OCR
Oxford Cambridge and RSA

Wednesday 16 May 2018 – Morning

A2 GCE MATHEMATICS (MEI)

4762/01 Mechanics 2

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:
- Printed Answer Book 4762/01
- MEI Examination Formulae and Tables (MF2)

Other materials required:
- Scientific or graphical calculator

Duration: 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

These instructions are the same on the Printed Answer Book and the Question Paper.

- The Question Paper will be found inside 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 barcodes.
- You are permitted to use a scientific or graphical calculator in this paper.
- Final answers should be given to a degree of accuracy appropriate to the context.
- The acceleration due to gravity is denoted by $g\,\mathrm{m\,s^{-2}}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.

INFORMATION FOR CANDIDATES

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- 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.

1 A and B are two points on smooth horizontal ground. Two particles, P of mass 5.5 kg and Q of mass 0.5 kg, are projected from these points with the velocity components shown in Fig. 1. Initially, the particles have the same horizontal speed of $15\,\text{m s}^{-1}$ and the same vertical speed of $U\,\text{m s}^{-1}$.

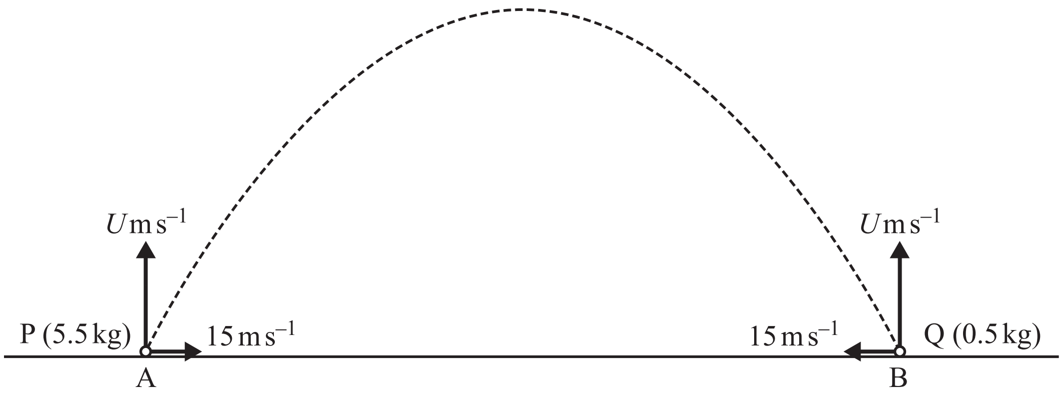

Fig. 1

Air resistance should be neglected.

The particles are projected at the same time and collide 2.5 s after projection when each is at the top of its trajectory.

(i) Find the value of U. **[2]**

(ii) Show that, immediately after the particles collide, they separate at $30e\,\text{m s}^{-1}$, where e is the coefficient of restitution in the collision. **[2]**

When the particles hit the ground they are 45 m apart.

(iii) Deduce that $e = 0.6$.

Find the velocities of P and of Q immediately after they collide. **[7]**

(iv) Calculate the impulse that acts on Q in the collision. **[2]**

(v) What is the displacement of Q from B when Q reaches the ground? **[2]**

When particle P reaches the ground it bounces with a coefficient of restitution of $\frac{2}{7}$.

(vi) At what angle to the horizontal does P leave the ground? **[4]**

2 A particle is pulled along a smooth horizontal floor by a force of magnitude 35 N inclined at a constant angle α to the horizontal, as shown in Fig. 2.1. The force acts in a fixed vertical plane.

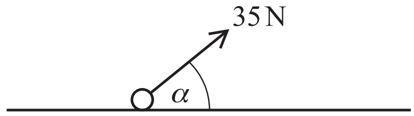

Fig. 2.1

144 J of work is done by the force on the particle as it slides through 5 m from A to B.

(i) Calculate the value of α. **[3]**

The mass of the particle is 6 kg and it has a speed of $4\,\text{m}\,\text{s}^{-1}$ at A.

(ii) Using an energy method, calculate the speed of the particle at B. Calculate the power of the pulling force at this point. **[5]**

In a new situation, shown in Fig. 2.2, the particle of mass 6 kg can move on a rough plane surface inclined at 50° to the horizontal.

At all times in parts **(iii)** and **(iv)**, a force of magnitude 35 N acts on the particle; this force is inclined at 30° to a line of greatest slope of the surface.

The coefficient of friction between the particle and the surface is μ.

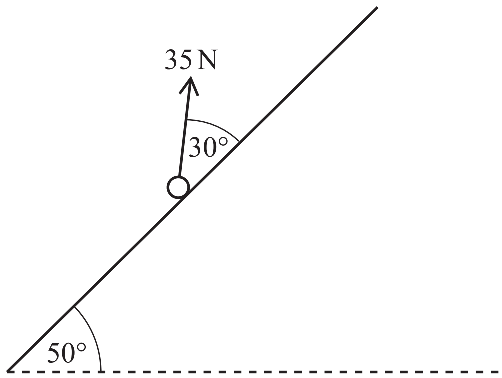

Fig. 2.2

(iii) The particle is placed on the surface and does not slide downwards.

Find the possible values of μ. **[6]**

The surface is now treated so that μ becomes 0.6 and the particle is placed on it.

(iv) Using an energy method, determine how far down the surface the particle has slid when it reaches a speed of $1.5\,\text{m}\,\text{s}^{-1}$. **[4]**

3 (a)

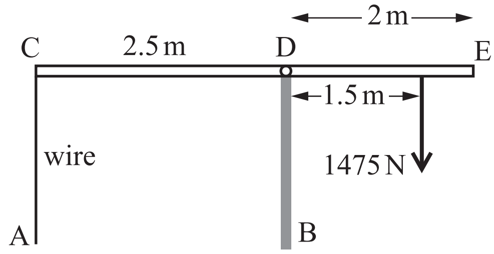

Fig. 3.1

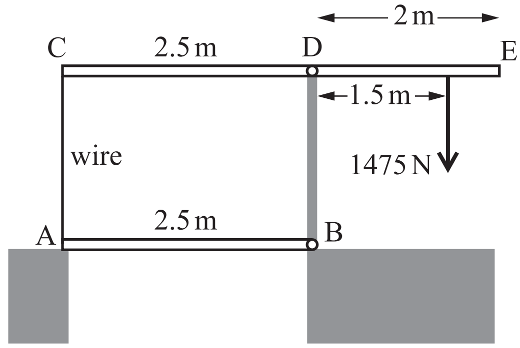

Fig. 3.2

Fig. 3.1 shows a uniform horizontal beam, CE, with weight 4000 N and length 4.5 m. BD is a rigid vertical support and the beam is freely pivoted at D, where CD is 2.5 m. The beam has a vertical load of 1475 N acting at a point that is 1.5 m from D. A vertical, light, inextensible wire is attached to the beam at C and held at A.

