanged, can vary greatly in their effects. For example, a misread of 1.02 as 10.2 (perhaps as a quoted value of a sample mean) may well be catastrophic; whereas a misread of 1.6748 as 1.6746 may have so slight an effect as to be almost unnoticeable in the candidate's work.

A misread should normally attract *some* penalty, though this would often be only 1 mark and should rarely if ever be more than 2. Commonly in sections of questions where there is a numerical answer either at the end of the section or to be obtained and commented on (eg the value of a test statistic), this answer will have an "A" mark that may actually be designated as "cao" [correct answer only]. This should be interpreted *strictly* – if the misread has led to failure to obtain this value, then this "A" mark must be withheld even if all method marks have been earned. It will also often be the case that such a mark is implicitly "cao" even if not explicitly designated as such.

On the other hand, we commonly allow "fresh starts" within a question or part of question. For example, a follow-through of the candidate's value of a test statistic is generally allowed (and often explicitly stated as such within the marking scheme), so that the candidate may exhibit knowledge of how to compare it with a critical value and draw conclusions. Such "fresh starts" are not affected by any earlier misreads.

A misread may be of a symbol rather than a number – for example, an algebraic symbol in a mathematical expression. Such misreads are more likely to bring about a considerable change in the object and/or difficulty of the question; but, if they do not, they should be treated as far as possible in the same way as numerical misreads, *mutatis mutandis*. This also applied to misreads of text, which are fairly rare but can cause major problems in fair marking.

The situation regarding any particular cases that arise while you are marking for which you feel you need detailed guidance should be discussed with your Team Leader.

Note that a miscopy of the candidate’s own working is not a misread but an accuracy error.

Question			Answer	Marks	Guidance	AO	Diff
1			Euros received (£150) × 1.15 (= €172.50)	M1	Selects correct exchange rate and multiplies	1	E
			Notes for changing back €90	M1	Spend €172.50 - €81.25 = €91.25 Rounds down to nearest €5 (**FT**) Allow coins €1.25	2	E
			£ received (€90 ÷ 1.25 =) £72	A1	Selects correct exchange rate and divides to achieve correct answer	2	E
				[3]			

Question			Answer	Marks	Guidance	AO	Diff
2	(*A*)		In kilometres: $1.5 \times 10^8 + 1.1 \times 10^8$ ($= 2.6 \times 10^8$) 150,000,000 + 110,000,000 (= 260,000,000) 150 (million) + 110 (million) (= 260 (million)) In metres: $1.5 \times 10^{11} + 1.1 \times 10^{11}$ ($= 2.6 \times 10^{11}$) 150,000,000,000 + 110,000,000,000 (= 260,000,000,000) 150 (billion) + 110 (billion) (= 260 (billion))	**M1**	Converts to similar units and adds Allow kilometres or metres	**3**	**E**
			To 1 sf 3×10^8 km	**A1**	cao but ISW any simplification afterwards	**1**	**E**
	(*B*)		In kilometres: $1.5 \times 10^8 - 1.1 \times 10^8$ ($= 0.4 \times 10^8$) 150,000,000 - 110,000,000 (= 40,000,000) 150 (million) - 110 (million) (= 40 (million)) In metres: $1.5 \times 10^{11} - 1.1 \times 10^{11}$ ($= 0.4 \times 10^{11}$) 150,000,000,000 - 110,000,000,000 (= 260,000,000,000) 150 (billion) - 110 (billion) (= 40 (billion))	**M1**	Converts to similar units and subtracts deduct only one mark for both parts if fails to convert units Allow kilometres or metres	**1**	**E**
			To 1 sf 4×10^7 km.	**A1**	cao but ISW any simplification afterwards	**1**	**E**
				[4]			

Question			Answer	Marks	Guidance	AO	Diff
3	(i)		Number of roads 26 Number with decrease in average speed 21	M1	May be seen in calculation $\frac{21}{26}\times 100$ Or in words "21 out of 26 (show decrease)" Allow Increase 5 Decrease 21	3	E
			Percentage with decrease 80.8% (3sf)	A1	Exact answer 80.7692307… Accept 81% (2sf) or 80.77% (4sf)	3	E
				[2]			

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th><th>AO</th><th>Diff</th></tr>
<tr><td></td><td>(ii)</td><td></td><td>
<table>
<tr><td>Route</td><td>(Dec 2008)</td><td>(Dec 2014)</td><td>(Change)</td><td>% change</td></tr>
<tr><td>A1309N</td><td>12</td><td>14.6</td><td>2.6</td><td>$\frac{2.6}{12} = 21.7\%$</td></tr>
<tr><td>A603W</td><td>23.7</td><td>26.7</td><td>3</td><td>$\frac{3}{23.7} = 12.7\%$</td></tr>
</table>
</td><td>E1</td><td>Exact answers 21.6666666…% and 12.6582278…%
Accept 22% and 13% (2sf) or better e.g. 21.67% and 12.66% (4sf) i.e. do not penalise rounding since intermediate step/justification not explicitly requested in question but necessary for correct conclusion
Allow comparison of new and old percentages (14.6/12 × 100 =) 12(1.66…) and (26.7/23.7 × 100 =) 11(2.658227…).
So allow 120 and 110 or better.
Allow use of new average speed as base for comparison 2.6/14.6 × 100 = 17.8080219… and 3/26.7 × 100 = 11.235955….
So allow 20 and 10 or better.</td><td>3</td><td>E</td></tr>
<tr><td></td><td></td><td></td><td>The A1309N has the larger (percentage) increase (by 9.0 percentage points)</td><td>E1</td><td>for making comparison
FT their percentages, may be stated before calculations</td><td>4</td><td>E</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[2]</td><td></td><td></td><td></td></tr>
</table>

