SACE
Board of SA

2013 MATHEMATICAL APPLICATIONS, Semester 1

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FIGURES

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MATHEMATICAL APPLICATIONS, Semester 1

Graphics calculator

Brand _____

Model _____

Computer software

Thursday 6 June: 9 a.m.

Time: 1½ hours in total (to complete two question booklets, one on each topic studied in Semester 1)

Pages: 12
Questions: 4

Topic 5: Optimisation

Examination material: two question booklets
one SACE registration number label

Approved dictionaries, notes, calculators, and computer software may be used.

Instructions to Students

1. You will have 10 minutes to read the question booklets. You must not write in your question booklets or use a calculator during this reading time but you may make notes on the scribbling paper provided.

2. Each of the following five topics is printed in a separate question booklet. ***Tick the boxes by the two topics you have studied in Semester 1***:

   Topic 2: Investment and Loans ☐

   Topic 4: Matrices ☐

   Topic 5: Optimisation ☐

   Topic 6: Share Investments ☐

   Topic 7: Statistics and Working with Data. ☐

3. The total mark for each topic is 35.

4. Answer **all** parts of Questions 1 to 4 in the spaces provided in this question booklet. There is no need to fill all the space provided.

5. Show all working in this booklet. (You are strongly advised **not** to use scribbling paper. Work that you consider incorrect should be crossed out with a single line.)

6. Write on page 12 if you need more space. Make sure to label each answer carefully.

7. Use only black or blue pens for all work other than graphs and diagrams, for which you may use a sharp dark pencil.

8. Appropriate steps of logic and correct answers are required.

9. Marks may be deducted if you do not clearly show all steps in the solution of problems, if your answers have an inappropriate number of decimal places, or if you use incorrect units.

10. Diagrams, where given, are not necessarily drawn to scale.

11. Complete the box on the top right-hand side of this page with information about the electronic technology you are using in this examination.

12. Attach your SACE registration number label to the box at the top of this page on one of your question booklets. Copy the information from your SACE registration number label into the box on the front cover of your other question booklet.

13. At the end of the examination, place one question booklet inside the back cover of the other question booklet.

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QUESTION 1

(a) The following network shows the possible routes between a school and a gymnasium.

Using the network, calculate the maximum number of routes that a student could take when driving from the school to the gymnasium.

Write the maximum number of routes in the box below.
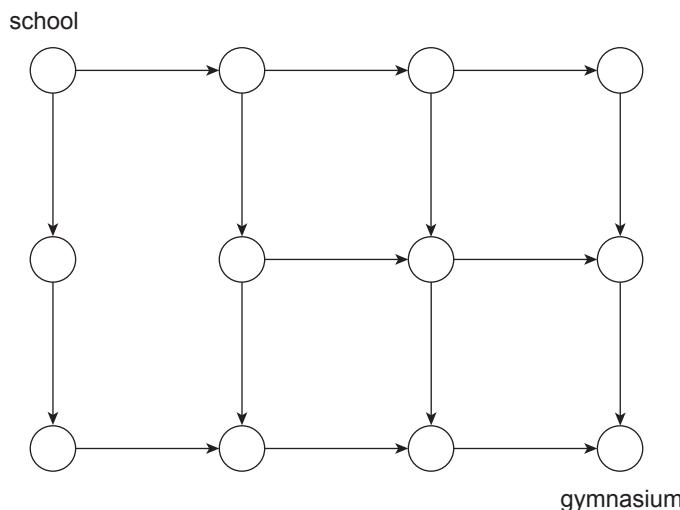
Maximum number of routes: ☐

(2 marks)

(b) A student who is planning to drive from the school to the gymnasium needs to go via the cafe. The cafe is shown on the following network.

Using the network, calculate the maximum number of routes that the student could take when travelling from the school to the gymnasium via the cafe.

Write the maximum number of routes in the box below.
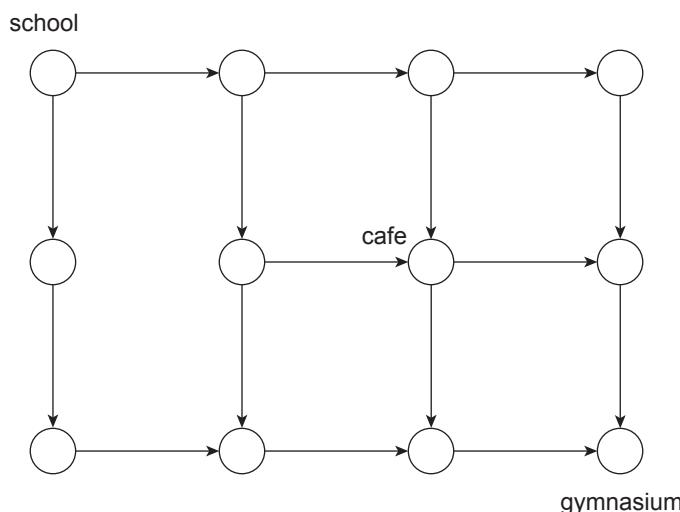
Maximum number of routes: ☐