The beam is in equilibrium.

(i) Calculate the tension in the wire AC. **[3]**

This beam is part of a simple lift bridge which is shown in its ‘down’ position in Fig. 3.2. The uniform lower beam, AB, has a weight of 1000 N and length 2.5 m. AB is freely pivoted at B, attached to the wire CA and also rests on a support at A. ABDC is a rectangle.

The bridge is in equilibrium.

(ii) Calculate the normal reaction on the beam AB of its support at A. **[4]**

(b) In this part of the question you may leave your answers in surd form.

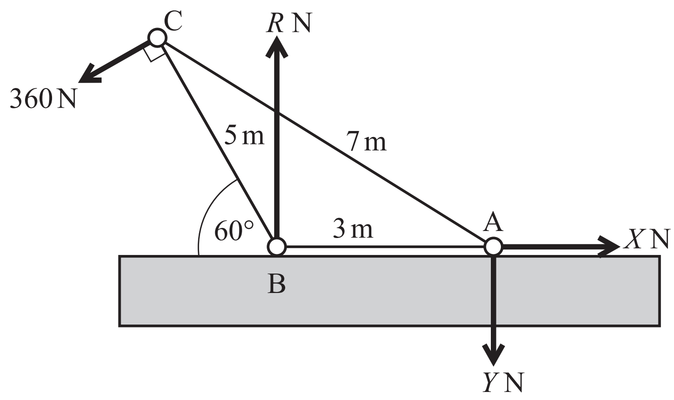

Fig. 3.3

Fig. 3.3 shows a framework in equilibrium in a vertical plane. The framework is made from three light rigid rods AB, AC and BC, of lengths 3 m, 7 m and 5 m respectively. AB is horizontal and BC is at 60° to the horizontal.

The rods are freely pin-jointed to each other at A, B and C. The pin-joint at A is fixed to a smooth horizontal floor and the pin-joint at B rests on this floor.

The figure also shows the external forces acting on the framework: there is a force of 360 N at C acting perpendicular to BC; the normal reaction of the floor on the pin-joint at B is R N; horizontal and vertical forces X N and Y N act on the framework from the pin-joint at A.

(i) Calculate the values of X and Y. Show that $R = 780$. **[4]**

(ii) Calculate the forces internal to the three rods, stating whether each rod is in tension or in compression (thrust). [You may use without proof that $\sin\alpha = \frac{5\sqrt{3}}{14}$, where α = angle BAC] **[8]**

4 The object shown in Fig. 4.1 is cut from a flat sheet of thin uniform rigid metal. OCFJ, OABC, CDEF, FHIJ and JKLO are rectangles with dimensions, in centimetres, shown in the figure.

(i) Calculate the coordinates of the centre of mass of the object referred to the axes shown in Fig. 4.1. **[4]**

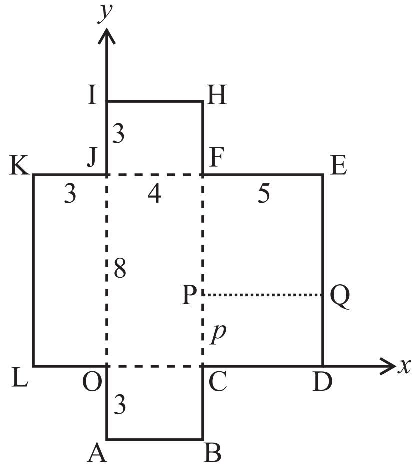

Fig. 4.1

Fig. 4.2 shows the object folded as follows: rectangle FHIJ is folded along FJ and rectangle JKLO along JO so that the edges JI and JK come together; rectangle OABC is folded along OC so that it is perpendicular to OCFJ and on the other side of OCFJ to FHIJ and JKLO.

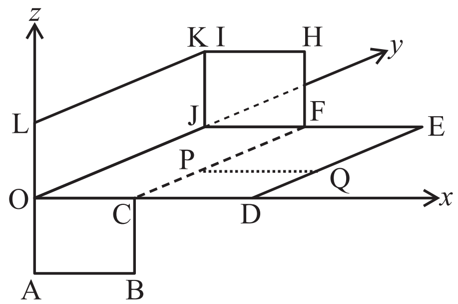

Fig. 4.2

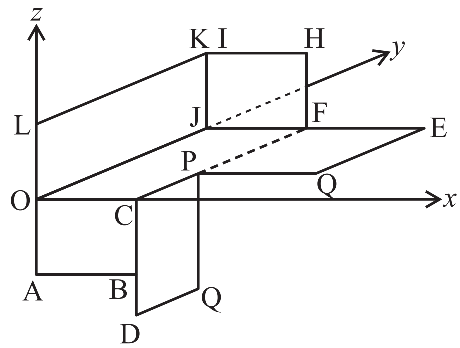

Fig. 4.3

(ii) Show that, referred to the axes shown in Fig. 4.2, the x-coordinate of the centre of mass of the folded object is 3.1. **[3]**

Rectangle CDEF is now cut along the line PQ which is perpendicular to CF. The distance CP is p cm. Rectangle CDQP is folded along CP so that part of CD is in contact with CB, as shown in Fig. 4.3. Referred to the axes shown in Fig. 4.3, the centre of mass of the folded object is at the point G with coordinates $(\bar{x}, \bar{y}, \bar{z})$.

(iii) Given that $\bar{z} = 0$, show that $p = 2.88$ and calculate $\bar{x}$ and $\bar{y}$. **[5]**

The folded object in Fig. 4.3 is now freely suspended from the point L and hangs in equilibrium.

