OCR
Oxford Cambridge and RSA

Level 3 Certificate

Quantitative Reasoning (MEI)

H866/02 Critical Maths

Sample Question Paper

Date – Morning/Afternoon

Time allowed: 2 hours

You must have:
- The Insert

You may use:
- A scientific or graphical calculator

First name	
Last name	
Centre number	Candidate number

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided.
- Additional paper may be used if required but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.
- 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.

INFORMATION
- The total mark for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- This document consists of **16** pages.
- Final answers should be given to a degree of accuracy appropriate to the context.

1 It is possible to drive from London to Leeds on the motorway all the way.
The distance is approximately 200 miles.

How long will it take?
Show your reasoning. **[3]**

1	

2 Dan wants to go on a holiday which costs £5000.
He will pay with his credit card which charges an annual interest rate (APR) of 16%.
Dan wants to pay back the money over two years.
He estimates that his monthly repayments will be £208 to the nearest pound.

(i) What calculation did Dan do to get £208? **[1]**

(ii) Decide whether Dan's estimate is too high, too low or about right. Give a reason for your answer. **[2]**

2 (i)	
2 (ii)	

3 Usain Bolt won the 100 m and the 200 m gold medals at the London 2012 Olympics.
His time for the 100 m was 9.63 seconds.
His time for the 200 m was 19.32 seconds.

Without using your calculator, decide in which race he had the greater average speed.
Justify your answer. **[3]**

3	

4

> "The new mathematics GCSE will be more demanding and we anticipate that schools will want to increase the time spent teaching mathematics. On average secondary schools in England spend only 116 hours per year teaching mathematics, which international studies show is far less time than that spent on this vital subject by our competitors. Just one extra lesson each week would put England closer to countries like Australia or Singapore who teach 143 and 138 hours a year of mathematics respectively."
>
> Michael Gove 1 Nov 2013

Estimate the number of extra mathematics teachers needed to increase average mathematics teaching time for years 7 to 11 in England from 116 hours per year up to the kind of time taken in Australia or Singapore.

You can use the following assumptions.

- There are about 500 000 school students in each year group in England.
- A typical secondary school mathematics teacher teaches between 20 and 25 hours a week.
- Students are at school for 190 days a year.

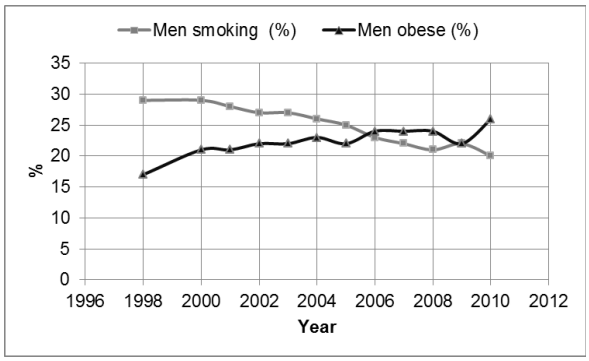
Any additional assumptions you make must be clear. **[7]**

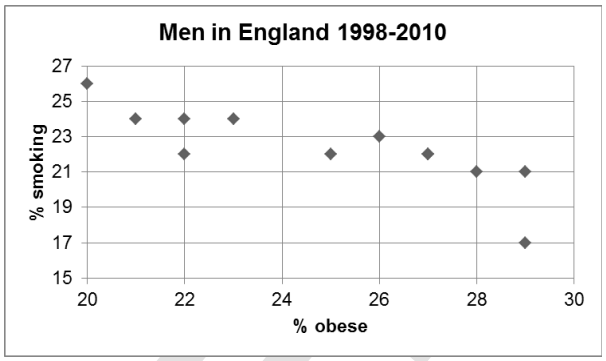
4

(answer space continued on the next page)

4 **(continued)**

5 The graphs below show data for smoking and obesity for men in England.





Do these graphs show that giving up smoking causes obesity? Justify your answer by making three comments about the data. **[3]**

5	

6 Two statements from different news websites about the same story are given below.

> 70% of parents were fined for taking their children out of school for a holiday in term time.

> The number of parents fined for taking their children out of school for a holiday in term time rose by 70% from the previous year.

Explain what each of these statements means and decide whether they mean the same thing. **[5]**

6

7 The male to female sex ratio at birth is the number of males that are born for every female born. The table below shows the countries with the two highest male to female sex ratios at birth in 2013.

