



ATAR course examination, 2024

Question/Answer booklet

MATHEMATICS APPLICATIONS

Section Two: Calculator-assumed

Place one of your candidate identification labels in this box.
Ensure the label is straight and within the lines of this box.

WA student number: In figures

| | | | | | | | | | |
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In words

Time allowed for this section

Reading time before commencing work: ten minutes
Working time: one hundred minutes

Number of additional
answer booklets used
(if applicable):

Materials required/recommended for this section

To be provided by the supervisor

This Question/Answer booklet
Formula sheet (retained from Section One)

To be provided by the candidate

Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, correction fluid/tape, eraser, ruler, highlighters

Special items: drawing instruments, templates, notes on two unfolded sheets of A4 paper, and up to three calculators, which can include scientific, graphic and Computer Algebra System (CAS) calculators, are permitted in this ATAR course examination

Important note to candidates

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised material. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.



Structure of this paper

| Section | Number of questions available | Number of questions to be answered | Working time (minutes) | Marks available | Percentage of examination |
|------------------------------------|-------------------------------|------------------------------------|------------------------|-----------------|---------------------------|
| Section One: Calculator-free | 5 | 5 | 50 | 54 | 35 |
| Section Two: Calculator-assumed | 8 | 8 | 100 | 99 | 65 |
| Total | | | | | 100 |

Instructions to candidates

1. The rules for the conduct of the Western Australian external examinations are detailed in the *Year 12 Information Handbook 2024: Part II Examinations*. Sitting this examination implies that you agree to abide by these rules.
2. Write your answers in this Question/Answer booklet preferably using a blue/black pen. Do not use erasable or gel pens.
3. You must be careful to confine your answers to the specific question asked and to follow any instructions that are specified to a particular question.
4. Show all your working clearly. Your working should be in sufficient detail to allow your answers to be checked readily and for marks to be awarded for reasoning. Incorrect answers given without supporting reasoning cannot be allocated any marks. For any question or part question worth more than two marks, valid working or justification is required to receive full marks. If you repeat any question, ensure that you cancel the answer you do not wish to have marked.
5. It is recommended that you do not use pencil, except in diagrams.
6. Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.
7. The Formula sheet is not to be handed in with your Question/Answer booklet.

Section Two: Calculator-assumed**65% (99 Marks)**

This section has **eight** questions. Answer **all** questions. Write your answers in the spaces provided.

Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

Working time: 100 minutes.

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See next page

Question 6

(10 marks)

Jenny has organised a housing loan. She has modelled the balance owing (in dollars) at the end of each month by the recursive rule $T_{n+1} = 1.0055T_n - 3200$, $T_0 = 430\,000$.

- (a) State
- (i) the amount borrowed. (1 mark)

 - (ii) the monthly repayment. (1 mark)
- (b) Determine the annual interest rate. (1 mark)
- (c) Assuming the interest rate remains unchanged,
- (i) how long will it take to pay off the loan? (1 mark)

 - (ii) determine the final repayment. (1 mark)

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At the beginning of the eighth year, Jenny makes an extra lump sum payment of \$50 000 and increases her repayments by \$100 per month.

- (d) Calculate how much interest will be saved compared to the original loan arrangement. Assume that the interest rate remains unchanged. (5 marks)

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Question 7

(12 marks)

A new entertainment streaming service is concerned because it is receiving cancellations and not gaining any new subscriptions. The number of subscriptions (in thousands) at the end of each week have been recorded in the table below.

| Week (n) | 1 | 2 | 3 | 4 | 5 |
|---|----------|----------|----------|----------|----------|
| Subscriptions (in thousands) | | 97 | 94.09 | 91.267 | |

(a) Show that the number of subscriptions is decreasing by 3% each week. (2 marks)

(b) Complete the table above. (1 mark)

(c) Deduce a rule for the n^{th} term for the number of subscriptions at the end of each week. (2 marks)

(d) During which week does the number of subscriptions first fall below 70 000? (2 marks)

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In an attempt to increase the total number of subscriptions to the streaming service, two possible loyalty programs are being developed, with a plan for one of these to be launched when the number of subscriptions falls to 50 000.