(iv) Calculate the angle between OG and the vertical. **[4]**

END OF QUESTION PAPER

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4762/01 Mechanics 2

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Candidate forename		Candidate surname	

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1 (i)	
1 (ii)	
1 (iii)	

1 (iii)	(continued)
1 (iv)	
1 (v)	
1 (vi)	

2 (i)	
2 (ii)	

2 (iii)	
2 (iv)	

3 (a) (i)	
3 (a) (ii)	

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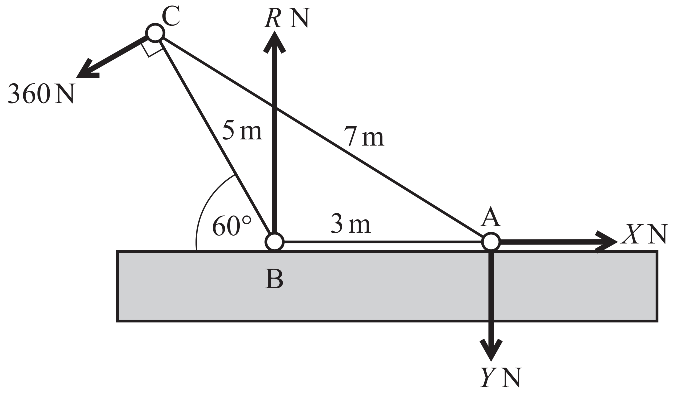
3 (b) (i)



3 (b) (ii)

4 (i)

4 (ii)

4 (iii)	

4 (iv)

OCR
Oxford Cambridge and RSA

GCE

Mathematics (MEI)

Unit **4762**: Mechanics 2

Advanced GCE

Mark Scheme for June 2018

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.

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) Mechanics 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 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 Unless units are specifically requested, there is no penalty for wrong or missing units as long as the answer is numerically correct and expressed either in SI or in the units of the question. (e.g. lengths will be assumed to be in metres unless in a particular question all the lengths are in km, when this would be assumed to be the unspecified unit.)

We are usually quite flexible about the accuracy to which the final answer is expressed and we do not penalise over-specification.

When a value is given in the paper
Only accept an answer correct to at least as many significant figures as the given value. This rule should be applied to each case.

When a value is not given in the paper
Accept any answer that agrees with the correct value to 2 s.f.

ft should be used so that only one mark is lost for each distinct error made in the accuracy to which working is done or an answer given. Refer cases to your Team Leader where the same type of error (e.g. errors due to premature approximation leading to error) has been made in different questions or parts of questions.

There are some mistakes that might be repeated throughout a paper. If a candidate makes such a mistake, (eg uses a calculator in wrong angle mode) then you will need to check the candidate's script for repetitions of the mistake and consult your Team Leader about what penalty should be given.

There is no penalty for using a wrong value for g. E marks will be lost except when results agree to the accuracy required in the question.

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.

Marks designated as cao may be awarded as long as there are no other errors. E marks are lost unless, by chance, the given results are established by equivalent working.

'Fresh starts' will not affect an earlier decision about a misread.

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

i If a graphical calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers (provided, of course, that there is nothing in the wording of the question specifying that analytical methods are required). Where an answer is wrong but there is some evidence of method, allow appropriate method marks. Wrong answers with no supporting method score zero. If in doubt, consult your Team Leader.

j If in any case the scheme operates with considerable unfairness consult your Team Leader.

Question			Answer	Marks	Guidance	
1		(i)	↑ $0 = U - 9.8 \times 2.5$	M1	Use of $v = u + at$ with $v = 0$, $a = \pm 9.8$ and $t = 2.5$	
			so $U = 24.5$	A1 **[2]**	cao	
		(ii)	NEL with velocities after collision v_P and v_Q →			
			$\frac{v_Q - v_P}{-15 - 15} = -e$	M1	Use of NEL. Allow sign errors.	
			so $v_Q - v_P = 30e$	E1 **[2]**	Need to see 15 + 15 oe for the second mark. Must be positive	
		(iii)	Separation after time T is $(v_Q - v_P)T$	M1		
			and $T = 2.5$	B1	May be implied	
			so $45 = 30e \times 2.5$ and $e = 0.6$	E1		
			Using PCLM → $5.5 \times 15 - 0.5 \times 15 = 5.5v_P + 0.5v_Q$	M1	Use of PCLM	
			so $11v_P + v_Q = 150$	A1	Any form signs **must** be consistent with their separation velocity.	
			Solving with $v_Q - v_P = 18$	M1	Using $e = 0.6$ in NEL expression and attempt to solve	
			gives $v_P = 11$ and $v_Q = 29$	A1	cao both cwo directions must be clear.	
				[7]	If $e = 0.6$ not shown, can get last 4 marks, and possibly the B1 if $T = 2.5$ is stated	
		(iv)	Take → +ve Impulse on Q is 0.5 × (29-(-15)) = 0.5 × (29 + 15)	M1	Use of $I = M(v - u)$ must be final velocity – initial velocity	
			so 22 N s	A1 **[2]**	FT **their** 29. Can find impulse on P and then reverse sign: 5.5(11-15) leads to - 22 Ns Impulse on P alone gets M0A0	

Question			Answer	Marks	Guidance	
		(v)	Collision is 2.5 × 15 = 37.5 m (to left of B) Q travels 29 × 2.5 = 72.5 m (to right) so ends up 35 m to right of B	B1 B1 **[2]**	One relevant distance seen or implied, FT their 29 cao 'to the right of B' must be stated or clear in some way.	
		(vi)	Horizontal speed 11 m s^{-1} **before and after impact** Vertical speed before: 24.5 m s^{-1} after: $24.5\times\frac{2}{7}=7$ angle is $\arctan\frac{7}{11}=32.4711\ldots$ so 32.5° (3 s. f.)	B1 M1 M1 A1 **[4]**	Used: FT their v_P from (iii) **AND** FT their 24.5 from (i) FT **their** 24.5 from (i) FT their 7 and their 11 cao Wrong particle: max of 1/4	
2		(i)	$5\times35\cos\alpha=144$ or $35\cos\alpha=28.8$ (so cosα = 0.82285…) α = 34.6281… so 34.6 ° (3 s. f.)	M1 A1 A1 **[3]**	Attempt to resolve force along plane ($35\cos\alpha$ seen)	
		(ii)	Using W-E $0.5\times6\times v^2-0.5\times6\times4^2=144$ so $v^2=64$ and v = 8 Power is $\frac{144}{5}\times8$ = 230.4 W so 230 W (3 s. f.)	M1 M1 A1 M1 F1 **[5]**	All terms present. Accept sign errors. Difference of KE terms Power as Fv FT **their** 8 only. (28.8 x their v) Note: 35 x 8 is M0A0	

