OCR
RECOGNISING ACHIEVEMENT

Monday 23 January 2012 – Morning

AS GCE MATHEMATICS (MEI)

4771 Decision Mathematics 1

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:
- Printed Answer Book 4771
- MEI Examination Formulae and Tables (MF2)

Other materials required:
- Scientific or graphical calculator

Duration: 1 hour 30 minutes

4732210112

INSTRUCTIONS TO CANDIDATES

These instructions are the same on the Printed Answer Book and the Question Paper.
- The Question Paper will be found in the centre of the Printed Answer Book.
- Write your name, centre number and candidate number in the spaces provided on the Printed Answer Book. Please write clearly and in capital letters.
- **Write your answer to each question in the space provided in the Printed Answer Book**. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- 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

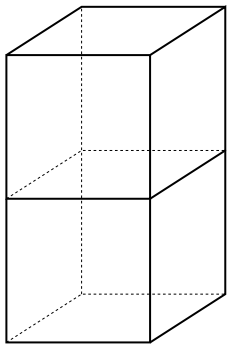
- This information is the same on the Printed Answer Book and the Question Paper.
- The number of marks is given in brackets **[ ]** at the end of each question or part question on the Question Paper.
- You are advised that an answer may receive **no marks** unless you show sufficient detail of the working to indicate that a correct method is being used.
- The total number of marks for this paper is **72**.
- The Printed Answer Book consists of **12** pages. The Question Paper consists of **8** pages. Any blank pages are indicated.

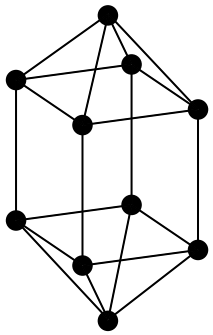
INSTRUCTION TO EXAMS OFFICER / INVIGILATOR

- Do not send this Question Paper for marking; it should be retained in the centre or recycled. Please contact OCR Copyright should you wish to re-use this document.

Section A (24 marks)

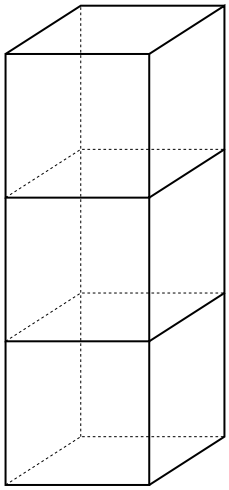
1 A graph is obtained from a solid by producing a vertex for each exterior face. Vertices in the graph are connected if their corresponding faces in the original solid share an edge. The diagram shows a solid followed by its graph. The solid is made up of two cubes stacked one on top of the other. This solid has 10 exterior faces, which correspond to the 10 vertices in the graph. (Note that in this question it is the exterior faces of the cubes that are being counted.)





(i) Draw the graph for a cube. **[4]**

(ii) Obtain the number of vertices and the number of edges for the graph of three cubes stacked on top of each other. **[4]**



2 The following is called the '1089' algorithm. In steps 1 to 4 numbers are to be written with exactly three digits; for example 42 is written as 042.

Step 1 Choose a 3-digit number, with no digit being repeated.

Step 2 Form a new number by reversing the order of the three digits.

Step 3 Subtract the smaller number from the larger and call the difference D. If the two numbers are the same then D = 000.

Step 4 Form a new number by reversing the order of the three digits of D, and call it R.

Step 5 Find the sum of D and R.

(i) Apply the algorithm, choosing 427 for your 3-digit number, and showing all of the steps. **[4]**

(ii) Apply the algorithm to a 3-digit number of your choice, showing all of the steps. **[2]**

(iii) Investigate what happens if digits may be repeated in the 3-digit number in step 1. **[2]**

3 Solve the following LP problem graphically.

Maximise $2x + 3y$
subject to $x + y \leqslant 11$
$3x + 5y \leqslant 39$
$x + 6y \leqslant 39$. **[8]**

Section B (48 marks)

4 The table defines a network in which the numbers represent lengths.

	A	B	C	D	E	F	G
A	–	5	2	3	–	–	–
B	5	–	–	–	1	1	–
C	2	–	–	–	4	1	–
D	3	–	–	–	4	2	–
E	–	1	4	4	–	–	1
F	–	1	1	2	–	–	5
G	–	–	–	–	1	5	–

(i) Draw the network. **[3]**

(ii) Use Dijkstra's algorithm to find the shortest paths from A to each of the other vertices. Give the paths and their lengths. **[6]**

(iii) Draw a new network containing all of the edges in your shortest paths, and find the total length of the edges in this network. **[2]**

(iv) Find a minimum connector for the original network, draw it, and give the total length of its edges. **[4]**

(v) Explain why the method defined by parts **(i)**, **(ii)** and **(iii)** does not always give a minimum connector. **[1]**

5 Five gifts are to be distributed among five people, A, B, C, D and E. The gifts are labelled from 1 to 5. Each gift is allocated randomly to one of the five people. A person can receive more than one gift.

