



Rewarding Learning

**General Certificate of Secondary Education
2016**

Further Mathematics

Unit 2
Mechanics and Statistics

[GMF21]

THURSDAY 23 JUNE, MORNING

**MARK
SCHEME**

GCSE Further Mathematics

Introduction

The mark scheme normally provides the most popular solution to each question. Other solutions given by candidates are evaluated and credit given as appropriate; these alternative methods are not usually illustrated in the published mark scheme.

The marks awarded for each question are shown in the right hand column and they are prefixed by the letters **M**, **W** and **MW** as appropriate. The key to the mark scheme is given below:

M indicates marks for correct method.

W indicates marks for accurate working, whether in calculation, reading from tables, graphs or answers.

MW indicates marks for combined method and accurate working.

A later part of a question may require a candidate to use an answer obtained from an earlier part of the same question. A candidate who gets the wrong answer to the earlier part and goes on to the later part is naturally unaware that the wrong data is being used and is actually undertaking the solution of a parallel problem from the point at which the error occurred. If such a candidate continues to apply correct method, then the candidate's individual working must be **followed through** from the error. If no further errors are made, then the candidate is penalised only for the initial error. Solutions containing two or more working or transcription errors are treated in the same way. This process is usually referred to as "follow-through marking" and allows a candidate to gain credit for that part of a solution which follows a working or transcription error.

It should be noted that where an error trivialises a question, or changes the nature of the skills being tested, then as a general rule, it would be the case that not more than half the marks for that question or part of that question would be awarded; in some cases the error may be such that no marks would be awarded.

Positive marking:

It is our intention to regard candidates for any demonstration of relevant knowledge, skills or understanding. For this reason we adopt a policy of **following through** their answers, that is, having penalised a candidate for an error, we mark the succeeding parts of the question using the candidate's value or answers and award marks accordingly.

Some common examples of this occur in the following cases:

- (a) a numerical error in one entry in a table of values might lead to several answers being incorrect, but these might not be essentially separate errors;
- (b) readings taken from candidates' inaccurate graphs may not agree with the answers expected but might be consistent with the graphs drawn.

When the candidate misreads a question in such a way as to make the question easier, only a proportion of the marks will be available (based on the professional judgement of the examiner).

		AVAILABLE MARKS
1	(a) CD	MW1
	(b) (i) Speed = $\frac{60}{30} = 2$ m/s	MW1
	(ii) Distance remains constant, so speed = 0 m/s	MW1
	(iii) Distance travelled = 60 m + 20 m = 80 m	MW1
4		
2	(i) $v = u + at$	
	$(-4\mathbf{i} - \mathbf{j}) = (4\mathbf{i} + 5\mathbf{j}) + 4a$	MW1
	$4a = -8\mathbf{i} - 6\mathbf{j}$	
	$a = (-2\mathbf{i} - 1.5\mathbf{j}) \text{ m/s}^2$	W1
	(ii) $s = ut + \frac{1}{2}at^2$	
	$= (4\mathbf{i} + 5\mathbf{j})4 + \frac{1}{2}(-2\mathbf{i} - 1.5\mathbf{j})16$	MW1
	$= 16\mathbf{i} + 20\mathbf{j} - 16\mathbf{i} - 12\mathbf{j}$	
	$= 8\mathbf{j} \text{ m}$	W1
4		
	Alternative solution	
	$s = \frac{1}{2}(u + v)t$	
	$= \frac{1}{2}[(4\mathbf{i} + 5\mathbf{j}) + (-4\mathbf{i} - \mathbf{j})]4$	MW1
	$= \frac{1}{2}(4\mathbf{j})4$	
	$= 8\mathbf{j} \text{ m}$	W1

3 (i) $v = u + at$

$$12 = u + 3a \quad (1)$$

MW1

$$16 = u + 8a \quad (2)$$

MW1

(ii) $(2) - (1) \rightarrow 5a = 4$
 $a = 0.8$

MW1

(iii) $12 = u + 3(0.8)$ or $16 = u + 8(0.8)$

$$u = 9.6$$

MW1

(iv) $s = \frac{1}{2}(u + v)t$

$$\begin{aligned} \text{Distance AB} &= \frac{1}{2}(12 + 16)5 \\ &= 70 \text{ m} \end{aligned}$$