Country	Male to female sex ratio at birth	Population (thousands)	Births per 1000 of population
Liechtenstein	1.26	37	10.67
Azerbaijan	1.13	9590	17.17

Data: CIA World Factbook

(i) Use the information in the table to show that the total number of births in 2013 in Liechtenstein can be estimated as 395. Show that approximately 175 are girls and approximately 220 are boys. **[4]**

7 (i)

A researcher is investigating whether the number of boys born in some countries is distinctly different from the number of girls.

Her initial model is that the long-term probability of a new baby being a boy is 0.5.

(ii) ***(A)*** For Liechtenstein investigate whether the figures of 175 girls and 220 boys provide strong evidence that the initial model is incorrect.
Explain your reasoning and show your working clearly. **[7]**

(B) In 2013 in Azerbaijan 77 305 girls and 87 355 boys were born. Do these figures provide strong evidence that the initial model is incorrect? **[4]**

7 (ii) (*A*)	
7 (ii) (*B*)	

8 A sign in a pay and display car park has the following information about charges for parking.

Car park charges

Monday to Friday 9 am to 5 pm
£3 for up to 8 hours

Other times
Free

£40 daily fine for parking without displaying a valid parking ticket

Drivers who pay get a ticket to display in their cars. A warden checks the cars from time to time. If the warden finds any cars which are not displaying a ticket, their drivers are fined £40 for that day.

The warden is paid to check the cars so the more often they are checked, the more it will cost the car park owner.

Many drivers use the car park every day from 9 am till 5 pm. Assume that some drivers always pay to park and some drivers never pay to park. Assume that all drivers who get a fine will pay it.

How often, on average, should the warden visit the car park to ensure that drivers who always pay end up better off than drivers who never pay? **[3]**

8

9 Athletes are tested to see if they have used performance enhancing drugs. Drug tests are not completely accurate. One drug test will show a positive result for 95% of people who have taken performance enhancing drugs and a negative result for 90% of those who have not.

Assume that 5% of athletes use performance enhancing drugs.

(i) What proportion of those who test positive in this test have actually used performance enhancing drugs? **[6]**

(ii) What percentage of those who are tested will test positive for use of performance enhancing drugs? **[2]**

9 (i)

9 (ii)

10 There are five competitors in a dancing competition.
Each dancer is judged by six judges who each give a score out of 20.

Design a method to decide which dancers should take first, second and third places.
Give your method as a set of rules that can be used for other similar competitions.
Explain why your design is fair.

The scores for the dancers in one such competition are shown below.

Dancer	Judge 1	Judge 2	Judge 3	Judge 4	Judge 5	Judge 6
Aretha	19	19	15	20	20	14
Esther	12	7	4	4	7	8
Mo	10	8	11	5	5	2
Vince	16	19	20	19	17	16
Yuri	15	6	12	15	6	9

Use your method to work out which dancers come first, second and third. **[10]**

10

(answer space continued on the next page)

10	**(continued)**

END OF QUESTION PAPER

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OCR
Oxford Cambridge and RSA

…day June 20XX – Morning/Afternoon

Level 3 Certificate in Quantitative Reasoning (MEI)

H866/02 Critical Maths

MARK SCHEME

Duration: 2 hours

MAXIMUM MARK 60

This document consists of 16 pages

MARKING INSTRUCTIONS

1. **Subject-specific Marking Instructions**

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, 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 components. 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.

i Anything in the mark scheme which is in square brackets […] is not required for the mark to be earned, but if present it must be correct.

Question			Answer	Marks	Guidance	
1			Speed between 50 and 70 mph chosen 200 ÷ their speed 3 hours	M1 M1 A1 [3]	 Time in hours or hours and minutes rounded to no more accurate than nearest 10 mins. ft their speed	Allow lower speed with reason e.g. if the journey takes place when the motorway is busy it might only be possible to go at 30mph
2	(i)		5000/24	[1]		
2	(ii)		Too low Dan is not allowing for interest in his calculations	B1 E1 [2]	Or equivalent e.g. the repayment will be higher.	
3			Doubling 100m time or halving 200 m time Time for same distance less in 100m Faster in 100m	M1 A1 A1 [3]	 Accept correct equivalent wording Accept correct equivalent wording	Accept use of error bounds