(i) Use one-digit random numbers to simulate this process. One-digit random numbers are provided in your answer book.

Explain how your simulation works.

Produce a table, showing how many gifts each person receives. **[6]**

(ii) Carry out four more simulations showing, in each case, how many gifts each person receives. **[2]**

(iii) Use your simulation to estimate the probabilities of a person receiving 0, 1, 2, 3, 4 and 5 gifts. **[5]**

(iv) Describe what you would have to do differently if there were six people and six gifts. **[3]**

6 The table shows the tasks involved in making a salad, their durations and their precedences.

Task		Duration (seconds)	Immediate predecessors
B	get out bowl and implements	10	–
I	get out ingredients	10	–
L	chop lettuce	15	B, I
W	wash tomatoes and celery	25	B, I
T	chop tomatoes	15	W
C	chop celery	10	W
P	peel apple	20	B, I
A	chop apple	10	P
D	dress salad	10	L, T, C, A

(i) Draw an activity on arc network for these activities. **[5]**

(ii) Mark on your diagram the early and late times for each event. Give the minimum completion time and the critical activities. **[6]**

(iii) Given that each task can only be done by one person, how many people are needed to prepare the salad in the minimum time?

What is the minimum time required to prepare the salad if only one person is available? **[2]**

(iv) Show how two people can prepare the salad as quickly as possible. **[3]**

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RECOGNISING ACHIEVEMENT

Monday 23 January 2012 – Morning

AS GCE MATHEMATICS (MEI)

4771 Decision Mathematics 1

PRINTED ANSWER BOOK

Candidates answer on this Printed Answer Book.

OCR supplied materials:
- Question Paper 4771 (inserted)
- MEI Examination Formulae and Tables (MF2)

Other materials required:
- Scientific or graphical calculator

Duration: 1 hour 30 minutes

Candidate forename		Candidate surname	

Centre number						Candidate number				

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DC (CW/CGW) 43636/4

Section A (24 marks)

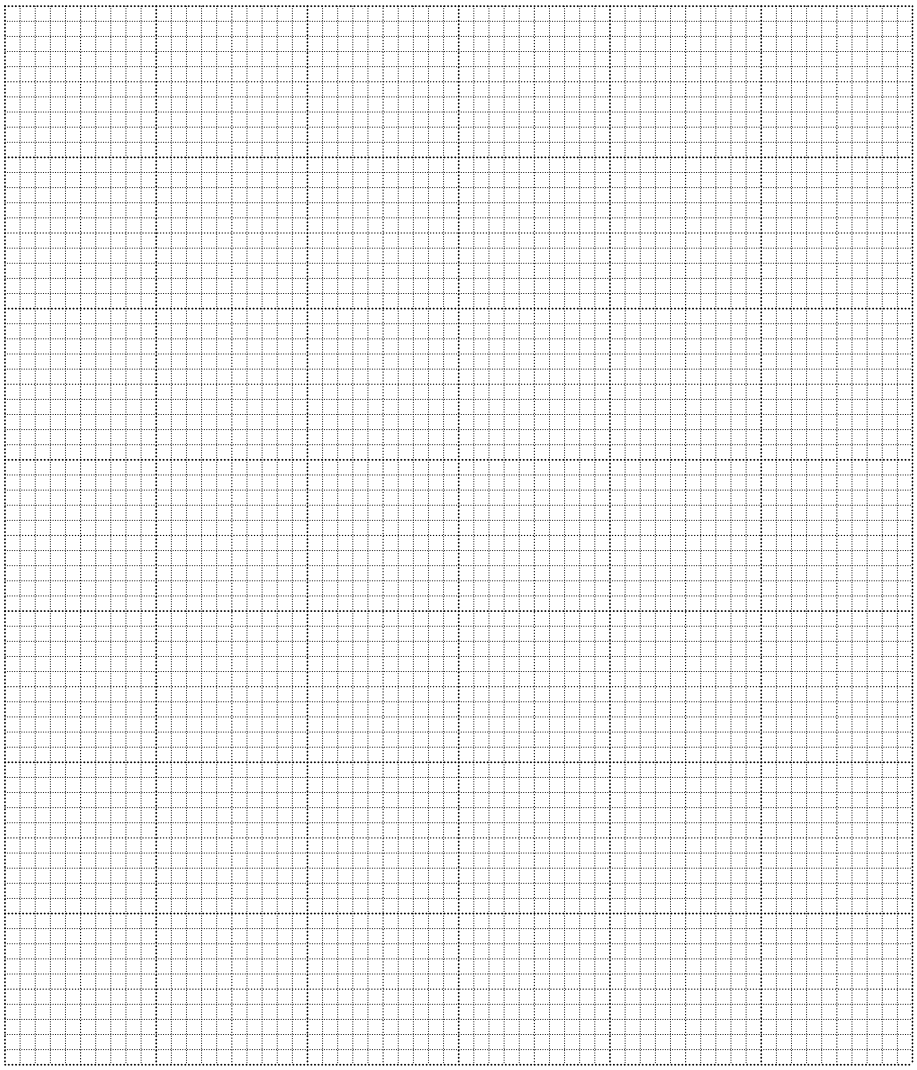
1 (i)	
1 (ii)	