- (e) It is hoped that the first loyalty program will change the percentage decrease of subscriptions per week from 3% to 1.4% and also increase the number of new subscriptions by 100 000 each week.

The total number of subscriptions can be represented by the recursive rule

$$T_{n+1} = aT_n + b, \quad T_0 = 50.$$

Determine the value of a and b .

(2 marks)

- (f) The total number of subscriptions from the second loyalty program can be represented by the recursive rule, $T_{n+1} = 0.99T_n + 95$, $T_0 = 50$.

- (i) Interpret the number 0.99 in the context of this question.

(1 mark)

- (ii) The streaming service will need to maintain 8.5 million total subscriptions if it is to be considered sustainable. Determine whether this is achievable with the second loyalty program.

(2 marks)

Question 8

(13 marks)

The owners of a small family business that sells farm-fresh honey decide to advertise their produce online. A website has been created and they monitor the number of visits to the website each day for three weeks. The table below shows time series analysis of the collected data using a seven-day period.

| Week | Day | Time (<i>t</i>) | Weekly mean | Visits as a percentage of the weekly mean | Deseasonalised data |
|------|-----------|-------------------|-------------|---|---------------------|
| 1 | Monday | 1 | 43.7 | 86.9 | 42.4 |
| | Tuesday | 2 | | 91.5 | 45.3 |
| | Wednesday | 3 | | 77.8 | 45.4 |
| | Thursday | 4 | | A | 41.2 |
| | Friday | 5 | | 116.7 | 42.6 |
| | Saturday | 6 | | 125.8 | 42.0 |
| | Sunday | 7 | | 130.4 | 47.0 |
| 2 | Monday | 8 | 45.9 | 89.4 | 45.8 |
| | Tuesday | 9 | | 85.0 | 44.1 |
| | Wednesday | 10 | | 72.0 | 44.1 |
| | Thursday | 11 | | 76.3 | 46.5 |
| | Friday | 12 | | 124.3 | 47.6 |
| | Saturday | 13 | | 135.2 | 47.4 |
| | Sunday | 14 | | 117.8 | 44.5 |
| 3 | Monday | 15 | 50.9 | 92.4 | 52.5 |
| | Tuesday | 16 | | 88.5 | B |
| | Wednesday | 17 | | 74.7 | 50.8 |
| | Thursday | 18 | | 78.7 | 53.1 |
| | Friday | 19 | | 118.0 | 50.1 |
| | Saturday | 20 | | 131.7 | 51.2 |
| | Sunday | 21 | | 116.0 | 48.6 |

(a) Complete the following table. (2 marks)

| Day | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
|-------------|--------|---------|-----------|----------|--------|----------|--------|
| Daily index | 89.6% | 88.3% | 74.8% | 75.3% | 119.7% | | |

(b) Determine the value of **A** in the table above. (2 marks)

(c) Given the actual website visits on Tuesday of week 3 was 45, determine the value of **B** in the table above. (2 marks)

- (d) Interpret the daily index for Friday in the context of this question. (1 mark)
- (e) Given there were 62 website visits on Friday of week 4, estimate the total of number of website visits for week 4. (2 marks)
- (f) Calculate the actual number of visits to the website on Monday of week 1. (1 mark)

The least-squares line for the deseasonalised data and time is $y = 0.47t + 41.70$.