2		(iii)	Let the friction be F. Require $6g \sin 50 \leq 35 \cos 30 + F$ also $F_{max} \geq F$ so $F_{max} \geq 6g\sin 50 - 35\cos 30 = 45.0434... - 30.3108...$ (= 14.7325…) Using $F_{max} = \mu R$ $\mu(6g \cos 50 - 35 \sin 30) \geq 14.7325$ ... so $\mu \geq$ 0.72588… = 0.726 (3 s. f.)	M1 A1 M1 B1 A1 A1 **[6]**	**Condone use of = or ≥ for first 5 marks** Allow sign error, allow sin/cos mix as long as one of each Need not be evaluated. 'max' not needed For correct expression for R. [R = 20.295911..] For 0.726 cao. cwo. ($0.726 \leq \mu \leq 1$ is A0)	
		(iv)	Using W-E $0.5 \times 6 \times 1.5^2 - 0$ $= (6g\sin 50 - 35\cos 30 - 0.6R)x$ [= 2.5549775…x] x = 2.6419… so 2.64 m (3 s. f.)	M1 B1 A1 A1 **[4]**	Condone at most 1 missing term. Allow sign errors. If the RHS has individual terms, each must be a work not a force term Use of μR (with their R as in **(iii)**). 6.75 = (45.04 - 30.31 - 12.18) x Allow only sign errors (must be correct R) cao Note: 0.6R missing implies M1 maximum	
3	(a)	(i)	c.w. moments about D 1475 × 1.5 – 4000 × 0.25 – T × 2.5 = 0 T = 485 so 485 N	M1 B1 A1 **[3]**	Moments of all relevant forces attempted Using the 0.25 cao	

		(ii)	c.w. moments about B for AB $(R + 485) \times 2.5 - 1000 \times 1.25 = 0$ $R = 15$	M1 B1 B1 A1 **[4]**	Complete method, all relevant terms, no extras R + their 485 o.e. 1000×1.25 cao	
			OR Moments about B/D for whole: $1475 \times 1.5 + R \times 2.5 = 4000 \times 0.25 + 1000 \times 1.25$ $R = 15$	M1 B1 B1 A1	Complete method, all relevant terms, no extras Using R, 1475, 4000 with correct signs 1000×1.25 cao	
			OR Moments about A for AB: $2.5R_B = 1.25 \times 1000$ $R_B = 500$ $1000 = 485 + R + R_B$ $R = 15$	B1 M1B1 A1	1000×1.25 Complete method, R + their 485 cao OR any other complete method with moments and resolution M1 Using as appropriate R, 485, 1475, 4000 B1 1000 × correct distance B1 cao A1	
3	(b)	(i)	Resolve horizontally → $X - 360\cos 30 = 0$ so $X = 180\sqrt{3}$ a.c. moments about B	B1	Or 311.77…	

			$5 \times 360 - 3 \times Y = 0$ so $Y = 600$ Resolve vertically ↓ $360\cos60 + Y - R = 0$ so $R = 780$ OR: $3R = 360cos60(3 + 5cos60) + 360sin60 \times 5sin60$: $R = 780$ $360\cos60 + Y - R = 0$ so $Y = 600$	M1 A1 E1 M1 E1 A1 **[4]**	Attempt at moments with all relevant forces Moments about A Dependent on the E1: (may not assume R = 780)	
		(ii)	Setting all internal forces as tensions, Equilibrium at B ↑ $T_{BC}\sin60 + R = 0$ so $T_{BC} = -520\sqrt{3}$ Force in BC is $520\sqrt{3}$ N (compression) 900.67 Equilibrium at B → $T_{AB} - T_{BC}\cos60 = 0$ so $T_{AB} = -260\sqrt{3}$ Force in AB is $260\sqrt{3}$ N (compression) 450.33 **either** Given $\sin\alpha = \frac{5\sqrt{3}}{14}$ Equilibrium at A ↑ $T_{AC}\sin\alpha - Y = 0$ so $T_{AC} = \frac{600}{\sin\alpha} = 560\sqrt{3}$ (969.9484…)	 M1 F1 M1 F1 M1	FT their X and Y, but R must be 780 Equilibrium at a pin-joint. All forces present. Accept T/C not given accept $1560/\sqrt{3}$ Equilibrium at a pin-joint. All forces present. Accept T/C not given accept $780/\sqrt{3}$	

			Force in AC is $560\sqrt{3}$ N (tension)	F1	FT only **their** *Y*. Accept T/C not given accept $1680/\sqrt{3}$
			or Apply Pythagoras' at A or C Force in AC is $560\sqrt{3}$ N (tension)	M1 F1	At A, forces are $\rightarrow$ $180\sqrt{3}+260\sqrt{3}$ and $\uparrow$ 600
				A1 B1 **[8]**	T/C: *AB* compression, *AC* tension, *BC* compression Award if everything completely correct
4		**(i)**	$120\begin{pmatrix}\bar{x}\\\bar{y}\end{pmatrix}=12\begin{pmatrix}2\\9.5\end{pmatrix}+96\begin{pmatrix}3\\4\end{pmatrix}+12\begin{pmatrix}2\\-1.5\end{pmatrix}$ $120\bar{x}=336,\quad \bar{x}=2.8$ $120\bar{y}=480,\quad \bar{y}=4$	M1 A1 A1 A1 **[4]**	Correct method attempted for at least *x* or *y* At least one term on RHS correct Correct Correct (or by symmetry)
		(ii)	**Either** $120\bar{X}=24\times 0+12\times 2+12\times 2+72\times 4.5$ (= 372)	M1 A1	Correct method dealing with fold (alternative last term: 32 x 2+ 40 x 6.5)
			or $120\bar{X}=120\bar{x}+24\times 1.5$	M1 A1	Correct method dealing with fold
			so $\bar{X}=3.1$	E1 **[3]**	Clearly shown

	(iii)	Need $24\times1.5=5p\times2.5$	M1	There may be extra cancelling terms seen in the working.	
		so p = 2.88	E1		
		$120\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix}=12\begin{pmatrix}2\\8\end{pmatrix}+24\begin{pmatrix}0\\4\end{pmatrix}+32\begin{pmatrix}2\\4\end{pmatrix}+12\begin{pmatrix}2\\0\end{pmatrix}+5(8-p)\begin{pmatrix}6.5\\4+\frac{1}{2}p\end{pmatrix}+5p\begin{pmatrix}4\\ \frac{1}{2}p\end{pmatrix}$	M1	Correct method for one component	
		$\bar{x}=2.8$	A1	cao	
		$\bar{y}=4$	A1	Or by symmetry [That the value of $\bar{x}$ does not change from (i) can be argued for M1A1 without this working]	
			[5]		
	(iv)	Require angle OGL	M1	May be implied from subsequent working, or identified in a diagram	
		OL = 3 and OG = $\sqrt{2.8^2+4^2}$	B1	FT **their** 2.8 and 4. Award for $\sqrt{3^2+2.8^2+4^2}$ if sine/cosine used below	
		Angle is $\arctan\dfrac{3}{\sqrt{2.8^2+4^2}}=31.5675\ldots$	M1	o.e. (either way up with 3 and OG FT with their 2.8, 4)	
		so 31.6° (3 s. f.)	A1	cao	
			[4]	(Find OLG: M0B1M1A0)	

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Examiners' report

MATHEMATICS (MEI)

3895-3898, 7895-7898

4762/01 Summer 2018 series

Version 1

Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates. The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report. A full copy of the question paper can be downloaded from OCR.