(2 marks)

QUESTION 2

Garth is a farmer who raises chickens to sell for their meat. The chickens have minimum daily requirements of protein, carbohydrates, and fats to ensure meat of optimal quality: at least 20 grams of protein, at least 54 grams of carbohydrates, and at least 30 grams of fats. The chickens should not consume more than 46 grams of protein each day.

Garth feeds the chickens a mixture of two types of feed: mash feed and grain feed. The two feeds contain varying amounts of protein, carbohydrates, and fats per standard measure, as shown in the following table:

Feed Type	Protein (g)	Protein (g)	Carbohydrates (g)	Fats (g)
mash feed	2	2	7	5
grain feed	8	8	12	3
Limits	20 (minimum)	46 (maximum)	54	30

Let x represent the amount of mash feed (per standard measure) and y represent the amount of grain feed (per standard measure).

(a) Six constraints are used to model this situation. Three of the constraints are shown below:

$$x \geq 0$$

$$y \geq 0$$

$$2x + 8y \geq 20$$

Write the three remaining constraints.

(3 marks)

4

(b) On the graph below:

   (i)   add the missing constraint line for the minimum protein requirement.   (2 marks)

   (ii) determine the coordinates of the two missing vertices and label   (2 marks)
         them D and E.

   (iii) indicate the feasible region.   (1 mark)

Chicken Feed Mixture
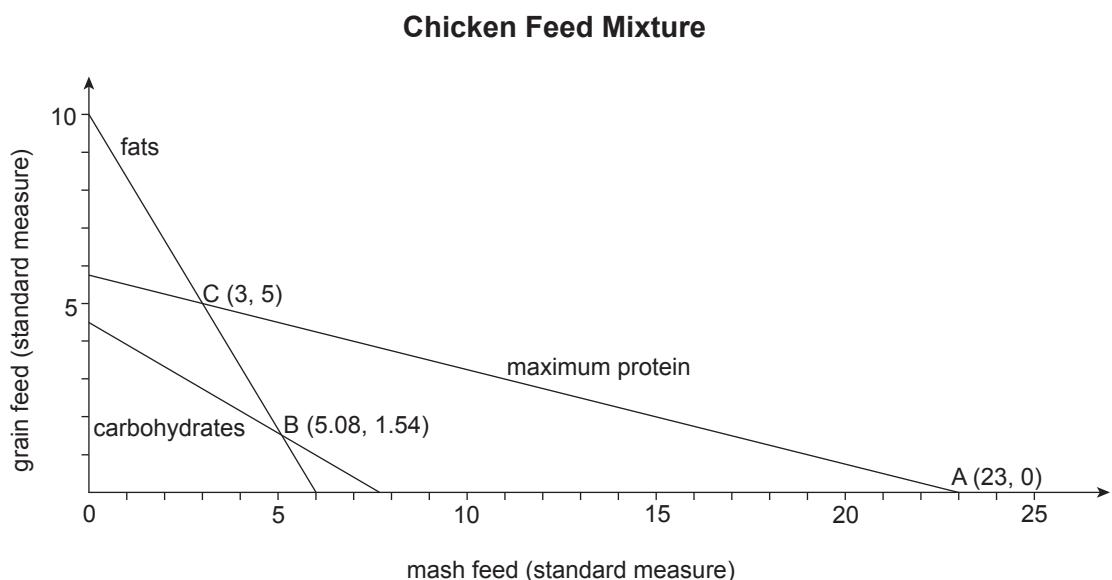
(c) If Garth runs out of mash feed, can he feed the chickens adequately with grain feed alone? Explain your answer.

(2 marks)

(d) The cost of mash feed is 12 cents per standard measure. The cost of grain feed is 23 cents per standard measure.

The objective function for the cost of the feeds is $C = 0.12x + 0.23y$.

(i) Complete the following table.