Question			Answer	Marks	Guidance	AO	Diff
	(iii)		Percentage increases: A (-)12.5%, B 0%, C (+)25%	B1	For all 3 correct and in correct places in table. Allow 13% or -25%.	3	C
			Weighted mean = $\frac{5000\times(-12.5)+3000\times0+2000\times25}{5000+3000+2000}$	M1 M1	for sum of products of each route by number of cars (i.e. numerator) FT percentages from table for dividing by total (= 10 000) …	1 2	A A
			= -1.25%	A1	… to achieve correct answer as a percentage. Allow correct answer without working as use of calculator likely. cao	2	A
			Special Case: calculates weighted mean for both years and then compares. 2008: $\frac{5000\times32+3000\times25.2+2000\times24}{10000}$ = 28.36 2014: $\frac{5000\times28+3000\times25.2+2000\times30}{10000}$ = 27.56 % Change = $\frac{27.56-28.36}{28.36}$ = -0.028 208 744 71 = approx -2.8%		SC1 both numerators correct SC2 divides both by 10,000 SC3 correct percentage decrease -2.8(2087447…)%		
				[4]			

Question			Answer	Marks	Guidance	AO	Diff
4	(i)		For example: The sample is very small	B1	1 mark for each sensible statement	3	C
			Data for 3 consecutive years cannot give information about a long term trend	B1	Allow "doesn't necessarily mean global warming is making the flowers bloom" or discussion of possible data collection errors such as the difficulty of observing any flowers in all locations (i.e. proving a negative) or only one flower or references to the article (e.g. natural variation in snowdrop flowering) or weaknesses of secondary data etc.	3	A
			The data are the dates of snowdrops being seen; the connection with global warming is no more than a conjecture (may mention invalid assumption of correlation between temperature and flowering implying causation). The dates for 2014 and 2015 are very close together so may not be a significant change (may mention confidence intervals or other environmental factors). **Award credit for other sensible comments**				
				[2]			
	(ii)		Year is the independent variable and Day is the dependent variable.	B1		2	E
				[1]			

Question			Answer	Marks	Guidance	AO	Diff
	(iii)	**(*A*)**	False. Fig 4.2 is not symmetrical. (Requires mention of shape of distribution for example skew)	**B1**	**Award credit for other sensible comments** Allow "would not fit"	**2**	**E**
		(*B*)	March 12th is day 31+28+12= 71 OR Fig 4.1 shows the latest date was before Day 70.	**M1**	May include mention of leap year. Allow concept of March 12th outside range of values or similar. Can infer value of 68 and date of 9th March 1986 from fig 4.1. Minimum "too late"	**4**	**C**
			False	**A1**		**3**	**E**
		(*C*)	False. Fig 4.1 shows the variability has reduced (since the early 1990s).	**B1**	Allow "(Earlier) first bloom in late Feb and March (as well)" or "(later) points are closer together"	**3**	**E**
				[4]			

Question			Answer	Marks	Guidance	AO	Diff
5	(i)		(16 × £75 =) £1200	**B1**		**1**	**E**
			50% (**of the repayments**) is interest	**B1**	Allow 100% **of principal amount** if made clear. Minimum required is "100% of the loan"	**1**	**E**
				[2]			
	(ii)		$\left(I = \frac{PRT}{100}\right) \Rightarrow 600 = \frac{600 \times R \times 1.33}{100}$	**M1**	For use of simple interest formula with correct values Be careful for use of compound interest formula for 1.25 years leading to (approximately) correct answer.	**1**	**E**
			$R = 75$ So the equivalent rate is 75%.	**A1**	Allow correct answer without working as use of calculator likely.	**2**	**C**
				[2]			

Question			Answer	Marks	Guidance	AO	Diff
	(iii)	(*A*)	**(C2)** = B2 * 0.1	**B1**	Or equivalent =B2/10	**5**	**E**
		(*B*)	**(E2)** = B2 + C2 - D2	**B1**	Or equivalent =B2 - (D2 - C2) Watch for wrong way round	**5**	**E**
		(*C*)	**(B12)** = E11	**B1**	Or equivalent =B11 + C11 – D11 =B11 – (D11 – C11)	**5**	**E**
				[3]	Deduct maximum of one mark in part iii for not keeping to common spreadsheet conventions e.g. missing equals or circular reference or × rather than * Ignore extra brackets, cell references to the cell being filled and prefixes/suffixes where logic of formula is unaffected.		