- (g) Predict the number of website visits on Tuesday of week 5. (3 marks)

Question 9

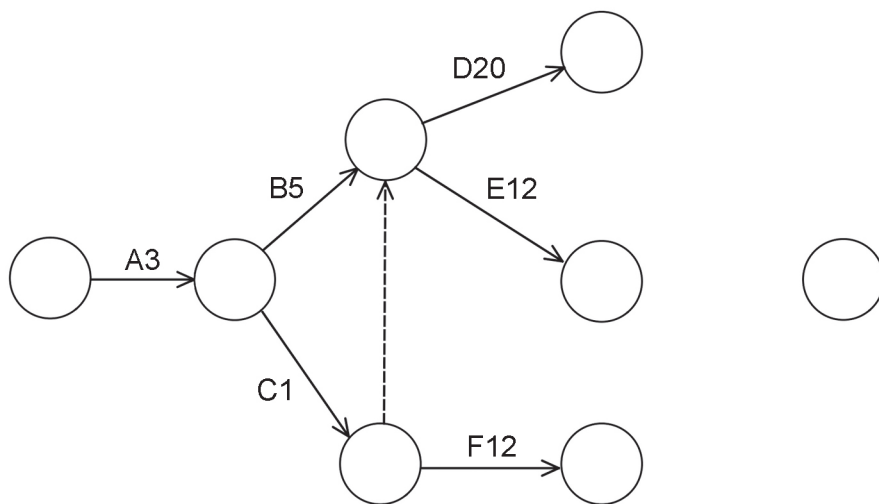
(10 marks)

A builder is planning the renovation of a bathroom. The table below shows each task, the immediate predecessors and the duration of the task, for the project.

| Task | Immediate predecessor(s) | Duration (days) |
|------|--------------------------|-----------------|
| A | - | 3 |
| B | A | 5 |
| C | A | 1 |
| D | B, C | 20 |
| E | B, C | 12 |
| F | C | 12 |
| G | D, E | 5 |
| J | E | 5 |
| K | E, F | 6 |
| L | J, K | 10 |
| M | G, L | 2 |

(a) Complete the project network diagram for the bathroom renovation.

(3 marks)



(b) Determine the critical path and the minimum completion time for the project.

(3 marks)

(c) Determine the float time for each of the following tasks.

(i) C (1 mark)

(ii) E (1 mark)

It is possible that one or more tasks can be delayed without affecting the minimum completion time of the project.

(d) Identify which task(s) will give the maximum possible time delay without affecting the minimum completion time and state the time delay. (2 marks)

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Question 10

(13 marks)

Matt is saving up to purchase a new boat. He deposits \$14 500 into a savings account which is compounded monthly. The account pays an annual interest rate of 4.8% and he also deposits \$300 into the account at the end of each month.

- (a) (i) Calculate the monthly interest rate. (1 mark)
- (ii) Determine a recursive rule to model the balance of the savings account at the end of each month. (2 marks)
- (b) After how many months will the balance of Matt's account first exceed \$20 000? (2 marks)

After four years, Matt makes a one-off deposit of \$2500 into the savings account. His goal is to have a total of \$50 000 by the end of the fifth year.

- (c) Determine the equal monthly deposits during the fifth year he will need to make to reach this amount. (5 marks)

- (d) Matt purchases his new boat, which costs him \$47 500. He decides to take the remaining money and re-invest it in one of the following high-interest savings accounts.

Option 1: 5.52% per annum, compounded six-monthly.

Option 2: 5.5% per annum, compounded quarterly.

Determine which option Matt should choose, by calculating the effective annual rates of interest. (3 marks)

Question 11

(19 marks)

University students from the faculty of Human Movement were tasked with determining the relationship between grip strength and age in adults who participate in regular exercise. They visited a health club and collected data from female volunteers. There is an expectation that grip strength will eventually decrease with age.

- (a) After data was collected and analysed from 13 female volunteers, the students stated: “51% of the variation in grip strength cannot be explained by the variation in age”. On the basis of this statement, determine the correlation coefficient between age and grip strength. (3 marks)

The students decided to omit one particular data point from all calculations.