2 (i)

2 (ii)

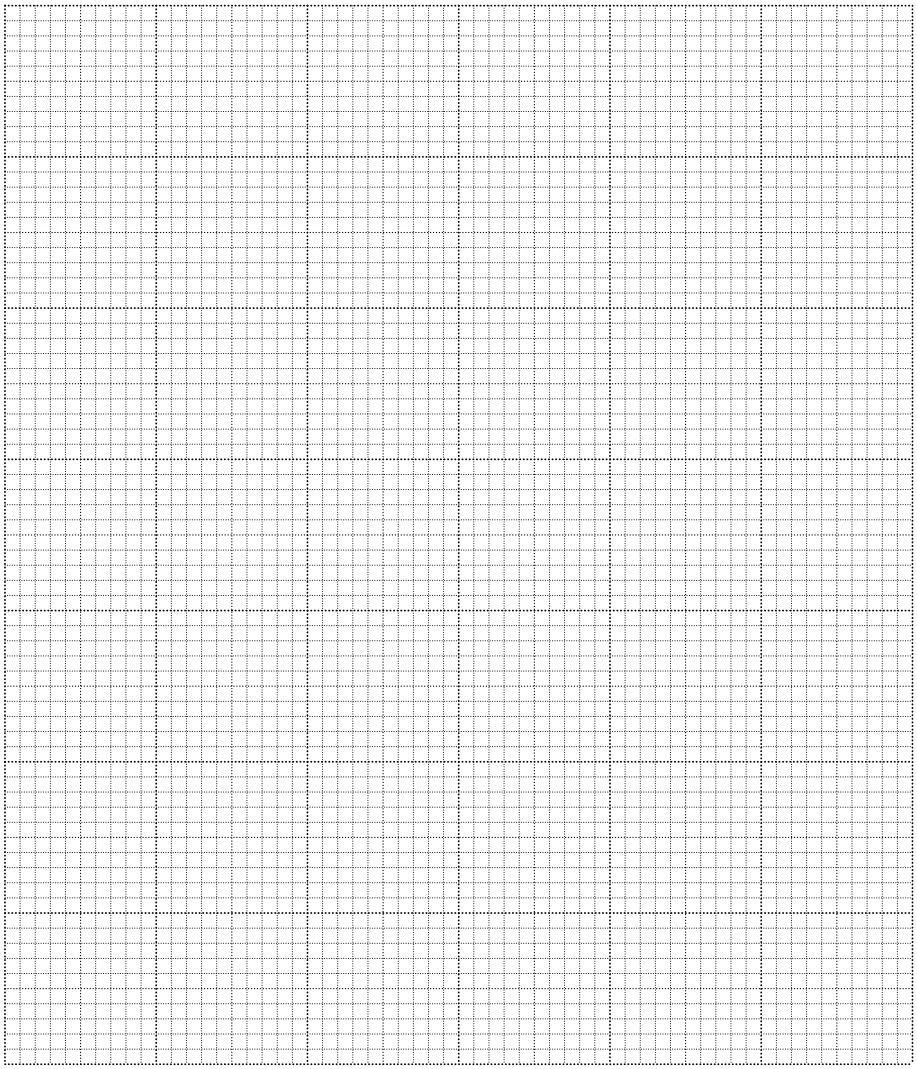
2 (iii)

3



A spare copy of this graph paper can be found on page 5.