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th><th>AO</th><th>Diff</th></tr>
<tr><td></td><td>(iv)</td><td></td><td>
<table>
<tr><th></th><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th></tr>
<tr><td>1</td><td>Month</td><td>Debt</td><td>Interest</td><td>Payment</td><td>Balance</td></tr>
<tr><td>2</td><td>0</td><td>£ 600.00</td><td>£ 60.00</td><td>£ 75.00</td><td>£ 585.00</td></tr>
<tr><td>3</td><td>1</td><td>£ 585.00</td><td>£ 58.50</td><td>£ 0.00</td><td>£ 643.50</td></tr>
<tr><td>4</td><td>2</td><td>£ 643.50</td><td>£ 64.35</td><td>£ 0.00</td><td>£ 707.85</td></tr>
<tr><td>5</td><td>3</td><td>£ 707.85</td><td>£ 70.79</td><td>£ 0.00</td><td>£ 778.64</td></tr>
<tr><td>6</td><td>4</td><td>£ 778.64</td><td>£ 77.86</td><td>£ 75.00</td><td>£ 781.50</td></tr>
<tr><td>7</td><td>5</td><td>£ 781.50</td><td>£ 78.15</td><td>£ 75.00</td><td>£ 784.65</td></tr>
<tr><td>8</td><td>6</td><td>£ 784.65</td><td>£ 78.46</td><td>£ 75.00</td><td>£ 788.11</td></tr>
<tr><td>...</td><td>...</td><td>...</td><td>...</td><td>...</td><td>...</td></tr>
</table>
</td><td>B3</td><td>Row 5: B1
Row 6: B1 (all)
Row 7: B1 (both)
Allow missing final 0 and ignore filling in extra final row</td><td>5
5
5</td><td>E
E
E</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[3]</td><td></td><td></td><td></td></tr>
<tr><td></td><td>(v)</td><td>(A)</td><td>She never does repay it. The loan keeps increasing.</td><td>B1</td><td>Minimum required “never”.
Allow “interest higher than payment” or “only when extra payments made”</td><td>4</td><td>C</td></tr>
<tr><td></td><td></td><td>(B)</td><td>Dawn's mother was right.</td><td>B1</td><td>Minimum required “good”</td><td>4</td><td>E</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[2]</td><td></td><td></td><td></td></tr>
</table>

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th><th>AO</th><th>Diff</th></tr>
<tr><td>6</td><td>(i)</td><td></td><td>
<table>
<tr><th></th><th>Treatment group</th><th>Control group</th><th></th></tr>
<tr><th></th><th>Inoculated</th><th>Not inoculated</th><th>Total</th></tr>
<tr><td>Get parasite</td><td>40</td><td>320</td><td>360</td></tr>
<tr><td>Do not get parasite</td><td>460</td><td>180</td><td>640</td></tr>
<tr><td>Total</td><td>500</td><td>500</td><td>1000</td></tr>
</table>
</td><td>B1

B1

B1</td><td>B1 for each correct answer</td><td>3

3

3</td><td>E

E

E</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[3]</td><td></td><td></td><td></td></tr>
<tr><td></td><td>(ii)</td><td>(A)</td><td>$\frac{40}{500} = 0.08$</td><td>B1</td><td>Allow 8%, fraction or decimal equivalent.</td><td>2</td><td>C</td></tr>
<tr><td></td><td></td><td>(B)</td><td>$\frac{320}{500} = 0.64$</td><td>B1</td><td>Allow 64%, fraction or decimal equivalent.
SC1 for both numerators correct in a fraction.</td><td>2</td><td>C</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[2]</td><td></td><td></td><td></td></tr>
</table>

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th><th>AO</th><th>Diff</th></tr>
<tr><td></td><td>(iii)</td><td></td><td>
<table>
<tr><th>Control group</th><th>Disability</th><th>No disability</th><th>Total</th></tr>
<tr><td>Get parasite</td><td>16</td><td>304</td><td>320</td></tr>
<tr><td>Do not get parasite</td><td>0</td><td>180</td><td>180</td></tr>
<tr><td>Total</td><td>16</td><td>484</td><td>500</td></tr>
</table>
</td><td>B2</td><td>-1 per error</td><td>2
2</td><td>C
C</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[2]</td><td></td><td></td><td></td></tr>
</table>

Question			Answer	Marks	Guidance	AO	Diff
	(iv)	**(*A*)**	P(Inoculated but suffer disability) = $\frac{4}{500}$ (= 0.08)	**M1**	Selecting right information	**4**	**C**
			P(Not inoculated but suffer disability) = $\frac{16}{500}$ (= 0.032)		Same denominator - allow (with=4 without=16 change = 4 – 16 = -12 so % change = -) 12 / 16 (× 100)		
			Reduction from 16 to 4 oe (is 75%).	**A1**	(Reduction of 75% given).	**4**	**C**
		(*B*)	P(Inoculated, get parasite and suffer disability) = $\frac{4}{40} = 0.1$	**M1**	Selecting right information Allow use of equivalent fraction 32/320 or decimals	**4**	**A**
			P(Not inoculated, get parasite and suffer disability) = $\frac{16}{320} = 0.05$		or change = 0.1-0.05 = 0.05 % change = 0.05/0.05×100 Allow (32 – 16 = 16 % change) 16/16 (× 100)		
			0.05 to 0.1 (is a 100% increase.)	**A1**	(Increase of 100% given). Beware comments about 100% of those with disability had parasite.	**4**	**A**
				[4]			