- (b) What is the most likely reason for removing this data point? (1 mark)

The table below shows the remaining 12 data points.

| | | | | | | | | | | | | |
|----------------------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Age (a) (years) | 34 | 61 | 20 | 41 | 49 | 26 | 63 | 38 | 56 | 55 | 46 | 35 |
| Grip strength (s) (kg) | 49.4 | 33.6 | 46.6 | 43.1 | 43.1 | 47.1 | 30.2 | 47.7 | 39.5 | 41.3 | 40.7 | 49.6 |

- (c) Calculate r_{as} the correlation coefficient between age and grip strength. (1 mark)
- (d) Determine the equation of the least-squares line between age and grip strength. (1 mark)
- (e) Interpret the gradient of the least-squares line in the context of this question. (2 marks)

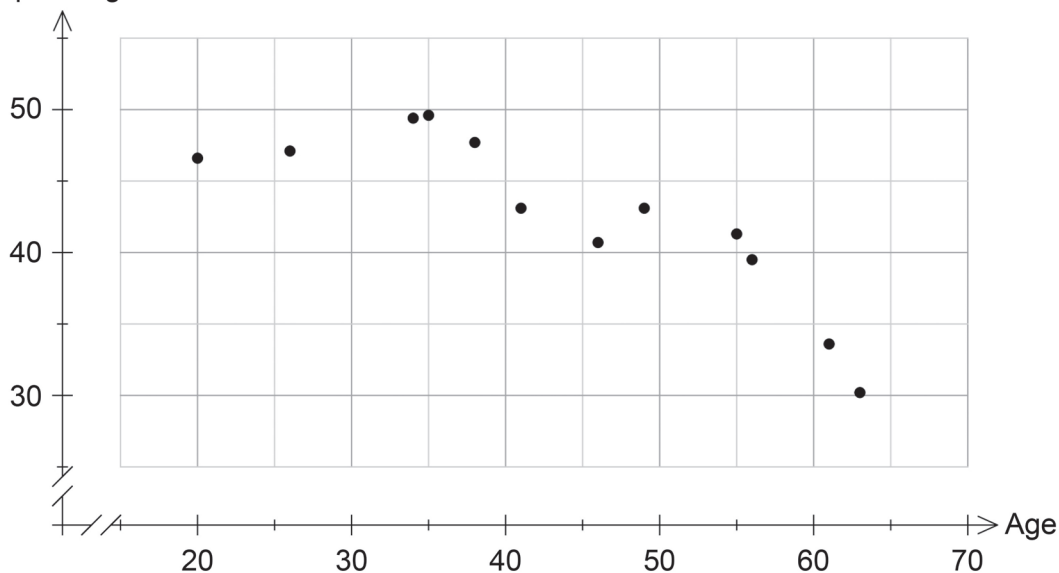
(f) Explain why the vertical intercept of the least-squares line is meaningless in the context of this question. (1 mark)

(g) Use your least-squares line to predict the grip strength of a female aged 64 who participates in regular exercise. (1 mark)

(h) Discuss the validity of the prediction in part (g) above. (2 marks)

(i) Draw the least-squares line for these data on the scatterplot below. (1 mark)