Spare copy of graph paper for question 3.



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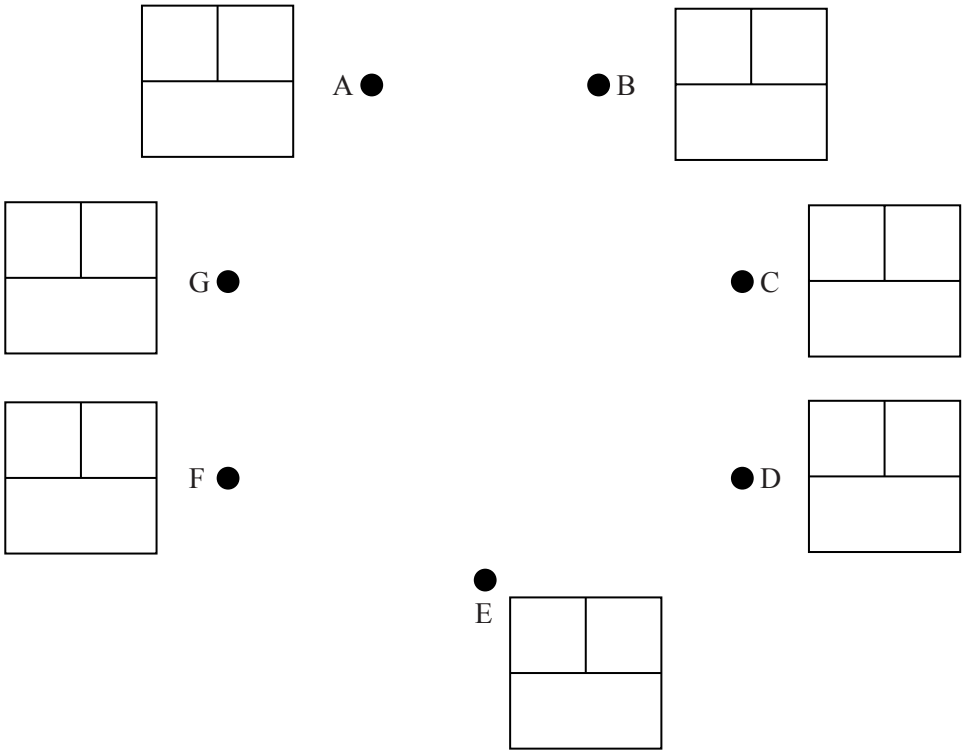
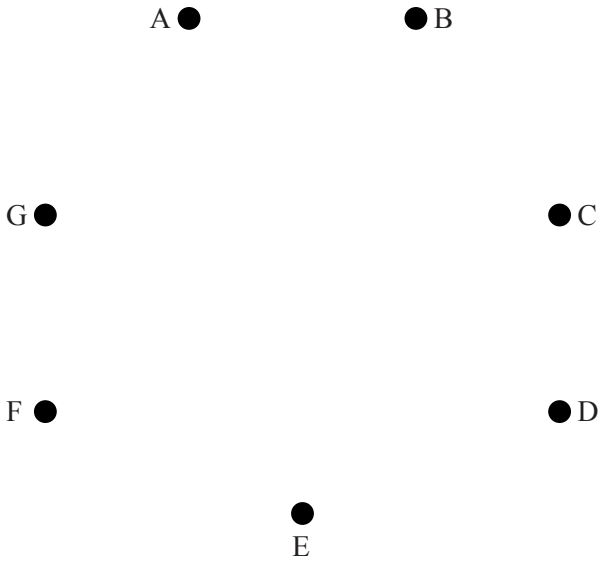
Section B (48 marks)

4 (i) & (ii)