MW1

W1

6

Alternative solution 1

$$s = ut + \frac{1}{2}at^2$$

$$\begin{aligned} \text{Distance AB} &= 12(5) + \frac{1}{2}(0.8)(5)^2 \\ &= 70 \text{ m} \end{aligned}$$

MW1

W1

Alternative solution 2

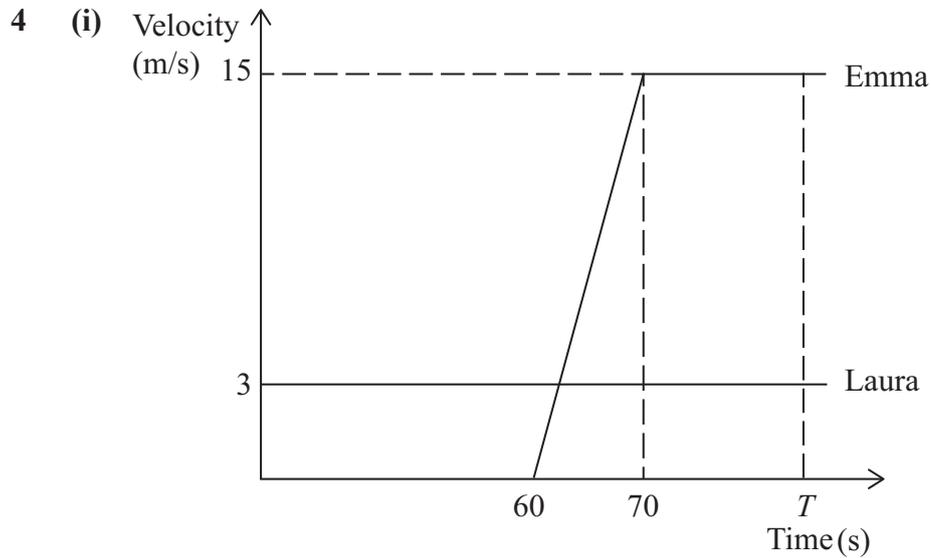
$$\begin{aligned} \text{at A: } s &= \frac{1}{2}(9.6 + 12)3 \\ &= 32.4 \text{ m} \end{aligned}$$

$$\begin{aligned} \text{at B: } s &= \frac{1}{2}(9.6 + 16)8 \\ &= 102.4 \text{ m} \end{aligned}$$

MW1

$$\begin{aligned} \text{Distance AB} &= 102.4 - 32.4 \\ &= 70 \text{ m} \end{aligned}$$

MW1



MW1
(for 60–70)

MW1
(for 70–T)

(ii) Distance for Laura = $3T$

MW1

(iii) Distance for Emma = $\frac{1}{2}(15)(10) + 15(T - 70)$

MW1

$$= 75 + 15T - 1050$$

$$= 15T - 975$$

W1

Alternative solution

$$\text{Distance for Emma} = \frac{1}{2}(T - 60 + T - 70)15$$

MW1

$$= 15T - 975$$

W1

(iv) So $3T = 15T - 975$

M1

$$12T = 975$$

$$T = 81.25 \text{ s}$$

So time to catch up = $81.25 - 60$

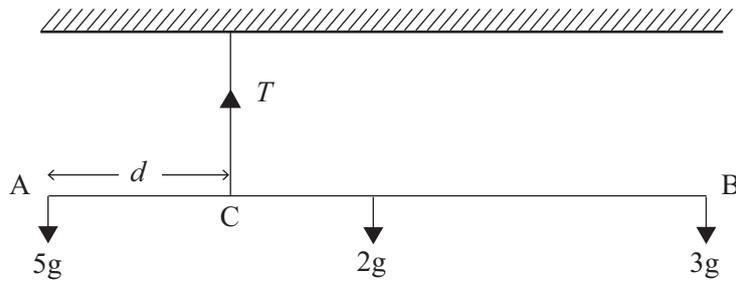
$$= 21.25 \text{ s}$$

MW1

7

AVAILABLE
MARKS

5 (i)