Vertex Label	Vertex	Cost
A	(23, 0)	$2.76
B	(5.08, 1.54)	$0.96
C	(3, 5)	_____
D	_____	_____
E	_____	_____

(3 marks)

(ii) State (in words) the combination of feeds that should be given to the chickens to minimise daily costs.
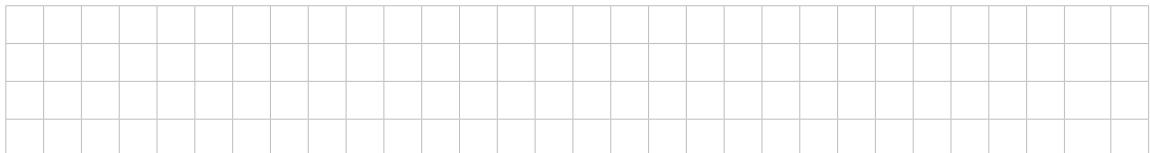
(1 mark)

(e) New scientific research indicates that the minimum daily protein requirement of chickens is 30 grams. The new constraint is shown on the graph below.

Chicken Feed Mixture
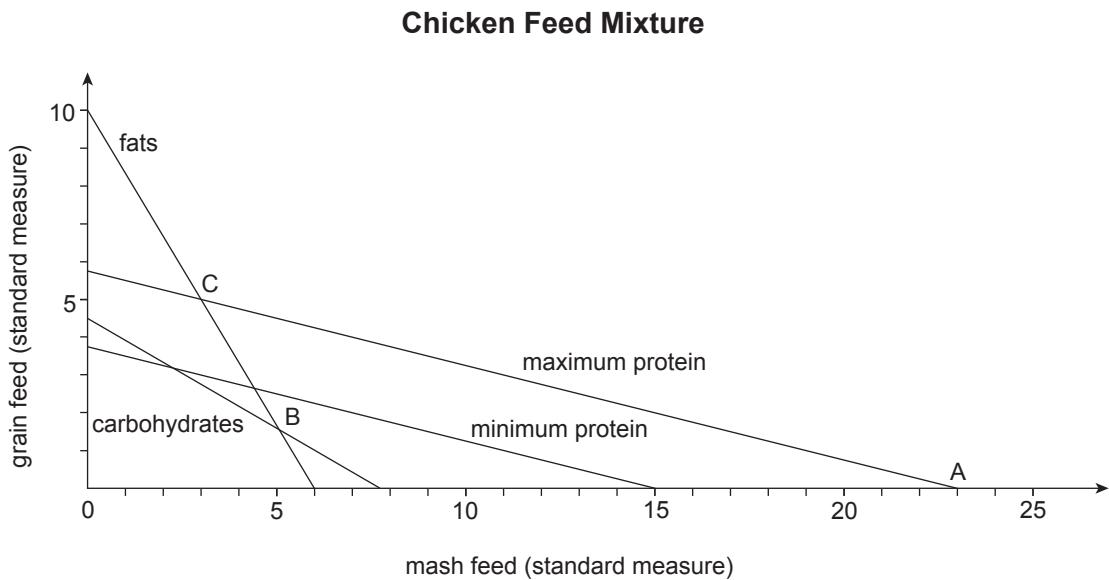
(i) Indicate the new feasible region on the graph above. (1 mark)

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(ii) Tick the appropriate box to indicate the dietary requirement that no longer affects the combination of feeds given to the chickens.

Protein ☐

Carbohydrates ☐

Fats ☐

(1 mark)

QUESTION 3

A company decided to improve a product and redesign its packaging. To do this efficiently it was necessary to produce a plan for the task.

The following separate jobs, their completion time (in weeks), and prerequisites were identified:

Job	Description of Job	Completion Time	Prerequisites
A	Improve product	6	–
B	Redesign packaging	2	–
C	Order and receive components and materials for product and redesigned packaging	5	A and B
D	Create improved product	4	C
E	Make up redesigned packaging	1	C
F	Test and collect feedback about product	4	D
G	Test and collect feedback about packaging	2	E
H	Prepare a marketing strategy	9	E
J	Complete minor changes to packaging	1	F and G
K	Present final results to Board	1	J and H

(a) Using the following network diagram:

   (i)   draw the position of job B on the network diagram.   (1 mark)

   (ii) complete a forward scan.   (1 mark)

   (iii) complete a backward scan.   (1 mark)

   (iv) find the minimum completion time for the task.   (1 mark)
        Write the time in the box below the diagram.

   (v) mark the critical path on the network diagram.   (1 mark)

Minimum completion time: ☐ weeks

(b) (i) Using the following network diagram, show that 1 week would be saved if the preparation of the marketing strategy (job H) could begin straight after job A.