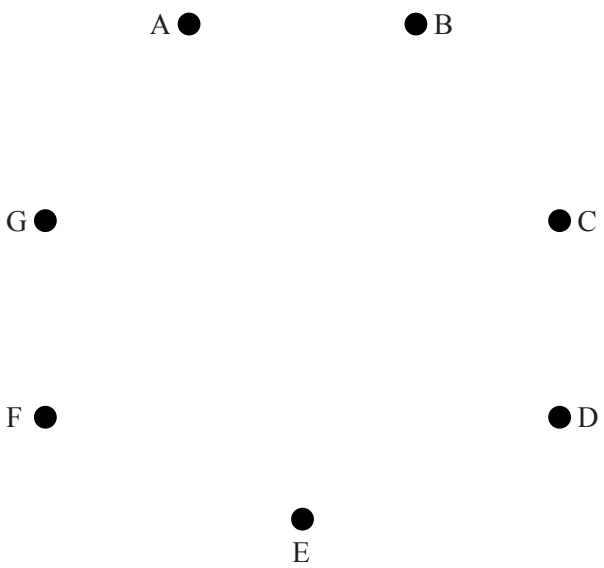


4 (iii)



Total length of edges:

4 (iv)



Total length of edges:

4 (v)

One-digit random numbers:

3	**3**	**7**	**5**	**2**	**9**	**3**	**0**	**6**	**2**	**4**	**9**	**0**	**6**	**2**	**7**	**2**	**2**	**1**	**6**
8	**2**	**3**	**6**	**4**	**8**	**0**	**2**	**9**	**1**	**7**	**5**	**2**	**3**	**0**	**8**	**7**	**0**	**6**	**7**

5 (i)

5 (ii)

5 (iii)

5 (iv)	

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6 (i) & (ii)	

6 (iii)	
6 (iv)	

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RECOGNISING ACHIEVEMENT

GCE

Mathematics (MEI)

Advanced Subsidiary GCE

Unit **4771:** Decision Mathematics 1

Mark Scheme for January 2012

Oxford Cambridge and RSA Examinations

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It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

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.

Any enquiries about publications should be addressed to:

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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

Subject-specific Marking Instructions for GCE Mathematics (MEI) Decision 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 f

or 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, with 3 significant figures often being the norm. Small variations in the degree of accuracy to which an answer is given (e.g. 2 or 4 significant figures where 3 is expected) should not normally be penalised, while answers which are grossly over- or under-specified should normally result in the loss of a mark. 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

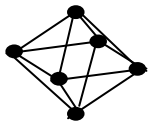
If a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests.

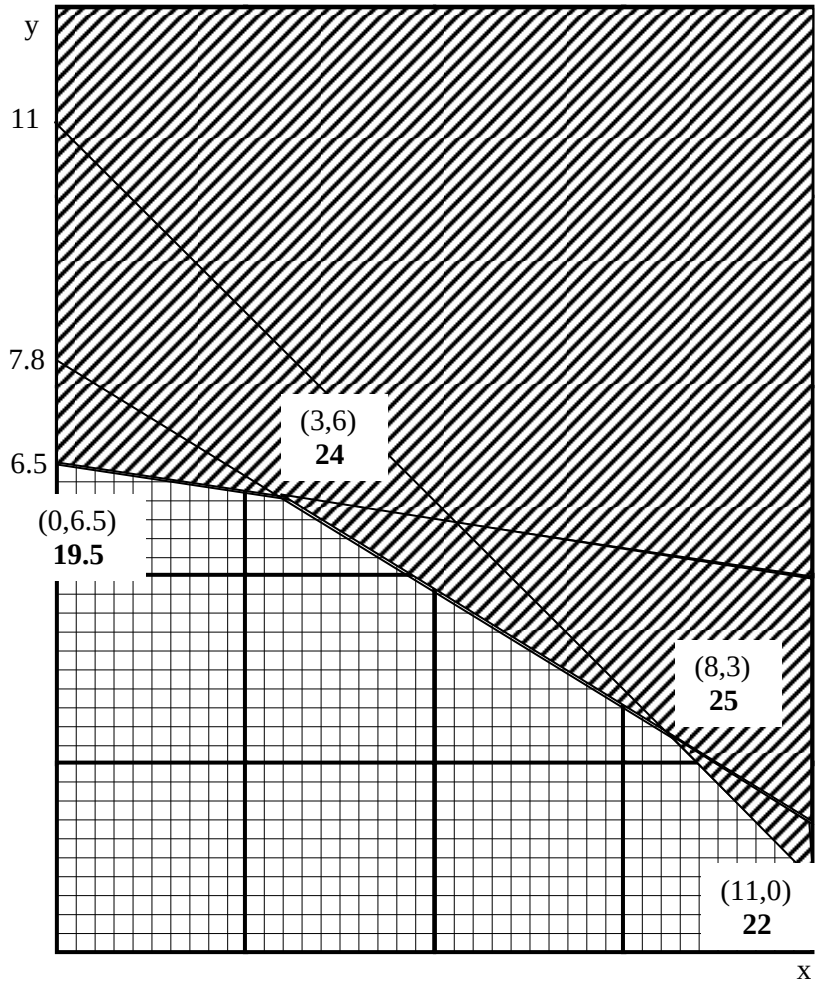
If there are two or more attempts at a question which have not been crossed out, examiners should mark what appears to be the last (complete) attempt and ignore the others.