Grip strength

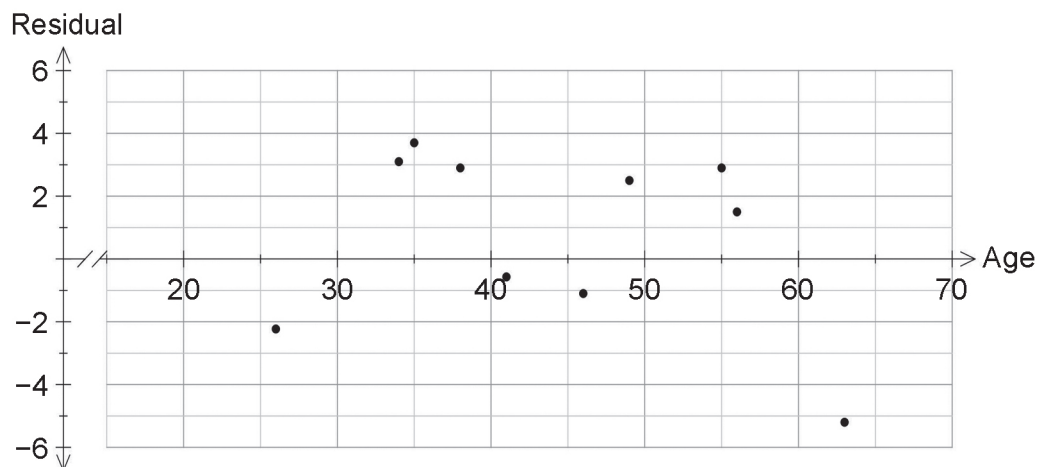


A spare grid is provided at the end of this Question/Answer booklet. If you need to use it, cross out your attempt and indicate that you have redrawn it on the spare grid.

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Question 11 (continued)

The incomplete residual plot for these data is drawn below.



- (j) Determine the **two** missing residuals and plot them on the graph above. (3 marks)

A spare grid is provided at the end of this Question/Answer booklet. If you need to use it, cross out your attempt and indicate that you have redrawn it on the spare grid.

- (k) On the basis of your analysis of the data, make **three** reasonable statements about the connection between age and grip strength for females. (3 marks)

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Question 12

(9 marks)

The sales manager of a large retail store plans to put the best salesperson as a sales specialist in each of the four departments within the store. Over a period of time and by rotating them through each of the four areas of the store, the sales (\$'000) made by the five people being considered for these positions have been summarised in the table below.

| | Computing | Kitchen and laundry | Audio-visual | Furnishing |
|---------|-----------|---------------------|--------------|------------|
| Thomas | 41 | 33 | 53 | 49 |
| Megan | 41 | 33 | 43 | 35 |
| Lim | 39 | 27 | 49 | 37 |
| Le-Tong | 27 | 33 | 37 | 43 |
| Heidi | 37 | 41 | 39 | 45 |

- (a) Use the Hungarian algorithm to determine the allocation of a salesperson to each of the four departments within the store to maximise sales. (4 marks)

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- (b) Show the allocation of departments to salespeople in the table below. (1 mark)

| | | | | | |
|--------------------|---------------|--------------|------------|----------------|--------------|
| Salesperson | Thomas | Megan | Lim | Le-Tong | Heidi |
| Department | | | | | |

- (c) Calculate the maximum sales figure determined in part (a). (1 mark)

- (d) After the allocations were made, Lim was dissatisfied and resigned from her job. Determine how this would affect the allocation and maximum sales figure. (3 marks)

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Question 13

(13 marks)

Ellie has retired from her job and plans to live off her acquired wealth. She has a superannuation balance of \$1 205 788 and a housing loan of \$205 749. Ellie sets up an annuity after paying off her housing loan. The annuity will have monthly investment returns and payments, and is modelled by the recursive rule

$$T_{n+1} = 1.005T_n - 6000, \quad T_0 = Z$$

(a) State how much Ellie receives as a monthly payment. (1 mark)

(b) Determine the value of Z in the recursive rule. (1 mark)

(c) Calculate what annual interest rate the annuity pays. (1 mark)

The annuity has a start date of 1 March 2024. At the end of the month when the balance of the annuity first drops below \$700 000, Ellie plans to convert the annuity to a perpetuity, paid at the end of each month, so that she will leave behind some family inheritance.

(d) (i) Determine the year and month when the annuity will end. (3 marks)

(ii) Determine the final balance at the end of the annuity. (1 mark)

Ellie receives advice that a perpetuity could now be arranged, receiving 5.95% per annum compounded daily.