(2 marks)

(ii) State the significance of the difference between the earliest and latest starting times for job G.

(2 marks)

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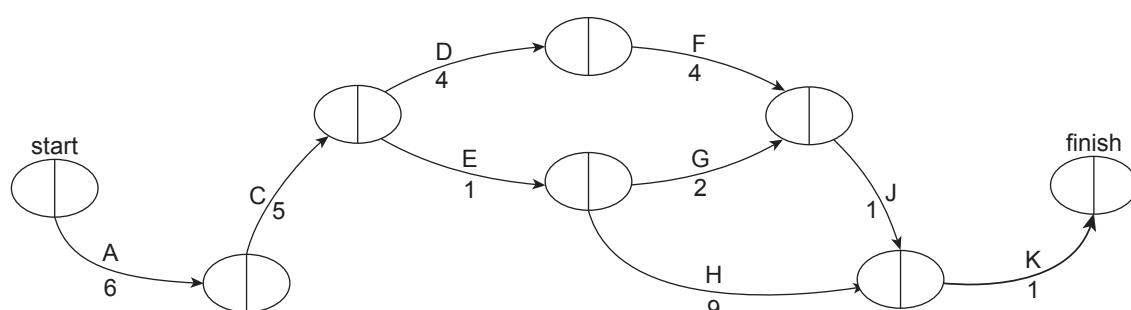
QUESTION 4

A telecommunications company needed to upgrade its copper wiring system by replacing some of the connections with fibre optics.

The diagram below shows the lengths (in kilometres) of the current wiring system between exchanges (nodes A to I):
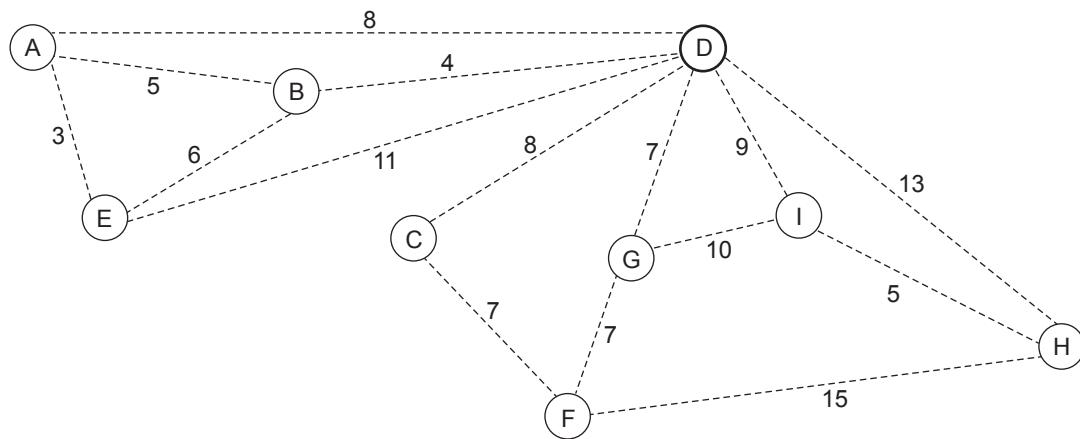
(a) Show the minimum spanning tree on the diagram above.   (2 marks)

(b) Assume that the minimum spanning tree represents the upgrade needed for the wiring system.

Find the minimum cost to upgrade the system if the fibre optics cost $100 350 per kilometre.

(2 marks)

(c) The company's communication hub is located at exchange D. No exchange should receive a signal through more than 15 kilometres of fibre optics, as signal quality weakens over distance. The minimum spanning tree shown in part (a) does not meet this requirement.

(i) Identify the problem with the minimum spanning tree in part (a).

(1 mark)

(ii) Suggest a reasonable solution to improve the signal.

(1 mark)

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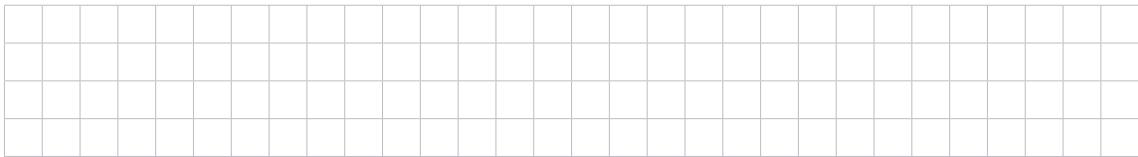
You may write on this page if you need more space to finish your answers to Topic 5. Make sure to label each answer carefully (e.g. 'Question 4(b) continued').

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