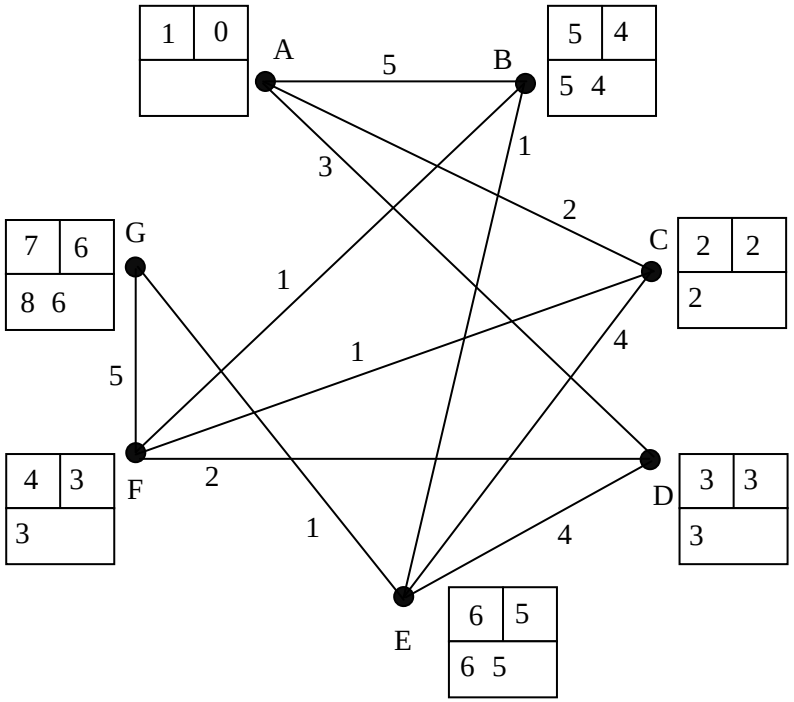
NB Follow these maths-specific instructions rather than those in the assessor handbook.

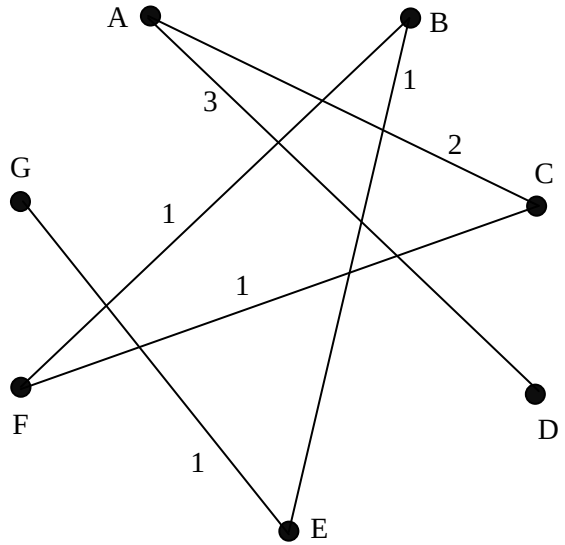
h For a *genuine* misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some units. This is achieved by withholding one A mark in the question.

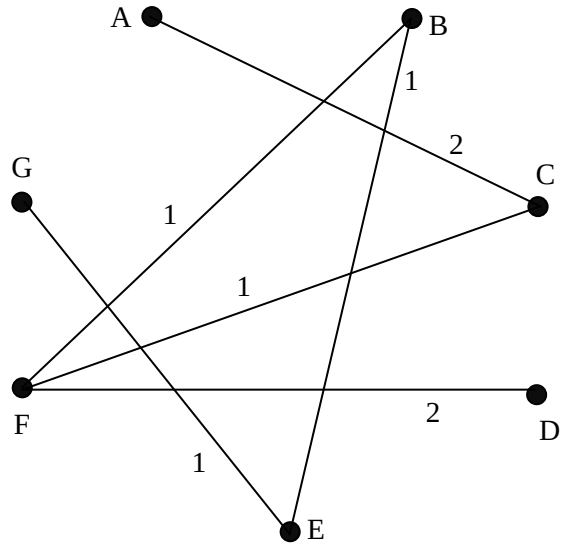
Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