Paper 4762/01 series overview

The standard of work presented by candidates was usually very good, demonstrating an understanding of the specification content and an ability to apply it. Q1 was an unfamiliar context and this did seem to confuse some candidates, although in this question, as in others, a clearly labelled diagram would have been of great help.

Question 1 (i)

1 A and B are two points on smooth horizontal ground. Two particles, P of mass 5.5 kg and Q of mass 0.5 kg, are projected from these points with the velocity components shown in Fig. 1. Initially, the particles have the same horizontal speed of $15\,\mathrm{m\,s^{-1}}$ and the same vertical speed of $U\,\mathrm{m\,s^{-1}}$.

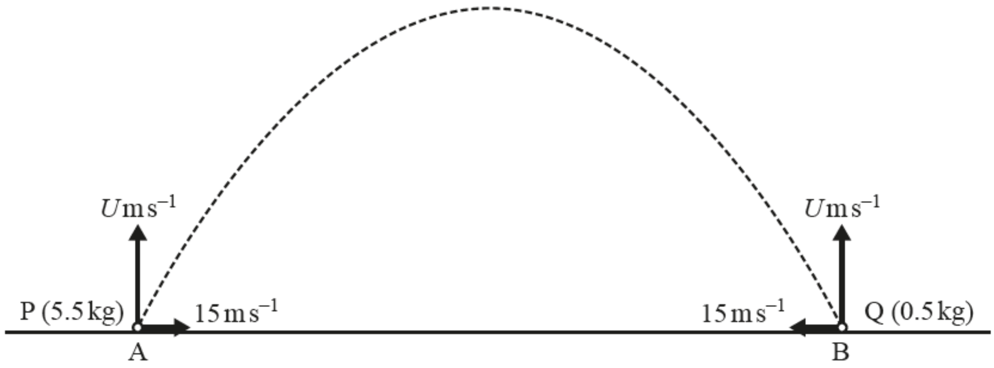

Fig. 1

Air resistance should be neglected.

The particles are projected at the same time and collide 2.5 s after projection when each is at the top of its trajectory.

(i) Find the value of U. **[2]**

The context of this question on collisions involved two projectiles. Some candidates struggled to apply their knowledge in this unfamiliar scenario. This first part was a simple application of the use of a *suvat* equation for the vertical motion of one of the particles to its greatest height.

Question 1 (ii)

(ii) Show that, immediately after the particles collide, they separate at $30e\,\mathrm{m\,s^{-1}}$, where e is the coefficient of restitution in the collision. **[2]**

In a 'show that' request, candidates need to show sufficient working to convince the examiner of their understanding. Here, it was essential to include 15 + 15 in the use of Newton's experimental law, to justify the 30 in the given result.

Question 1 (iii)

When the particles hit the ground they are 45 m apart.

(iii) Deduce that $e = 0.6$.

Find the velocities of P and of Q immediately after they collide. **[7]**

The majority of candidates omitted the request to deduce the value of *e* and instead assumed it. They were then on familiar territory with the application of conservation of momentum and Newton's experimental law. Finding *e* required use of the fact that the particles took 2.5 s to return to ground level, giving $30e = \frac{45}{2.5}$.

Inaccuracies in finding the velocities of P and Q were prevalent. There were many sign errors and inconsistencies between the momentum and restitution equations. Most of these could have been avoided if the candidate had drawn a diagram with the directions of the velocities clearly shown. There continues to be a reluctance by candidates to draw diagrams and it should be stressed that a clear diagram almost always helps in solving a mechanics problem accurately.

Question 1 (iv)

(iv) Calculate the impulse that acts on Q in the collision. **[2]**

All candidates knew the definition of impulse as the change in momentum, but again, there were many sign errors resulting from unclear directions of the velocities. A minority of candidates found the impulse of P and then related it to the impulse on Q.

Question 1 (v)

(v) What is the displacement of Q from B when Q reaches the ground? **[2]**

Few candidates scored full marks in this part. The common error was to find the distance of Q from B, and not the displacement.

Question 1 (vi)

When particle P reaches the ground it bounces with a coefficient of restitution of $\frac{2}{7}$.

(vi) At what angle to the horizontal does P leave the ground? **[4]**

Many candidates were able to make an attempt at this part, although by this stage many of their numbers were inaccurate. They knew that the horizontal component of the velocity was unchanged and that the vertical component was reduced by a factor $\frac{2}{7}$. Some candidates quoted the formula $\tan\alpha = e\tan b$, but they rarely made any credit-worthy progress.

Question 2 (i)

2 A particle is pulled along a smooth horizontal floor by a force of magnitude 35 N inclined at a constant angle α to the horizontal, as shown in Fig. 2.1. The force acts in a fixed vertical plane.

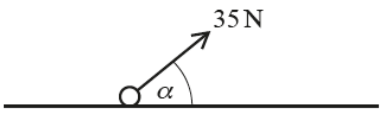

Fig. 2.1

144 J of work is done by the force on the particle as it slides through 5 m from A to B.

(i) Calculate the value of α. **[3]**

Question 2 (ii)

The mass of the particle is 6 kg and it has a speed of $4\,\text{m}\,\text{s}^{-1}$ at A.

(ii) Using an energy method, calculate the speed of the particle at B. Calculate the power of the pulling force at this point. **[5]**

Most candidates equated the change in the kinetic energy of the particle to the work done by the force and successfully obtained the speed at B. A minority of candidates did not follow the instruction to 'use an energy method' and were not credited marks. A common error in finding the power of the pulling force was to use 35 N rather than the resolved part of 35 N along the direction of motion.

Question 2 (iii)

In a new situation, shown in Fig. 2.2, the particle of mass 6 kg can move on a rough plane surface inclined at 50° to the horizontal.

At all times in parts **(iii)** and **(iv)**, a force of magnitude 35 N acts on the particle; this force is inclined at 30° to a line of greatest slope of the surface.

The coefficient of friction between the particle and the surface is μ.