(e) Determine the monthly perpetuity payment. (3 marks)

(f) Ellie is curious as to whether the annuity or the perpetuity pays the better annual rate of interest. Determine which pays the higher interest rate. (3 marks)

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End of questions

Supplementary page

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Supplementary page

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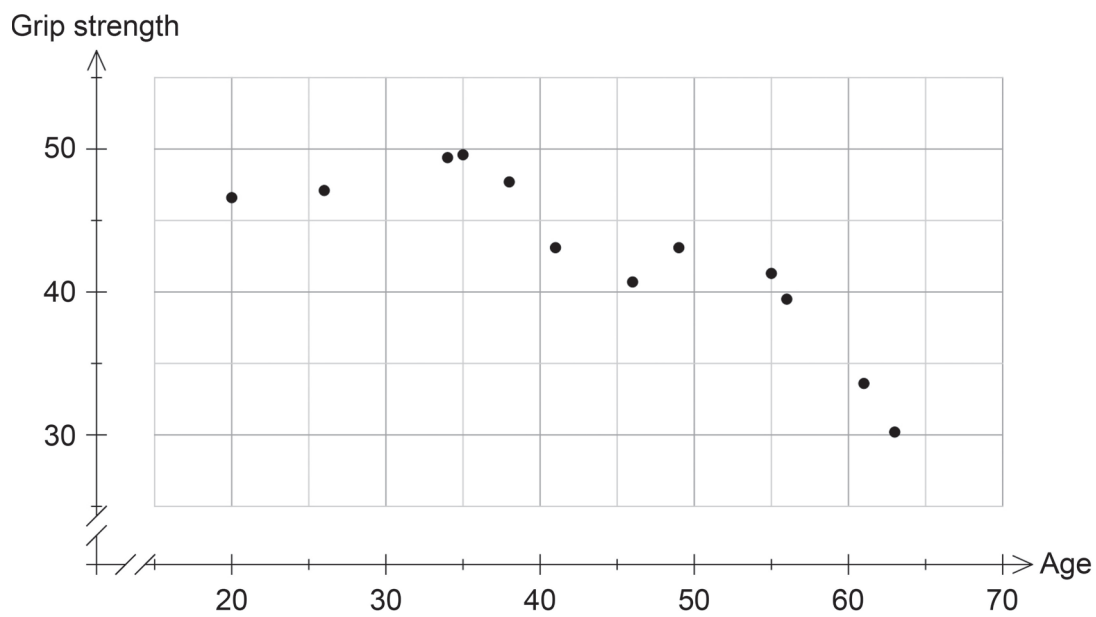
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Supplementary page

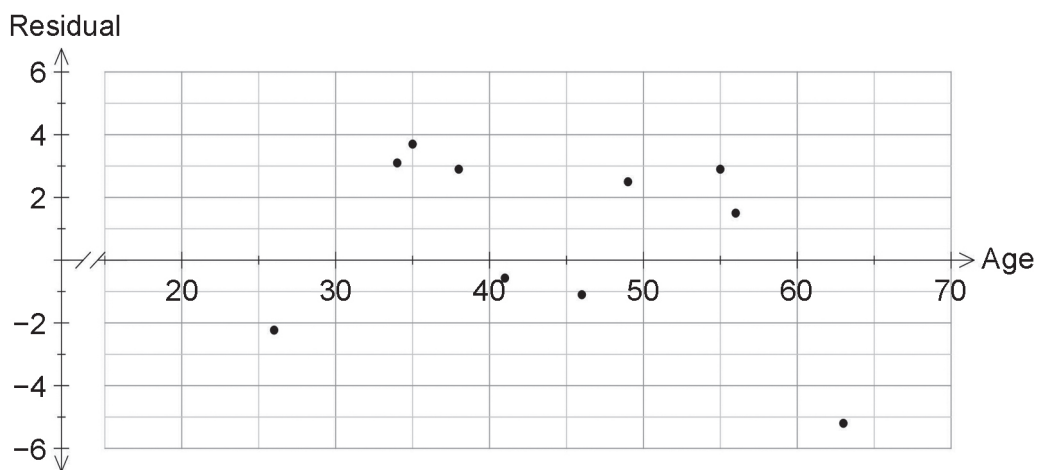
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Spare grid for Question 11(i)



Spare grid for Question 11(j)



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