Question			Answer	Marks	Guidance	AO	Diff
7	(i)		(The number of Tom's ancestors is) $2^{(10)}$	M1	Allow Gen0: 1, Gen1: 2, Gen2: 4... (so doubling).	1	C
			(2^{10} =) 1024 (so is just over 1000)	A1	Comparison with 1000 may be implied. Allow listing values.	2	C
				[2]			
	(ii)	(*A*)	(2000 - 1700 = 300 years ÷ 30 = 10 generations. So) 1000 (in 1700.) (One thousand)	B1	Allow 1024 or 1×10^3.	3	E
		(*B*)	(2000 – 1400 = 600 years ÷ 30 = 20 = 2 × 10 generations. So 1000 × 1000 =) 1 000 000 (in 1400.) (One million)	B1	Allow 1 048 576 for using 1024 or 1×10^6.	3	C
		(*C*)	(2000 – 1100 = 900 years ÷ 30 = 30 = 3 × 10 generations. So 1000 × 1000 × 1000 =) 1 000 000 000 (in 1100.) (One billion)	B1	Allow 1 073 741 824 for using 1024 or 1×10^9	3	C
				[3]			
	(iii)	(*A*)	A curve going steeply from the top left and flattening out at the bottom right	B1		1	E
		(*B*)	Points (1100, 10^9), (1400, 10^6), (1700, 10^3) and (2000, 10^0)	M1	Allow one error. May be implied by correct straight line.	1	A
			Straight line through the points	A1		2	A
				[3]			

Question			Answer	Marks	Guidance	AO	Diff
	(iv)		It doesn't go off the scale It gives a straight line It is easier to work with a straight line	B1	Any sensible comment Allow more accurate, see more clearly (especially lower values), fit more data/easily on graph, can use large numbers.	4	A
				[1]			

Question			Answer	Marks	Guidance	AO	Diff
	(v)		<table><tr><td>Year (AD)</td><td>800</td><td>1100</td><td>1400</td><td>1700</td></tr><tr><td>Tom's ancestors (millions)</td><td>1 000 000</td><td>1000</td><td>1</td><td>0.001</td></tr></table> **Table 7.5**	B2	Allow 1 099 512,1 073, 1.048 for using 1024. Allow B1 for 1 mistake	3	A
			In the early years the number of Tom's living ancestors is greater than the number of people in the world at the time	B1		4	A
			The assumption that all Tom's ancestors in any generation were all different people. (Relaxing this assumption would mean that the number of Tom's ancestors would not increase exponentially.)	B1		3	A
				[4]			

Question			Answer	Marks	Guidance	AO	Diff
8	(i)		48 km = 48 000 OR 1 hour = 3600 seconds	M1	oe may be implied by division in next step.	1	E
			$\frac{48000}{3600}$ = 40/3 = 13 1/3 (ms^{-1}) 3600	A1	Units not required as given in question. Allow 13.3 or better. M1A1 for answer correct	1	E
				[2]			
	(ii)		Thinking distance = 9 m OR their 9 / 13 1/3 OR their 9 × 3600 / 48000	M1	For correct value (may be seen in division rather than stated explicitly) or operation	1	E
			Thinking time = $\frac{9}{13\frac{1}{3}} = 0.675\,\text{s}$	A1	0.675 s given in question	2	C
			112 km h^{-1} = $\frac{112000}{3600}$ m s^{-1} (= 31 1/9 m s^{-1})				
			$\frac{112000}{3600} \times 0.675 = 21\,\text{m}$, As required. OR 21/31.111111… = 0.675 s OR 21/0.675 = 31 1/9	B1	For using S × T = D OR D / S = T OR D / T= S to verify thinking time = 0.675 s for second converted speed 31 1/9 m s^{-1}.	4	A
				[3]			

(iii)

Speed in km/h	v (m s^{-1})	d (m)	b (m)	s (m)
32	8.89	6	6	12
48	13.33	**9**	**14**	**23**
64	17.78	12	24	36
80	22.22	15	38	53
96	**26.67**	18	55	73
112	31.11	21	75	96

Question	Answer	Marks	Guidance	AO	Diff
		B1	Readings from 30 mph on diagram	**1**	**E**
		B1	Allow 26.6’ or 26.66. Allow 26.6 from 96000 / 3600 (i.e. working seen)	**1**	**E**
		[2]			
(iv)	$d = 0.675v$	**B1**	Allow 0.68 v	**2**	**E**
		[1]			

Question	Answer	Marks	Guidance	AO	Diff
(v)	$14 = k \times \left(\frac{40}{3}\right)^2$ OR 14 = k × (13.3')^2 OR 14 = k × (13 1/3)^2	M1	Allow 13.3' ^{2} = 177 7/9 or 177.7' OR 13.3 ^{2} = 176.89 OR 13.33 ^{2} = 177.6889 in correct formula equal to 14 or rearranged version.	4	A
	$k = 0.07875$	A1	Accept 0.079(145231…) or better (from use of 13.3) OR 0.0788 or better (from using 13.33 to obtain 0.0787893897…)	2	A
		[2]			
(vi)	100 mph = 160 km h^{-1}				
	$\Rightarrow v = \frac{160000}{3600} = 44.44$ m s^{-1} = 44 4/9 m s^{-1}	B1	Allow 44.44(44…) or better	1	C
	$d = 0.675 \times 44.44 = 30\,\text{m}$	B1	Allow d = 160 ÷ 5 1/3 (factor includes conversion from km/h to m for previous B1 mark as well) OR 29.997 from use of 44.44	1	C
	$b = 0.07875 \times (44.44)^2 = 155.55\,\text{m}$	B1	Allow range 155 to 156	5	A
	$s = 185.55$ so 186 metres.	B1	Allow range 185 to 186.05	2	A
	NB Check 2 pages of Additional Answer Space. Use Fit Height to help.	[4]			