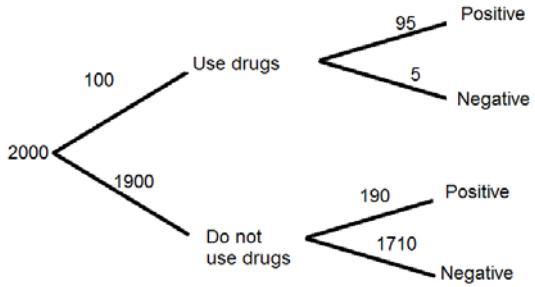
Question			Answer	Marks	Guidance	
4			Assumption that the target number of hours is e.g. 140	**M1**	Implied by 22 to 27 hours more per year on average	Answers in range 1900 to 6000 can be expected, depending on the assumptions and approximations which students make. **SC2** for an answer in range 1900 to 6000 with no working.
			Assumption that a teacher teaches e.g. 20 hrs	**M1**		
			Each teacher teaches for 38 × 20 hrs 760 hours	**A1**	FT *their* 20 hours	
			Assumption that average class size is e.g. 30 (between 15 and 30 chosen)	**M1**	May be seen in working	
			2 500 000 ÷ 30 ≈ 83 000 classes	**A1**	FT *their* 30	
			24 × 83 000 2 000 000 teacher hours needed	**M1**	FT	
			About 2500 extra mathematics teachers are needed	**A1**	Must follow through from their working and be given to at most 2 s.f.	
			ALTERNATIVE METHOD **(**working from 1 extra lesson per week)			
			Assumption that lesson time is between 30 mins & 1 hour	**M1**		
			Comparing increase from *their* lesson time to number in range 138 to 143	**M1**		
			Assumption that a teacher teaches e.g. 20 hrs a week	**M1**		
			Assumption that average class size is e.g. 30 (between 15 and 30 chosen)	**M1** May be seen in working		
			2 500 000 ÷ 30 ≈ 83 000 classes	**A1** FT *their* class size		
			$\frac{83000 \times 0.5}{20}$	**M1** FT *their* number of classes, class time and teacher time		
			About 2000 more teachers needed	**A1** Must follow through from their working and be given to at most 2 s.f.		
				[7]		

Question			Answer	Marks	Guidance	
5			There is a tendency for obesity levels to go up as smoking levels go down	**B1**	Statement about negative correlation related to context	
			This does not mean that the drop in smoking is causing the increase in obesity	**B1**	Cannot tell if either causes the other e.g. correlation does not imply causation	
			Other relevant and true comment	**B1**	e.g. • Cannot tell if trend will continue • Sample limited to men/England • Suggest alternative cause for correlation • Suggests way of investigating causality	
				[3]		

Question			Answer	Marks	Guidance	
6			Clear and correct explanations comparing the two statements with the conclusion that the statements do not mean the same thing.	[5]	**5** Clear and convincing explanations with correct conclusion **4** Explanations which deal with both statements correctly but may not include comparison and/or conclusion **3** Correct explanation of one statement with correct conclusion **2** Correct explanation of one statement e.g. The first statement means that most parents are fined e.g. The second statement could mean that the number of parents fined went up from 10 to 17 **1** Some relevant work or correct conclusion with no supporting explanation **0** No worthwhile work attempted	e.g. Of answer for 5 marks. A 70% increase might be going up from 10 to 17 parents fined. The first statement says that most parents are being fined but the latter statement need not so the two statements do not mean the same thing.

Question			Answer	Marks	Guidance	
7	(i)		Births: 37 × 10.67 Two numbers in correct ratio identified Dividing 395 in ratio Rounding to given numbers 175 girls, 220 boys	**M1** **M1** **M1** **A1** **[4]**		Eg 126 boys for every 100 girls or 1.26 boys for 1 girl
7	(ii)	(*A*)	Assuming equal prob, Mean: Liechtenstein 197(.5) Standard deviation: Liechtenstein 9.9 Liechtenstein is about 2sd away from mean Liechtenstein result not that unusual (within 3sd)	**M1** **A1** **M1** **A1** **M1** **A1** **E1** **[7]**	Use of $\frac{n}{2}$ for mean Use of $\frac{\sqrt{n}}{2}$ for standard deviation Calculation of number of standard deviations from mean	Allow sensible rounding (as above) for means but also allow values which are not whole numbers Standard deviations can be rounded to 1sf $\frac{220-197.5}{9.9}=2.27$ e.g. You might expect the Liechtenstein result once in 20 years