MW2

[MW1 for 2 forces correct
MW2 for all forces correct]

(ii) Resolve vertically:

$$T = 5g + 2g + 3g$$

$$= 10g = 100\text{N}$$

MW1

(iii) Take moments about A:

$$10gd = 2g \times 3 + 3g \times 6$$

MW1, MW1

$$10d = 24$$

$$d = 2.4\text{ m}$$

W1

Alternative solution

Take moments about C:

$$5gd = 2g(3 - d) + 3g(6 - d)$$

MW1, MW1

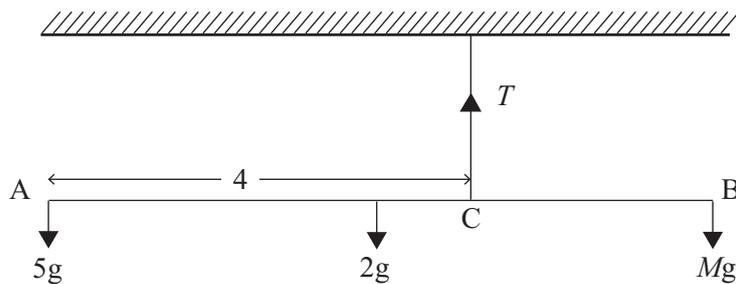
$$5d = 6 - 2d + 18 - 3d$$

$$10d = 24$$

$$d = 2.4\text{ m}$$

W1

(iv)



Take moments about C:

$$5g \times 4 + 2g \times 1 = Mg \times 2$$

MW1, MW1

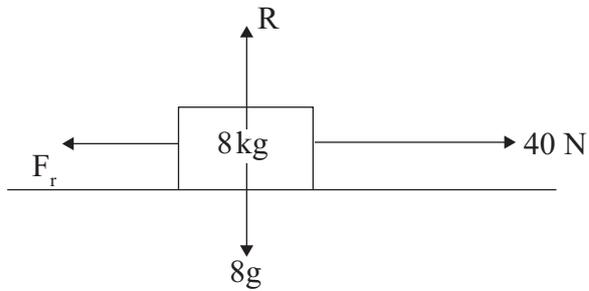
$$22 = 2M$$

$$M = 11$$

W1

9

6 (i)



MW1

- (ii) Resolve vertically: $R = 8g = 80 \text{ N}$
 Resolve horizontally: $F_r = 40 \text{ N}$

$$F_r = \mu R$$

$$40 = 80\mu$$

$$\mu = 0.5$$

MW1
W1

- (iii) Resolve vertically:
 $50 \sin 40^\circ + R = 8g$

MW1

$$R = 80 - 50 \sin 40^\circ$$

$$= 47.861 \text{ N} \rightarrow 47.86 \text{ N}$$

W1

- (iv) Resolve horizontally:

$$50 \cos 40^\circ - F_r = 8a$$

MW1, MW1

$$F_r = \mu R = 0.5 \times 47.861$$

$$= 23.931$$

MW1

$$8a = 50 \cos 40^\circ - 23.931$$

$$a = 1.796 \text{ m/s}^2 \rightarrow 1.80 \text{ m/s}^2$$

W1

AVAILABLE
MARKS

9

		AVAILABLE MARKS
7	(i) Total resistance = $1200 \times 1.6 + 500 \times 0.7$ $= 2270 \text{ N}$	M1 W1
	(ii) Forward force – total resistance $= \text{total mass} \times \text{acceleration}$ $5330 - 2270 = 1700 a$ $a = 1.8 \text{ m/s}^2$	MW1 W1
	(iii) Forces on trailer: $T - 500 \times 0.7 = 500 \times 1.8$ $T = 1250 \text{ N}$	MW1 W1
	Alternative solution Forces on car: $5330 - 1200 \times 1.6 - T = 1200 \times 1.8$ $T = 1250 \text{ N}$	MW1 W1
	(iv) $v = u + at$ $v = 0 + 1.8 \times 10$ $= 18 \text{ m/s}^2$	MW1
	(v) Acceleration of trailer $0 - 500 \times 0.7 = 500a$ $a = -0.7 \text{ m/s}^2$ $v^2 = u^2 + 2as$ $0 = 18^2 + 2(-0.7)s$ $s = 231.43 \text{ m}$	MW1 W1 MW1 W1
8	(i) $\frac{50}{2} = 25$ So median class = 11.4 – 12.3	M1 MW1
	(ii) Modal class is 10.4 – 11.3 Boundaries are 10.35 – 11.35	M1 MW1
	(iii) Class width = e.g. 11.35 – 10.35 = 1 cm	MW1
		11
		5