Question			Answer	Marks	Guidance
1	(i)			M1 A1 A1 A1 **[4]**	6 vertices 8 faces 12 edges all correct
1	(ii)		14 vertices 28 edges	M1 A1 M1 A1 **[4]**	13–15 24–32 or 56
2	(i)		427 724 297 792 1089	 B1 B1 B1 B1 **[4]**	 √ √ cao
2	(ii)		steps as above	M1 A1 **[2]**	all steps attempted
2	(iii)		xxy or yxx $\rightarrow$ 1089 xyx $\rightarrow$ 0 and/or xxx $\rightarrow$ 0	B1 B1 **[2]**	 wrong work –1

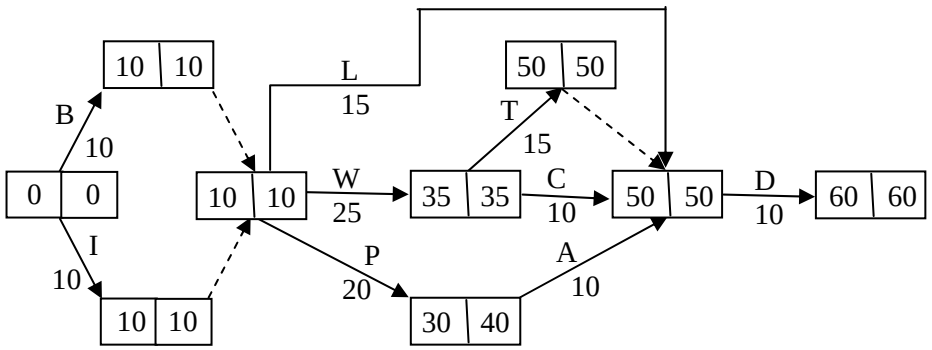
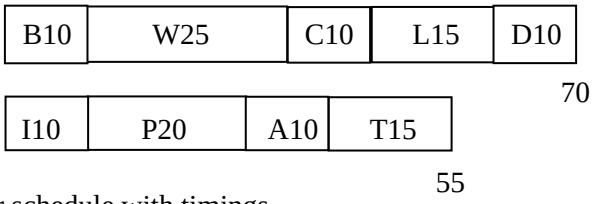
Question	Answer	Marks	Guidance
3			
		B1 B1 B1	Lines (+/–0.1 vertically at x=0 and x=8)
		B1	shading
		M1	Optimisation - either profit line or evaluating at vertices
		A1	comparing values at his 3 points (3,6), (8,3) and (11,0)
	Solution is x=8 and y=3 (+/–0.25) with objective=25 (23.75 to 26.25)	B1 B1 **[8]**	cao cao

Question			Answer	Marks	Guidance
4	(i)& (ii)			M1 A1 A1 **[3]**	Network - at least one weighted arc Arcs - count an omission as one error lengths
				M1 A1 B1 B1	Dijkstra (check wv's at B) working values allow legitimate later and order of labelling larger wv's which are listed, Labels but not used Order of labelling for D and F could be reversed.
			ACFB 4 AC 2 AD 3 ACFBE 5 ACF 3 ACFBEG 6	M1 A1 **[6]**	M1 for ACFB or ACFBE or ACFBEG cao

Question			Answer	Marks	Guidance
4	(iii)			B1	tree, cao
			total length = 9	B1 **[2]**	cao

Question			Answer	Marks	Guidance
4	(iv)			M1 A2	6 arc tree drawn correct arcs (–1 each error)
			total length = 8	B1 **[4]**	cao
4	(v)		To connect a vertex in may be cheaper than to provide the shortest connection from it to A. eg if AB=AC=2, and BC=1, then min connectors are of length 3, but the arcs in the shortest routes sum to 4.	B1 **[1]**	Focus on individual vertex