Question			Answer	Marks	Guidance	
7	(ii)	(*B*)	Mean: Azerbaijan 82 330	**B1**		
			Standard deviation: Azerbaijan 203	**B1**		
			Azerbaijan is about 25 sd from mean	**B1**		$\frac{87355-82330}{203}$
			Azerbaijan is unusual so provides strong evidence that numbers are not equal	**E1** **[4]**		(or from girl numbers)
8			40÷3	**M1**	**OR** multiples of 3 to approach 40 **OR** drivers who pay every day pay £15 a week	If zero scored, SC1 for saying there is no point in the warden checking more than once a day
			13 and a bit days	**M1**	**OR** It takes 3 weeks (or 14 days) to cost more than £40	
			The warden needs to check [at least] every 13 [working] days, on average.	**A1** **[3]**	Allow every 12 days or once a fortnight if supported by correct working **OR** every 17 days if weekends are included	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th><th></th></tr>
<tr><td>9</td><td>(i)</td><td></td><td> 

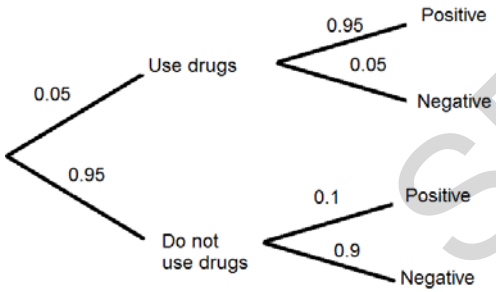
$\frac{1}{3}$ oe</td><td>M1

M1

A1

A1

M1

A1</td><td>Selection of a suitable number e.g. a multiple of 2000 as total for working out partial frequencies
Tree diagram with branches labelled or table with labels or equivalent numbers clearly shown
Correct partial frequencies on first set of branches
Correct partial frequencies on at least one second set
Adding their 95 and 190</td><td>Working can be shown in a two way table instead of a tree diagram
<table><tr><th></th><th>+ve</th><th>-ve</th><th>total</th></tr><tr><td>Use drugs</td><td>95</td><td>5</td><td>100</td></tr><tr><td>No drugs</td><td>190</td><td>1710</td><td>1900</td></tr><tr><td>total</td><td>285</td><td>1715</td><td>2000</td></tr></table></td></tr>
<tr><td></td><td></td><td></td><td>ALTERNATIVE METHOD</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td>Probabilities can be used on tree diagram instead of frequencies.
 
</td><td>[6]</td><td>M1 tree diagram with branches labelled.
A1 correct probs on first set of branches
A1 correct probs on at least one second set of branches
M1 0.05 × 0.95 (drugs and positive)
M1 0.05 × 0.95 + 0.95 × 0.1 (positive)
A1 $\frac{1}{3}$ oe</td><td></td></tr>
<tr><td>9</td><td>(ii)</td><td></td><td>$\frac{95+190}{2000}$ oe
14[.25]%</td><td>M1

A1
[2]</td><td>

FT</td><td>If ALTERNATIVE METHOD used
M1for 0.05 × 0.95 + 0.95×0.1 [= 0.1425]
A1 for 14[.25]%</td></tr>
</table>

Question			Answer	Marks	Guidance
10			Solutions are likely to include the following points. • A description of a method to make a decision. • Reasons for choosing a particular method. • Working showing the chosen method in practice. • A rank order of first, second, third based on the working. Choices of decision methods for the top three levels should take account of all the data in the table. This may include clear decisions about (say) ignoring the top and/or bottom score for each dancer as untypical. Students who decide to make the decision based on total score (or mean) in order to use all information can justify a rank order for the example without actually calculating the totals.	**[10]**	**9-10** for a clear method with reasons for deciding on this method and correct application of the method to the data in the table to identify 1st, 2nd and 3rd places. Method should include what to do if the rule produces a tie. **7-8** for a clear method with application to the data in the table to identify 1st, 2nd and 3rd places but • there are no clear reasons for choice of method • **or** there are errors in application of the method • **or** the description of the method is not clear but the example clarifies what is meant. **5-6** for substantial progress towards a complete solution. This level includes responses which correctly describe a decision method that takes account of all the information but there are no reasons for choice of this method and the application of it to the data in the table is incomplete. **3-4** for some progress towards a complete solution. Responses at this level include some correct work, for example, describing a decision method but not applying it. This level also includes responses that correctly use a very simple decision method applied to the data in the table with a reason but without giving the general rules for the method. **Example of 3-4 category** Aretha got 20 marks twice so should come top. Vince got 20 marks once so he comes second. Yuri got 15 twice so he comes third. **1-2** for some relevant work. Responses at this level have at least one correct statement or some relevant working. **Example of 1-2 category** Aretha got 20 marks twice and 19 marks twice. **0** No worthwhile work attempted