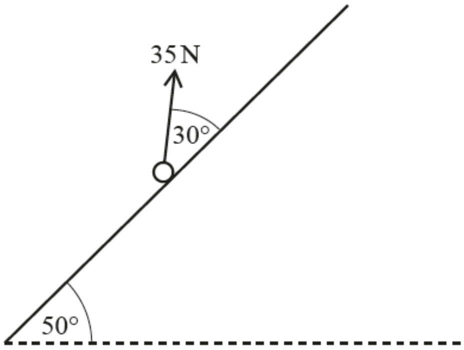

Fig. 2.2

(iii) The particle is placed on the surface and does not slide downwards.

Find the possible values of μ. **[6]**

The majority of candidates knew what they needed to do to answer this part, but there were several common errors. Many candidates omitted the component of the pulling force from the normal reaction. Others had friction acting in the wrong direction and then conveniently lost minus signs so that their value of the coefficient of friction μ was positive. There were also the usual resolution errors, with sine and cosine confusion. Unusually, there was a lot of premature rounding in this part, and the critical value of 0.726 (0.73) was incorrect.

Almost all candidates realised that they needed to give an inequality as their final answer, but all possible variations were seen. Only a few candidates worked through the question with the inequality $F \le \mu R$. Most opted to work with equality and then seemingly hope for the best as they inserted an inequality.

Some candidates colluded with the misconception that the coefficient of friction has to be less than one, and added this to their solution.

Question 2 (iv)

The surface is now treated so that μ becomes 0.6 and the particle is placed on it.

(iv) Using an energy method, determine how far down the surface the particle has slid when it reaches a speed of $1.5\,\mathrm{m\,s^{-1}}$. **[4]**

Most candidates made a good attempt at this part, but a significant number did not achieve the correct final answer. As in part (iii), there were sign errors, resolution errors and omission of the effect of one of the forces in the work-energy equation.

Question 3 (a) (i)

3 (a)

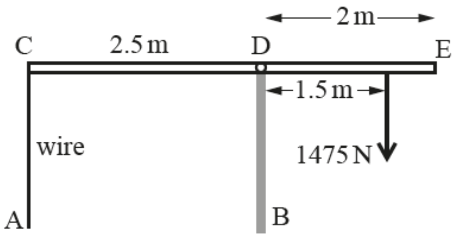

Fig. 3.1

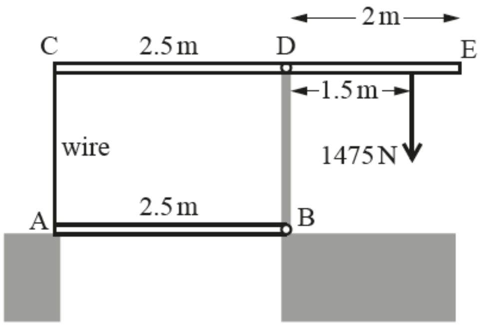

Fig. 3.2

Fig. 3.1 shows a uniform horizontal beam, CE, with weight 4000 N and length 4.5 m. BD is a rigid vertical support and the beam is freely pivoted at D, where CD is 2.5 m. The beam has a vertical load of 1475 N acting at a point that is 1.5 m from D. A vertical, light, inextensible wire is attached to the beam at C and held at A.

The beam is in equilibrium.

(i) Calculate the tension in the wire AC. **[3]**

Question 3 (a) (ii)

This beam is part of a simple lift bridge which is shown in its 'down' position in Fig. 3.2. The uniform lower beam, AB, has a weight of 1000 N and length 2.5 m. AB is freely pivoted at B, attached to the wire CA and also rests on a support at A. ABDC is a rectangle.

The bridge is in equilibrium.

(ii) Calculate the normal reaction on the beam AB of its support at A. **[4]**

The normal reaction on the beam AB of its support at A is most easily found by taking moments about B for the rod AB. The only other forces involved are then the weight of AB and the tension in AC found in part (i). A significant number of candidates opted to take moments about B (and sometimes D) for the whole system. Almost invariably, the tension in the wire AC was included, even though when the whole system is considered, the effects of the tension at A and C cancel each other out.

Question 3 (b) (i)

(b) In this part of the question you may leave your answers in surd form.

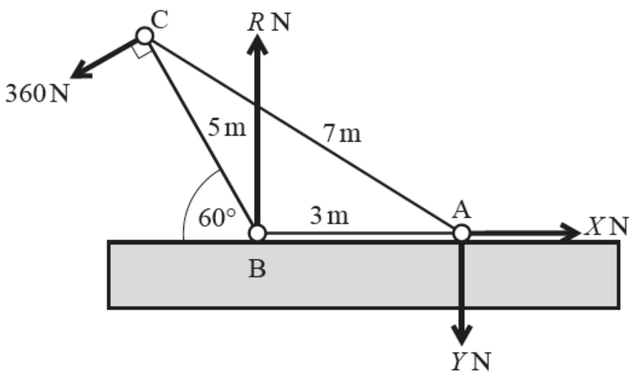

Fig. 3.3

Fig. 3.3 shows a framework in equilibrium in a vertical plane. The framework is made from three light rigid rods AB, AC and BC, of lengths 3 m, 7 m and 5 m respectively. AB is horizontal and BC is at 60° to the horizontal.

The rods are freely pin-jointed to each other at A, B and C. The pin-joint at A is fixed to a smooth horizontal floor and the pin-joint at B rests on this floor.

The figure also shows the external forces acting on the framework: there is a force of 360 N at C acting perpendicular to BC; the normal reaction of the floor on the pin-joint at B is R N; horizontal and vertical forces X N and Y N act on the framework from the pin-joint at A.

(i) Calculate the values of X and Y. Show that $R = 780$. **[4]**

This part is most easily solved by taking moments about B to find Y and then resolving horizontally to find X and vertically to find R. A significant number of candidates decided to take moments about A and then struggled to find the moment of the 360 N force.

Question 3 (b) (ii)

(ii) Calculate the forces internal to the three rods, stating whether each rod is in tension or in compression (thrust). [You may use without proof that $\sin\alpha = \frac{5\sqrt{3}}{14}$, where α = angle BAC] **[8]**

Many candidates gave clear and concise solutions to this part.

Question 4 (i)

4 The object shown in Fig. 4.1 is cut from a flat sheet of thin uniform rigid metal. OCFJ, OABC, CDEF, FHIJ and JKLO are rectangles with dimensions, in centimetres, shown in the figure.