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Question			Answer	Marks	Guidance	
1	(i)		<table><tr><th>*n*</th><th>exact</th><th>approx</th><th>error</th><th>rel error</th></tr><tr><td>40</td><td>1.012739</td><td>1</td><td>−0.012739</td><td>−0.012580</td></tr></table>	B1 B1 **[2]**	Error (with either sign) Relative error: must be negative unless absolutely clear that the opposite convention has been used. At least 3 dp required	
	(ii)		Trial and error gives $n = 51$	M1 A1 **[2]**	Evidence of a serious and sensible attempt	
2	(i)		f '(x) = $3x^2 + 1$ NR formula Iterations, e.g.: 1.5 1.258065 1.214705 1.213413 1.213412 Hence 1.21341 to 5 dp	B1 B1 M1A1 A1 **[5]**	 Soi First iteration Answer to 5 dp	
	(ii)		Differences and ratios of differences for this iteration are: −0.24194 −0.04336 −0.00129 −1.1E−06 0.179218 0.02981 0.000869 Comment that ratios decreasing (so not first order)	 M1A1 E1 **[3]**	 Allow 1 mark if differences only shown FT decreasing but incorrect ratios	
3	(i)		Using $x = 0.5$, 1.5 and 2.5: $S = 1.286080$ Using all values of x: $S = 1.285453$	M1A1 A1 **[3]**	M1 for correct formula For correct second S	
	(ii)		S is of order h^4, or fourth order Difference in S values is (−)0.000627 Reduce difference by a factor of 16 (Next difference is (−)0.000039) So next S is estimated as 1.285414	B1 B1 M1 A1 **[4]**	 May be implied FT an incorrect difference here	
	(iii)		1.2854 is secure; accept also 1.28541	B1 **[1]**		
4	(i)		Forward difference is first order (order h) Central difference is second order (order h^2) This (usually) means that central difference is more accurate than forward difference, and that central difference converges faster than forward difference.	B1 B1 B1 **[3]**	 Accept either statement for the mark	

Question			Answer	Marks	Guidance	
	(ii)		h forward central 0.2 1.2220 1.2220 0.1 1.2314 1.2314 In this case the central difference is the same as the forward difference (There is a point of inflection at $x = 1$ (not required))	M1A1 M1A1 E1 [5]	For forward differences For central differences	
5	(i)		0 1.35701 0.5 1.41333 0.05632 1 1.38177 −0.03156 −0.08788 1.5 1.26431 −0.11746 −0.08590 2nd differences approximately equal so quadratic a good fit	M1A1 E1 **[3]**		
	(ii)		$h(x) = 1.35701 + 0.05632\, x / 0.5 - 0.08788\, x\,(x - 0.5) / 2\,(0.5)^2$	M1 A1 A1 **[3]**	Need to see attempt at second term	
	(iii)		Substitute to get h(1.5) = 1.26233 Hence error is 1.26233 – 1.26431 = – 0.00198	B1 B1 **[2]**	Follow through trivial errors Condone opposite sign convention	
6	(i)		Sketch of $y = kx$ Sketch of $y = 3^{-x}$ Some consideration or mention of varying k	G1 G2 E1 **[4]**	G1 shape; then G1 location if shape correct	
	(ii)	(A)	$k = 0.5$ gives iterates 1 0.666667 0.9615 0.695469 0.931551 0.718732 The interval is narrowing so the iteration is converging	M1A1 E1	Must be enough terms (at least 4) to see the pattern	
		(B)	$k = 0.4$ gives iterates 1 0.833333 1.000781 0.832619 1.001567 0.8319 The interval is getting wider so the iteration is diverging	M1A1 E1	Must be enough terms (at least 4) to see the pattern	
			The convergence with $k = 0.5$ is very slow	E1 **[7]**	Dependent on (A) being correct	

Question			Answer	Marks	Guidance	
	(iii)		Convincing algebra (in either direction) to show the equivalence $k = 0.5$ gives 1 0.833333 0.816979 0.816059 0.816011 0.816009 Hence root is 0.8160 to 4dp $k = 0.4$ gives 1 0.916667 0.914947 0.914951 0.914951 0.914951 Hence root is 0.9150 to 4dp	M1A1 M1A1 A1 B1 B1 **[7]**		
7	**(i)**		$S_{1001} = 0.692647 + 1 / 1001 = 0.693646 = 0.69365$ to 5 dp $S_{1002} = 0.693646 – 1 / 1002 = 0.692648 = 0.69265$ to 5 dp (Still variation in 3rd dp so) convergence is slow	M1A1 A1 E1 **[4]**	M1 for method in either evaluation 'slow' is the key word: the qn states the convergence	
	(ii)		Convincing arithmetic to 1/2 and 1/12 1/5 – 1/6 = 1/30 1/7 – 1/8 = 1/56	B1 B1 B1 **[3]**		
	(iii)		$T_{500} = S_{1000}$ $T_{501} = S_{1002} = 0.69265$ to 5 dp $T_{502} = S_{1004} = 0.692648 + 1/1003 – 1/1004 = 0.692649 = 0.69265$ to 5 dp T_n *appears* to be converging judging by agreement to 5 dp	E1 B1 B1 E1 **[4]**	Do not accept T_n is converging	
	(iv)		With correction, $n = 500$ gives 0.693147 so 0.69315 to 5 dp With correction, $n = 501$ gives 0.693147 so 0.69315 to 5 dp The corrected formula gives different values to those obtained earlier	M1A1 A1 E1 **[4]**	6 dp values not required	
	(v)		Agreement to (5) dp does not indicate convergence to (5) dp So be cautious about accepting any of the values calculated Though the last is likely to be more reliable than the others (because it's an improved method, or because it is in the middle of the oscillations)	E1 E1 E1 **[3]**	Accept other sensible discussion points	