9 (i) median class is $3.0 < M \leq 3.8$

M1

$$\text{median} = 3.0 + \frac{(18.5 - 14) \times 0.8}{7}$$

$$= 3\frac{18}{35} = 3.51 \text{ kg}$$

M1 for 3.0+(...)
 MW1 (18.5 - 14)
 MW1 $\left(\frac{0.8}{7}\right)$
 W1

(ii) We don't know what the exact masses are,
 so D

M1

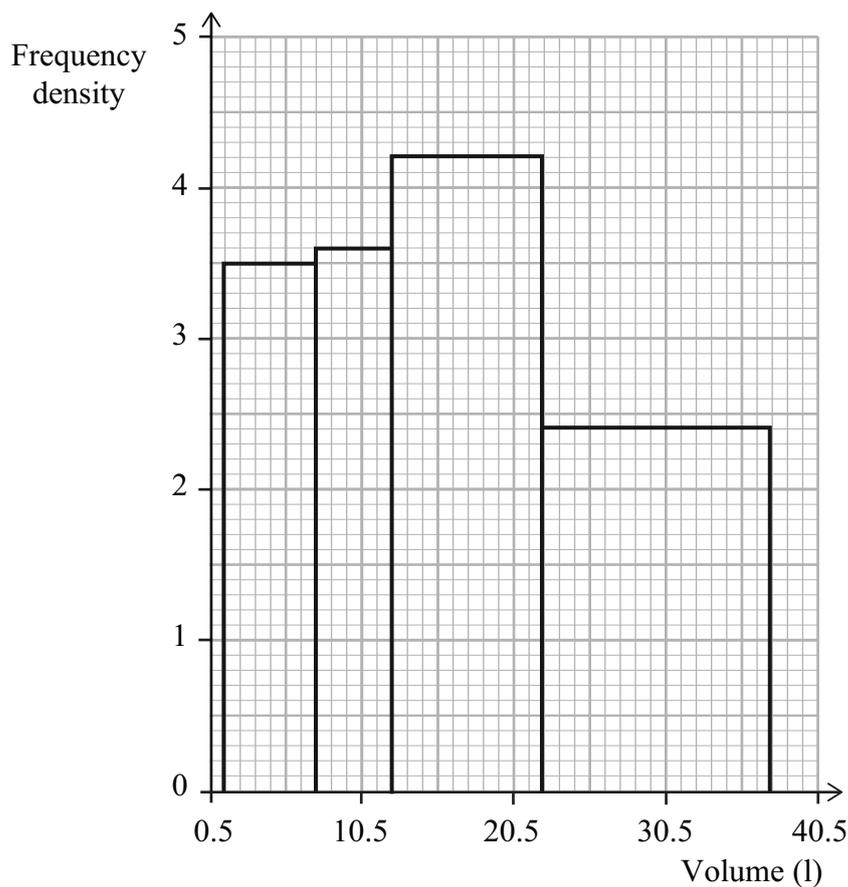
5

10 (i) Frequency = $(7.5 - 1.5) \times 3.5 = 21$

M1, W1

Volume (l)	8-12	13-22	23-37
Frequency	18	42	36
Frequency density	3.6	4.2	2.4

M1, W1



MW1 (boundaries)
 MW1 (heights)

6

	Actual marks	Uniform marks
Mean	31	72
Standard deviation	4.6	9.2

MW1

MW1

(ii) Total marks for 5 candidates = $31 \times 5 = 155$ Total marks for 6 candidates = $155 + 43 = 198$