(i) Calculate the coordinates of the centre of mass of the object referred to the axes shown in Fig. 4.1. **[4]**

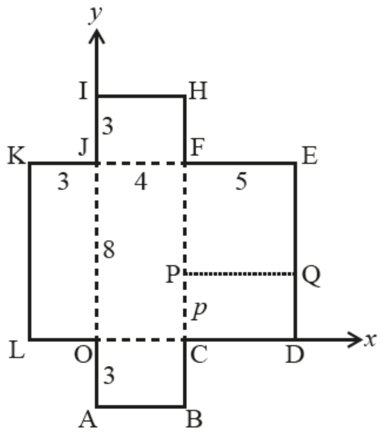

Fig. 4.1

Candidates are well-drilled in finding centres of mass of composite bodies and they work methodically through the procedure. In this question, they could have invoked the use of symmetry and reduced the number of calculations: $\overline{y} = 4$.

Question 4 (ii)

Fig. 4.2 shows the object folded as follows: rectangle FHIJ is folded along FJ and rectangle JKLO along JO so that the edges JI and JK come together; rectangle OABC is folded along OC so that it is perpendicular to OCFJ and on the other side of OCFJ to FHIJ and JKLO.

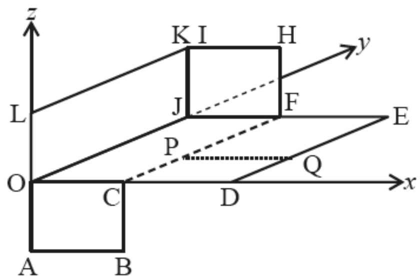

Fig. 4.2

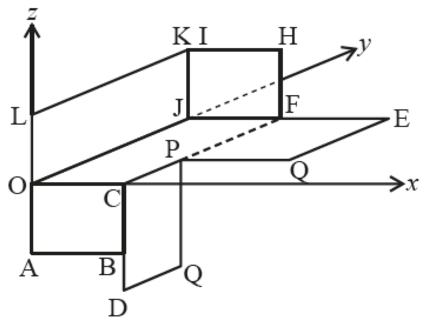

Fig. 4.3

(ii) Show that, referred to the axes shown in Fig. 4.2, the x-coordinate of the centre of mass of the folded object is 3.1. **[3]**

Again, candidates applied their tried-and-tested routine method and most worked accurately to gain full marks.

Question 4 (iii)

Rectangle CDEF is now cut along the line PQ which is perpendicular to CF. The distance CP is p cm. Rectangle CDQP is folded along CP so that part of CD is in contact with CB, as shown in Fig. 4.3. Referred to the axes shown in Fig. 4.3, the centre of mass of the folded object is at the point G with coordinates $(\bar{x}, \bar{y}, \bar{z})$.

(iii) Given that $\bar{z} = 0$, show that $p = 2.88$ and calculate $\bar{x}$ and $\bar{y}$. **[5]**

There were few problems beyond arithmetical errors in this part.

Question 4 (iv)

The folded object in Fig. 4.3 is now freely suspended from the point L and hangs in equilibrium.

(iv) Calculate the angle between OG and the vertical. **[4]**

This part required a little thought to determine which triangle to use. A significant number of candidates used their 'formula' $\tan\theta = \frac{\bar{x}}{\bar{y}}$ without stopping to consider the geometry and trigonometry of the situation.

Those candidates who drew a diagram usually identified the correct angle as $\angle$OGL and then proceeded to calculate it successfully.

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AS & Advanced GCE Mathematics

				Max Mark	a	b	c	d	e	u
4721	01	C1 Core mathematics 1 (AS)	Raw	72	61	55	50	45	40	0
			UMS	100	80	70	60	50	40	0
4722	01	C2 Core mathematics 2 (AS)	Raw	72	55	49	43	37	31	0
			UMS	100	80	70	60	50	40	0
4723	01	C3 Core mathematics 3 (A2)	Raw	72	55	48	41	34	28	0
			UMS	100	80	70	60	50	40	0
4724	01	C4 Core mathematics 4 (A2)	Raw	72	54	47	40	34	28	0
			UMS	100	80	70	60	50	40	0
4725	01	FP1 Further pure mathematics 1 (AS)	Raw	72	56	50	45	40	35	0
			UMS	100	80	70	60	50	40	0
4726	01	FP2 Further pure mathematics 2 (A2)	Raw	72	59	53	47	41	35	0
			UMS	100	80	70	60	50	40	0
4727	01	FP3 Further pure mathematics 3 (A2)	Raw	72	47	41	36	31	26	0
			UMS	100	80	70	60	50	40	0
4728	01	M1 Mechanics 1 (AS)	Raw	72	60	51	42	34	26	0
			UMS	100	80	70	60	50	40	0
4729	01	M2 Mechanics 2 (A2)	Raw	72	53	46	39	32	26	0
			UMS	100	80	70	60	50	40	0
4730	01	M3 Mechanics 3 (A2)	Raw	72	50	42	34	27	20	0
			UMS	100	80	70	60	50	40	0
4731	01	M4 Mechanics 4 (A2)	Raw	72	59	53	47	42	37	0
			UMS	100	80	70	60	50	40	0
4732	01	S1 – Probability and statistics 1 (AS)	Raw	72	57	50	43	36	29	0
			UMS	100	80	70	60	50	40	0
4733	01	S2 – Probability and statistics 2 (A2)	Raw	72	56	49	42	35	28	0
			UMS	100	80	70	60	50	40	0
4734	01	S3 – Probability and statistics 3 (A2)	Raw	72	59	50	41	32	24	0
			UMS	100	80	70	60	50	40	0
4735	01	S4 – Probability and statistics 4 (A2)	Raw	72	56	49	42	35	28	0
			UMS	100	80	70	60	50	40	0
4736	01	D1 – Decision mathematics 1 (AS)	Raw	72	55	48	42	36	30	0
			UMS	100	80	70	60	50	40	0
4737	01	D2 – Decision mathematics 2 (A2)	Raw	72	58	53	48	44	40	0
			UMS	100	80	70	60	50	40	0

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AS & Advanced GCE Mathematics (MEI)