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Assessment Objectives (AO) Grid

Question	AO1	AO2	AO3	Total
1	2		1	3
2 (i)		1		1
2 (ii)		1	1	2
3	1	1	1	3
4	3	2	2	7
5	1		2	3
6	1	1	3	5
7 (i)	1	2	1	4
7(ii)	6	2	3	11
8		2	1	3
9 (i)	2	3	1	6
9 (ii)			2	2
10		8	2	10
Totals	**17**	**23**	**20**	**60**

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Oxford Cambridge and RSA

Level 3 Certificate

Quantitative Reasoning (MEI)

H866/02 Critical Maths

Sample Insert

Date – Morning/Afternoon

NOTES FOR GUIDANCE (CANDIDATES)

- This leaflet contains pre-release material which is needed in preparation for the examination of H866/02 (Critical Maths).
- You will need to read the material carefully. The examination paper will contain questions related to this material. You will be expected to apply your knowledge and understanding of the work covered in H866/02 (Critical Maths) to answer the questions.
- You will **not** be able to bring your copy of the material, or other materials, into the examination. The examination paper will contain a fresh copy of the material as an insert.
- You will not have time to read this material for the first time in the examination if you are to complete the examination paper within the specified time. However, you should refer to the material when answering the questions.
- This document consists of **4** pages. Any blank pages are indicated.

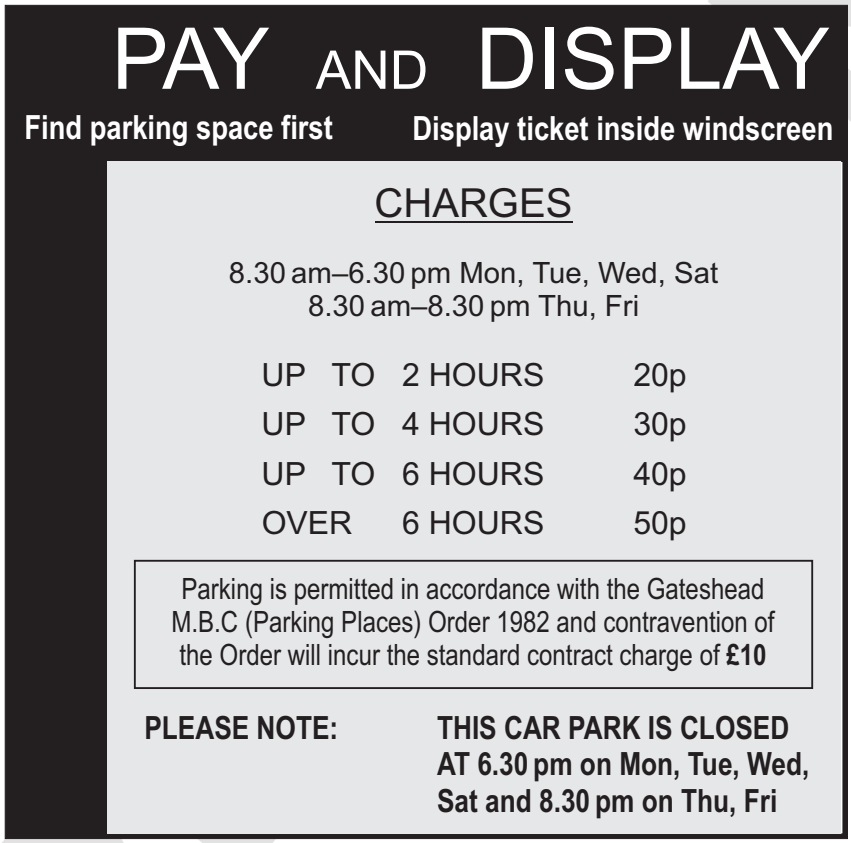
INSTRUCTION TO EXAMS OFFICER/INVIGILATOR

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

Car parking

Car parks often have charges for parking in them. In a pay and display car park, people who have paid are required to display a ticket in the car.

From time to time a warden will check all the cars in the car park and fine drivers who are not displaying a ticket.



Male to female sex ratio

When working with probability, we often assume that equal numbers of boys and girls are born. This is not quite the case. There are often slightly more boys born than girls. Historically, about 105 boys are born for every 100 girls. This means that the probability of a new baby being a boy is 0.51 rather than 0.5. However, it is often convenient to approximate this to 0.5.