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GCE

Quantitative Methods (MEI)

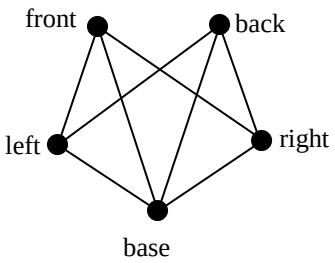
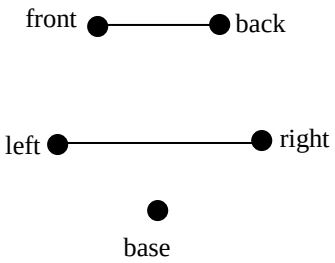
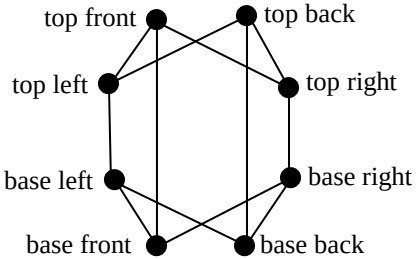
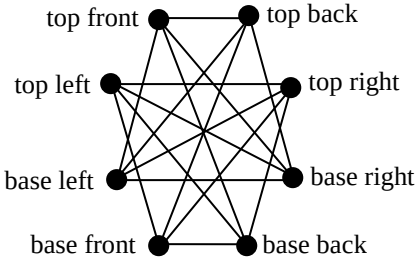
Unit **G246**: Decision Mathematics 1