				Max Mark	a	b	c	d	e	u
4751	01	C1 – Introduction to advanced mathematics (AS)	Raw	72	60	55	50	45	40	0
			UMS	100	80	70	60	50	40	0
4752	01	C2 – Concepts for advanced mathematics (AS)	Raw	72	53	47	41	36	31	0
			UMS	100	80	70	60	50	40	0
4753	01	(C3) Methods for Advanced Mathematics (A2): Written Paper	Raw	72	61	56	51	46	40	0
4753	02	(C3) Methods for Advanced Mathematics (A2): Coursework	Raw	18	15	13	11	9	8	0
4753	82	(C3) Methods for Advanced Mathematics (A2): Carried Forward Coursework Mark	Raw	18	15	13	11	9	8	0
			UMS	100	80	70	60	50	40	0
4754	01	C4 – Applications of advanced mathematics (A2)	Raw	90	63	56	49	43	37	0
			UMS	100	80	70	60	50	40	0
4755	01	FP1 – Further concepts for advanced mathematics (AS)	Raw	72	55	51	47	43	40	0
			UMS	100	80	70	60	50	40	0
4756	01	FP2 – Further methods for advanced mathematics (A2)	Raw	72	48	42	36	31	26	0
			UMS	100	80	70	60	50	40	0
4757	01	FP3 – Further applications of advanced mathematics (A2)	Raw	72	63	56	49	42	35	0
			UMS	100	80	70	60	50	40	0
4758	01	(DE) Differential Equations (A2): Written Paper	Raw	72	61	54	48	42	35	0
4758	02	(DE) Differential Equations (A2): Coursework	Raw	18	15	13	11	9	8	0
4758	82	(DE) Differential Equations (A2): Carried Forward Coursework Mark	Raw	18	15	13	11	9	8	0
			UMS	100	80	70	60	50	40	0
4761	01	M1 – Mechanics 1 (AS)	Raw	72	51	44	37	31	25	0
			UMS	100	80	70	60	50	40	0
4762	01	M2 – Mechanics 2 (A2)	Raw	72	59	53	47	41	35	0
			UMS	100	80	70	60	50	40	0
4763	01	M3 – Mechanics 3 (A2)	Raw	72	61	54	48	42	36	0
			UMS	100	80	70	60	50	40	0
4764	01	M4 – Mechanics 4 (A2)	Raw	72	59	51	44	37	30	0
			UMS	100	80	70	60	50	40	0
4766	01	S1 – Statistics 1 (AS)	Raw	72	59	53	47	42	37	0
			UMS	100	80	70	60	50	40	0
4767	01	S2 – Statistics 2 (A2)	Raw	72	54	47	41	35	29	0
			UMS	100	80	70	60	50	40	0
4768	01	S3 – Statistics 3 (A2)	Raw	72	61	54	47	41	35	0
			UMS	100	80	70	60	50	40	0
4769	01	S4 – Statistics 4 (A2)	Raw	72	56	49	42	35	28	0
			UMS	100	80	70	60	50	40	0
4771	01	D1 – Decision mathematics 1 (AS)	Raw	72	50	44	38	32	26	0
			UMS	100	80	70	60	50	40	0
4772	01	D2 – Decision mathematics 2 (A2)	Raw	72	55	51	47	43	39	0
			UMS	100	80	70	60	50	40	0
4773	01	DC – Decision mathematics computation (A2)	Raw	72	46	40	34	29	24	0
			UMS	100	80	70	60	50	40	0
4776	01	(NM) Numerical Methods (AS): Written Paper	Raw	72	57	52	48	44	39	0
4776	02	(NM) Numerical Methods (AS): Coursework	Raw	18	14	12	10	8	7	0
4776	82	(NM) Numerical Methods (AS): Carried Forward Coursework Mark	Raw	18	14	12	10	8	7	0
			UMS	100	80	70	60	50	40	0
4777	01	NC – Numerical computation (A2)	Raw	72	55	47	39	32	25	0
			UMS	100	80	70	60	50	40	0
4798	01	FPT - Further pure mathematics with technology (A2)	Raw	72	57	49	41	33	26	0
			UMS	100	80	70	60	50	40	0

AS GCE Statistics (MEI)

				Max Mark	a	b	c	d	e	u
G241	01	Statistics 1 MEI	Raw	72		No entry in June 2018				
			UMS	100	80	70	60	50	40	0
G242	01	Statistics 2 MEI	Raw	72		No entry in June 2018				
			UMS	100	80	70	60	50	40	0
G243	01	Statistics 3 MEI	Raw	72		No entry in June 2018				
			UMS	100	80	70	60	50	40	0

AS GCE Quantitative Methods (MEI)

				Max Mark	a	b	c	d	e	u
G244	01	Introduction to Quantitative Methods (Written Paper)	Raw	72	58	50	43	36	28	0
G244	02	Introduction to Quantitative Methods (Coursework)	Raw	18	14	12	10	8	7	0
			UMS	100	80	70	60	50	40	0
G245	01	Statistics 1	Raw	72	61	55	49	43	37	0
			UMS	100	80	70	60	50	40	0
G246	01	Decision Mathematics 1	Raw	72	50	44	38	32	26	0
			UMS	100	80	70	60	50	40	0

Level 3 Certificate, Level 3 Extended Project and FSMQ raw mark grade boundaries June 2018 series

For more information about results and grade calculations, see https://www.ocr.org.uk/students/getting-your-results/

Level 3 Certificate Mathematics - Quantitative Methods (MEI)

					Max Mark	a	b	c	d	e	u
G244	A	01	Introduction to Quantitative Methods with Coursework (Written Paper)	Raw	72	58	50	43	36	28	0
G244	A	02	Introduction to Quantitative Methods with Coursework (Coursework)	Raw	18	14	12	10	8	7	0
				UMS	100	80	70	60	50	40	0
				Overall	90	72	62	53	44	35	0

Level 3 Certificate Mathematics - Quantitative Reasoning (MEI)

				Max Mark	a	b	c	d	e	u
H866	01	Introduction to quantitative reasoning	Raw	72	56	49	42	35	28	0
H866	02	Critical maths	Raw	60	44	39	34	29	24	0
		*To create the overall boundaries, component 02 is weighted to give marks out of 72	Overall	144	109	96	83	70	57	0

Level 3 Certificate Mathematics - Quantitative Problem Solving (MEI)

				Max Mark	a	b	c	d	e	u
H867	01	Introduction to quantitative reasoning	Raw	72	56	49	42	35	28	0
H867	02	Statistical problem solving	Raw	60	40	36	32	28	24	0
		*To create the overall boundaries, component 02 is weighted to give marks out of 72	Overall	144	104	92	80	69	57	0

Advanced Free Standing Mathematics Qualification (FSMQ)

				Max Mark	a	b	c	d	e	u
6993	01	Additional Mathematics	Raw	100	56	50	44	38	33	0

Intermediate Free Standing Mathematics Qualification (FSMQ)

				Max Mark	a	b	c	d	e	u
6989	01	Foundations of Advanced Mathematics (MEI)	Raw	40	35	30	25	20	16	0