Women tend to live longer than men which is one reason why the proportions of males and females in a population are slightly different for different age groups. The number of males for every female is the male to female sex ratio. The male to female sex ratio at birth is shown below for a sample of countries.

Country	Male to female sex ratio at birth
Albania	1.11
American Samoa	1.06
Angola	1.05
Barbados	1.01
Bhutan	1.05
Bulgaria	1.06
Cook Islands	1.04
Gabon	1.03
Germany	1.06
Guinea-Bissau	1.03
Guyana	1.05
Kosovo	1.08
Luxembourg	1.07
Madagascar	1.03
Norway	1.06
Portugal	1.07
United Kingdom	1.05
Uruguay	1.04
Zambia	1.03

Data: CIA World Factbook

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Level 3 Certificate

Quantitative Reasoning (MEI)

H866/02 Critical Maths

Sample Pre-release Material

For issue on or after: Date/Year

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- You can seek advice from your teacher about the content of the material and you can discuss it with others in your class. You may also investigate the topic yourself using any resources available to you.
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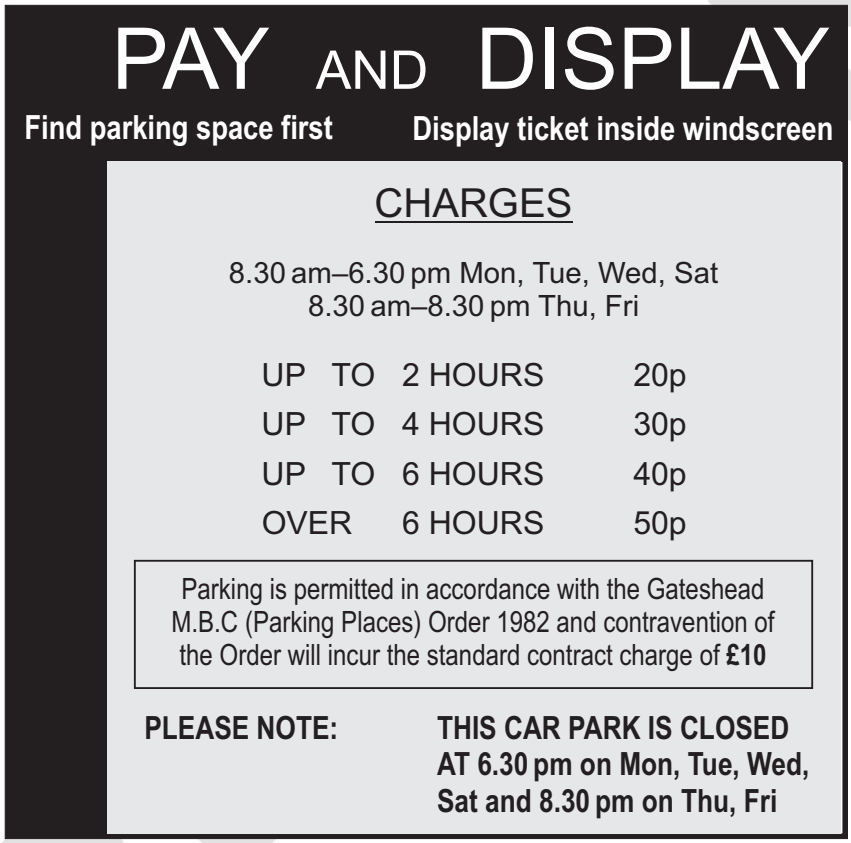

Male to female sex ratio

When working with probability, we often assume that equal numbers of boys and girls are born. This is not quite the case. There are often slightly more boys born than girls. Historically, about 105 boys are born for every 100 girls. This means that the probability of a new baby being a boy is 0.51 rather than 0.5. However, it is often convenient to approximate this to 0.5.

Women tend to live longer than men which is one reason why the proportions of males and females in a population are slightly different for different age groups. The number of males for every female is the male to female sex ratio. The male to female sex ratio at birth is shown below for a sample of countries.

Country	Male to female sex ratio at birth
Albania	1.11
American Samoa	1.06
Angola	1.05
Barbados	1.01
Bhutan	1.05
Bulgaria	1.06
Cook Islands	1.04
Gabon	1.03
Germany	1.06
Guinea-Bissau	1.03
Guyana	1.05
Kosovo	1.08
Luxembourg	1.07
Madagascar	1.03
Norway	1.06
Portugal	1.07
United Kingdom	1.05
Uruguay	1.04
Zambia	1.03

Data: CIA World Factbook

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