Question			Answer	Marks	Guidance
5	(i)		using single-digit random numbers explanation who got how many	B1 M1 A1 A1 A1 B1 **[6]**	 allocates RN(s) to **people** correct proportions efficient RN→person=winner (× 5) ... or BBDCB or equivalent no requirement to identify which prize was which
5	(ii)		repetitions	B1 B1 **[2]**	simulations results – distributions of 5 prizes
5	(iii)		analysis expectation is binomial (5, 0.2) ... 0 1 2 3 4 5 0.33 0.41 0.20 0.05 0.01 0.00	M1 A4 **[5]**	Award M only if prob. dist. of 0, 1, 2, 3, 4, 5 gifts attempted, probs with denominators of 25 or 20 –1 each error, checking against results from (i) and (ii) if denominator of 25, or against (ii) only if denominator of 20.
5	(iv)		new rule needed with rejections reject 4 1 RN for each person ... ... or 2-digit RNs done similarly	M1 A1 A1 **[3]**	RN(s) rejected

Question			Answer	Marks	Guidance
6	(i) & (ii)		 Minimum completion time = 60 secs Critical activities ... B, I, W, T, D	M1 A1 A1 A1 A1 **[5]** M1 A1 M1 A1 B1 B1 **[6]**	activity on arc single start and end precedences for B, I, W, L and P (inc dummy) precedences for T and C plus dummy rest forward pass √ backward pass √ cao cao
	(iii)		3 people 125 seconds	B1 B1 **[2]**	cao cao
	(iv)		eg  ... or schedule with timings	M1 A1 A1 **[3]**	cascade ... length must be proportional to time Person 1 cao Person 2 cao

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4771 Decision Mathematics 1

General Comments

Candidates generally did well on this paper. Section A was found to be very straightforward, as it should have been. In question 3 many candidates did lose marks for failing to answer the question. They hoped, or assumed, that the examiner would take the last deductive step for them – from working to solution. The examiner will not do this.

In section B there were some more challenging part marks, particularly the "Explain" in Q4(v) and the "Describe" in Q5(iv). Many candidates had difficulty with explaining and/or describing. Question 5 was the most difficult, with many candidates imagining that they had somehow to simulate numbers of gifts, rather than who received each gift.

Comments on Individual Questions

1 Almost all candidates succeeded with part (i). In part (ii) most answers were correct, with a smattering of "56"'s for the number of edges, and some that were one or two off in their obviously non-structured counting.

2 A surprising number of candidates, though still only a small proportion, could not follow the instruction to reverse the order of the digits of a three-digit number. These were not slips. Such candidates would systematically, in all parts of the question, do some other transformation of the three digits.

Many candidates did not score both marks in part (iii) as a consequence of submitting an incomplete answer.

3 Most candidates could draw the graph, though inaccuracies and misreads abounded. As always, it was acceptable for candidates to use a sketch to drive a solution involving the solution of simultaneous linear equations. Other candidates needed an accurate graph to read off the points.

The required solution required the optimal point and optimal value, and many, many candidates, having done all of the work, failed to provide these. As remarked above, the examiner will not do the candidate's work on his/her behalf!

4 In D1 papers there is always a sizeable proportion of candidates who do not succeed in applying Dijkstra, and this paper was no exception. Few candidates who did not apply the algorithm successfully subsequently recovered shortest path marks, because the shortest paths were not clear to see ... examiners were alert for "ACF..." and "ACFB..." Candidates were often successful with the minimum connector in part (iv), but few could manage the mark for part (v). Most answers represented, logically, no more than a rephrasing of the question. The few high quality answers seen noted that vertex D could be connected into the network by using DF, an arc of length 2, but that FD is not in the shortest path from A to D. Students might usefully learn that the mathematical way to disprove is to provide a specific counterexample.

5 As remarked above, a substantial minority of candidates lost many marks on this question by attempting to simulate numbers of gifts, rather than by simulating, repeatedly, which person receives the next gift.

Some candidates attempted to answer part (iii) theoretically. Theoretic answers are provided in the mark scheme for comparison and interest, but candidates received no marks for such attempts. They were required to use their simulations to estimate the probabilities.

In part (iv) most candidates, but not all, noted the essence – that some random numbers would have to be rejected.

6 The CPA question was answered well. There were very few, but some, candidates who forfeited most of the marks by attempting activity-on-node.

Some candidates seemed to think that a dummy activity could have two directions. There were several candidates who simply omitted activity D.

Others allowed a plethora of dummy activities. This is not of itself wrong, but many subsequently lost forward and backward pass accuracy marks because of the extra complexity introduced by their superfluous dummies.

In part (iv) some candidates seemed to think that they could show how two people could do the job as quickly as possible without showing who does what and when.