MW1

$$\text{mean} = \frac{198}{6} = 33$$

W1

4

Ranks (Average speed)	2	3	8	6	5	9	1	4	7
Ranks (Time)	8	5	6	4	3	1	8	8	2

MW1

MW1

Alternative solution

Ranks (Average speed)	8	7	2	4	5	1	9	6	3
Ranks (Time)	2	5	4	6	7	9	2	2	8

MW1

MW1

d^2	36	4	4	4	4	64	49	16	25
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M1, W1

$$r = 1 - \frac{6 \sum d^2}{n(n^2 - 1)}$$

$$= 1 - \frac{6(206)}{9(80)}$$

MW1

$$= -\frac{43}{60} = -0.72$$

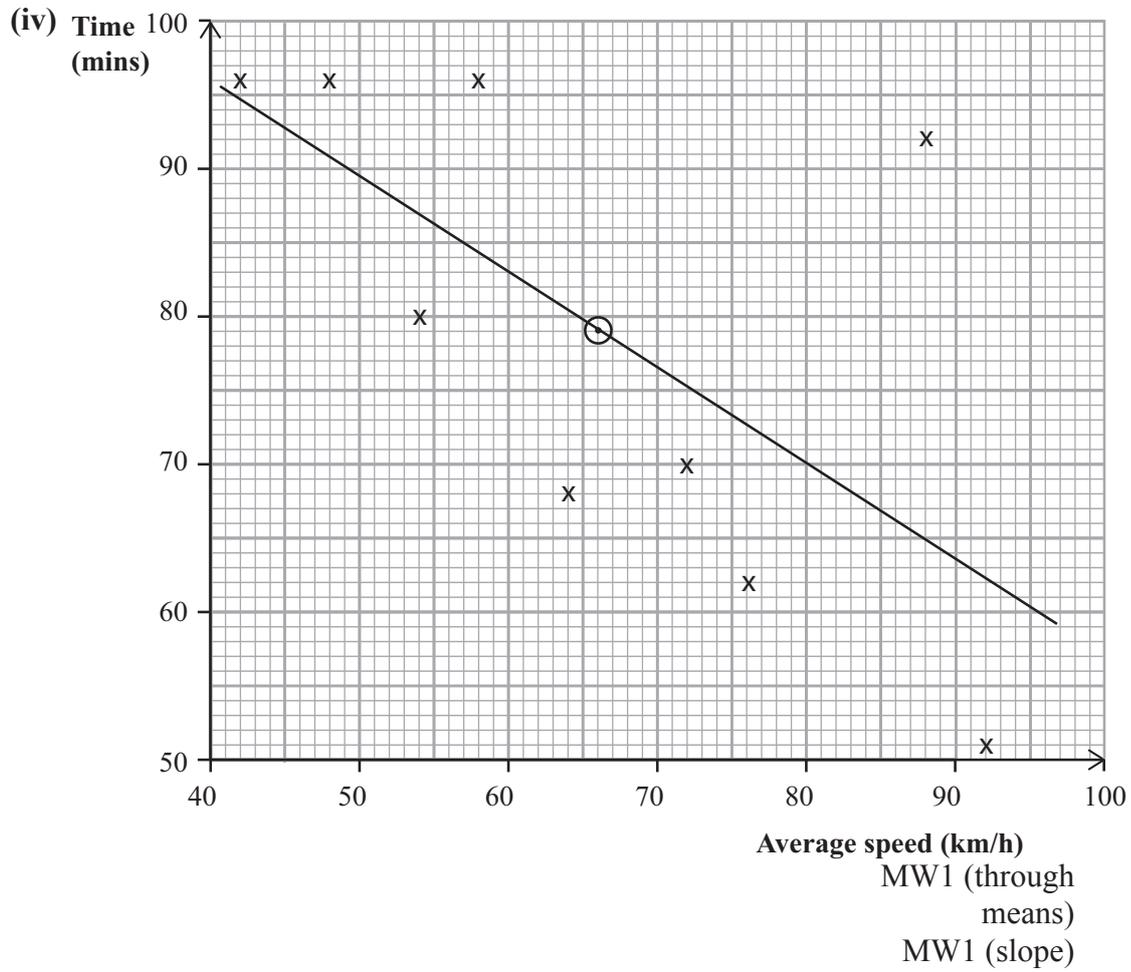
W1

(ii) Negative correlation

M1

(iii) mean of average speeds = $\frac{594}{9} = 66$ km/hmean of times = $\frac{711}{9} = 79$ mins