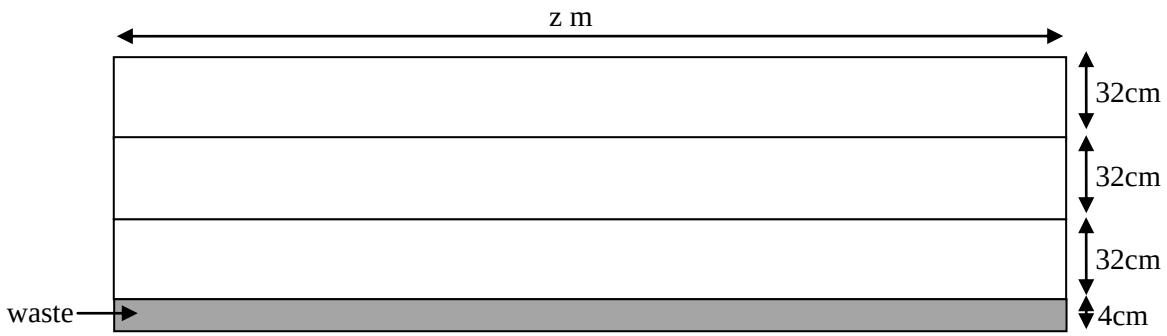
Advanced Subsidiary GCE

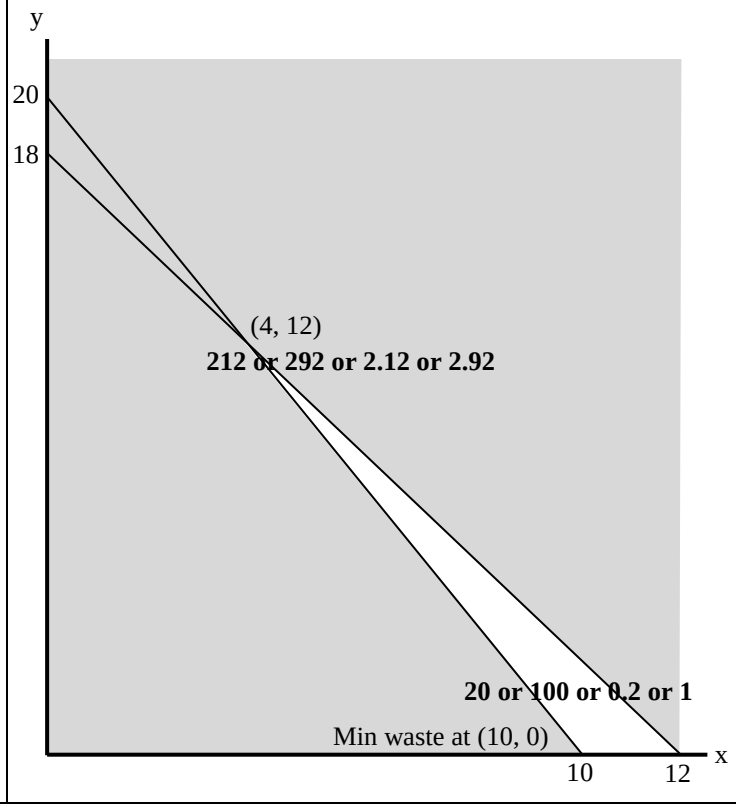
Mark Scheme for June 2016

Question			Answer	Marks	Guidance
1	(i)		e.g. 0, 1, 2, 3 → win 4, 5, 6, 7, 8, 9 → lose or 0, 1, 2, 3, 4, 5 → lose 6, 7, 8, 9 → win	M1 A1	correct rule efficient rule disallow 1, 8, 3, 5 → win disallow 6, 7, 1, 3 → win
	(ii)		In the worst case Pierre will suffer 3 consecutive losses, of £100, £200 and £400 respectively. He will then be unable to fund the next bet of £800.	B1	100, 200, 400 may by implied, eg by 700 lost or 300 left
	(iii)		e.g. or 1, 6, 4 → win 1, 6, 4 → win 8, 6, 4 → lose 8, 6, 4 → win 8, 7, 4 → lose 8, 7, 4 → win 3, 1, 1 → win 3, 1, 1 → lose 5, 3, 2 → win 5, 3, 2 → lose	M1 A1√ or M1 A1√	correct identification of first win and of first loss rest numbers → L/W for 1 6 4 and 8 6 4 rest + interpretation
	(iv)		100 x no of wins + 700 x no of losses eg1 … -£1100 eg2 … £3900 eg1 … on average a loss of £220 per application of the strategy eg2 … on average £780 left	M1 A1√ A1√	weighted sum or 5 monetary outcomes – implied OK (Their "700" OK here) correct sum following their simulation but not their 700. their sum/5

Question			Answer	Marks	Guidance
2	(i)		n 1 2 3 4 5 6 7 p 1 0.962 0.888 0.785 0.664 0.537 0.413	M1 M1 A1 A1	n=2 … awrt 0.96 n=3 … awrt 0.88 or 0.89 n=4 … awrt 0.79 stopping at n=7 with p<0.5
	(ii)		Need to select 7 cards for the probability of repetition on the list to exceed 0.5.	B1 B1	their "7" P(repetition) exceeds 0.5
	(iii)		Step 1 Set n = 1. Step 2 Set p = 1. Step 3 Set n = n + 1. Step 4 Set p = p × (366-n)/365. Step 5 If p < 0.5 then stop. Step 6 Go to Step 3.	B1	both changes (step 4) and no others
	(iv)		Because they do not have the same frequency of occurrence (probability) as other birthdays.	B1	

Question			Answer	Marks	Guidance
3	(i)		  So 3 colours are needed	B1 B1 B1	adjacency graph all correct cao complement graph correct cao three colours
	(ii)		A  	M1 A1 A1	top front adjacency OK adjacency graph all correct complement graph correct cao
			B Two disjoint, complementary and complete subgraphs can be identified (in several ways)	M1 A1	two subgraphs complete

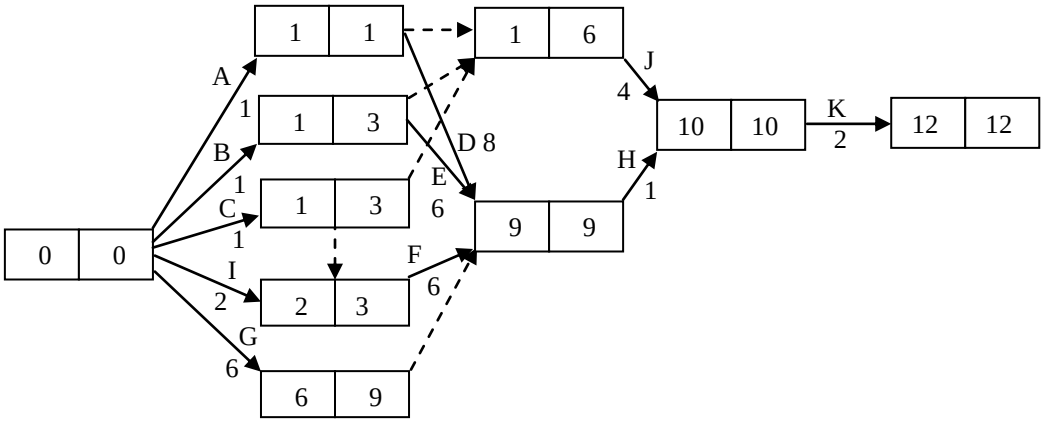
Question			Answer	Marks	Guidance
4	(i)			M1 A1	3 widths + waste
4	(ii)		$0.06x + 0.21y + 0.04z$ (m^2)	M1 A1√	3 areas any units OK ... ignore scaling
4	(iii)		$2x + y > 20$	B1	
4	(iv)		$y + 3z > 24$	B1√	
4	(v)		Use of $z = 20 – x – y$ Minimise $0.02x + 0.17y$ (constant of 0.8 not needed but OK if there) st $2x + y > 20$ $-3x – 2y > -36$ or $3x + 2y < 36$	M1 A1√ A1√	“minimise” not needed - given

Question			Answer	Marks	Guidance
4	(vi)				
			Cut 10m according to plan x and 10m according to plan z.	M1	z =10
			Gives ...		
			20m of material with width 47cm		
			30m of material with width 32cm	A1	both
			$1m^2$ of waste.	A1	waste
				B1	line (cao)
				B1	line (cao)
				B1	shading – follow two neg grad lines making a triangle with base on x-axis
				M1	objective valued at (10,0) and at (4,12)

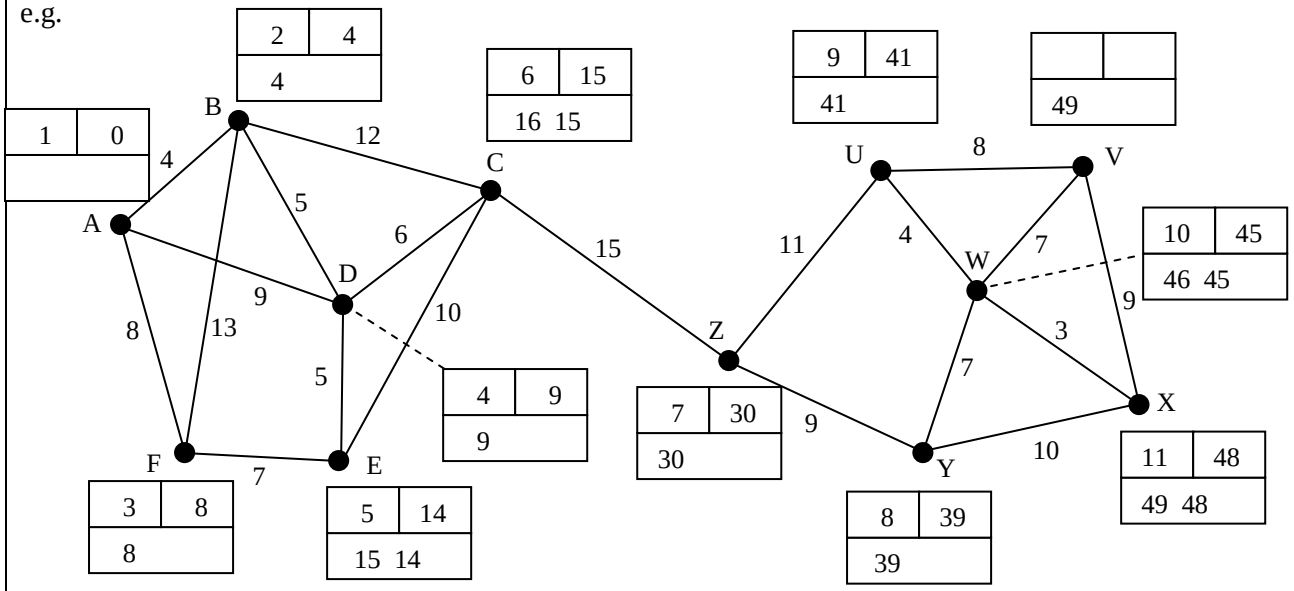
Question			Answer	Marks	Guidance
5	(i)				

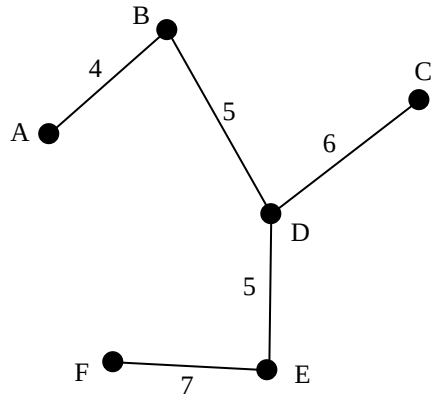
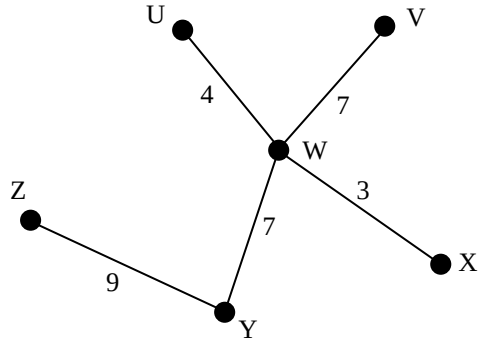
Activity	Duration (weeks)	Immediate predecessors
A	1	–
B	1	–
C	1	–
D	8	A
E	6	B
F	6	C, I
G	6	–
H	1	D, E, F,G
I	2	–
J	4	A, B, C
K	2	H, J

		B1	A, B, C, G and I	
		B3	-1 for 1 or 2 wrong rows -2 for 3 or 4 wrong rows -3 for 5 or 6 wrong rows	

5	(ii)+ (iii)		 Critical activities ... A, D, H, K	M1 A1 A1 A1 M1 A1√ M1 A1√ B1cao	activity on arc immediate predecessors A, B, C, I, G immediate predecessors D (A), E(B), F(C,I,) immediate predecessors J(A,B,C), H(D,E,F,G) immediate predecessors K(J,H) + rest forward pass backward pass

Question			Answer	Marks	Guidance
5	(iv)		eg Week 1 2 3 4 5 6 7 8 9 10 11 12 CPA start time 0 1 2 3 4 5 6 7 8 9 10 11 Room 1 A D D D D D D D D H K K Room 2 B E E E E E E F F Room 3 C F F F F G G G G G G I I J J J J	B1cao B1cao	F (ES2, LF9) rest

Question			Answer	Marks	Guidance
6	(a)	(i)	e.g.  Route – A D C Z U W X or A B D C Z U W X Distance – 48 km	B1 B1 B1 B1 B1 B1	Dijkstra – E correct other working values order of labelling labels
6	(a)	(ii)	No difference, but allow “one fewer”, as 15 (CZ) does not need to be added on to determine the route. Part (i) is effectively using Dijkstra on the left network then Dijkstra on right network, but starting at 30 instead of 0 on the right network.	M1 A1	Need comment re just one arc connecting the two networks.

Question			Answer	Marks	Guidance
6	(b)	(i)	Order of choice ... AB, BD ↔ DE, DC, EF 	M1 A1 B1	Kruskal (first 2 arcs identified – OK if by length) min connector
6	(b)	(ii)	Order of inclusion ... U, W, X, V ↔ Y, Z 	M1 A1 B1	Prim (first 2 vertices identified - OK to say UW, WX, etc, but in that order. Not OK to identify by lengths) min connector
6	(b)	(iii)	Total length = 72 km.	B1cao B1	27 + 30 + 15 for the pass

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