MW1



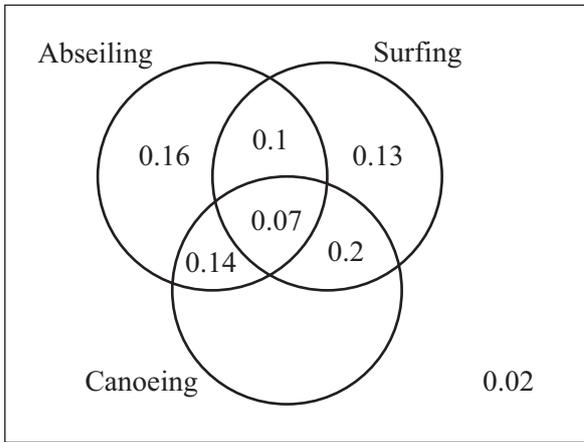
AVAILABLE MARKS

(v) Frank – he has to travel much further to work than the rest.

M1

11

13 (i)



MW1
(0.07)

MW1
(0.1, 0.14, 0.2)

MW1
(0.16, 0.13, 0.02)

(ii) $1 - (0.16 + 0.1 + 0.14 + 0.07 + 0.13 + 0.2 + 0.02)$

M1

$= 1 - 0.82 = 0.18$

W1

(iii) $P(\text{not abseiling}) = 0.13 + 0.2 + 0.18 + 0.02$

$= 0.53$

$P(\text{surfing and not abseiling}) = 0.13 + 0.2$

$= 0.33$

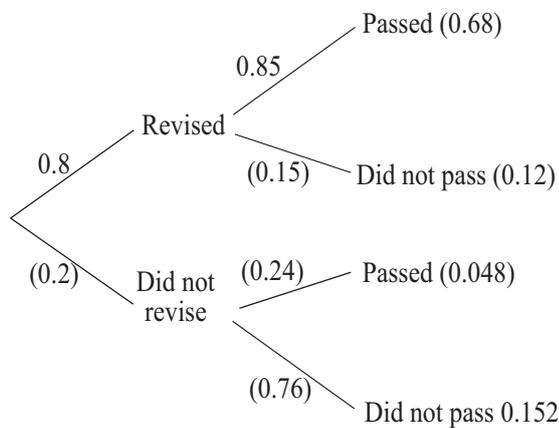
MW1

$P(\text{surfing}|\text{not abseiling}) = \frac{0.33}{0.53} = 0.62$

MW1

7

14



(i) $P = 0.8 \times 0.85 = 0.68$

MW1

(ii) $0.2 p = 0.152$
 $p = 0.76$

MW1
W1

(iii) $P(\text{Did not revise and passed}) = 0.2 \times 0.24 = 0.048$

MW1

$P(\text{passed}) = 0.68 + 0.048 = 0.728$

MW1

No. of candidates passed = $125 \times 0.728 = 91$

MW1

6

$$15 \text{ (i)} \quad P(\text{shop}|\text{granny}) = \frac{P(\text{shop and granny})}{P(\text{granny})}$$

$$0.4 = \frac{P(\text{shop and granny})}{0.55}$$

$$\text{So } P(\text{shop and granny}) = 0.4 \times 0.55 = 0.22$$

$$\text{(ii)} \quad P(\text{granny}|\text{shop}) = \frac{P(\text{shop and granny})}{P(\text{shop})}$$

$$0.88 = \frac{0.22}{P(\text{shop})}$$

$$P(\text{shop}) = \frac{0.22}{0.88} = 0.25$$

$$\text{(iii)} \quad P(\text{shop or granny}) = P(\text{shop}) + P(\text{granny}) - P(\text{shop and granny})$$

$$= 0.25 + 0.55 - 0.22$$

$$= 0.58$$

		AVAILABLE MARKS
	M1	
	W1	
	M1	
	W1	
	M1	
	W1	6
Total		100