OCR
Oxford Cambridge and RSA

AS Level Further Mathematics B (MEI)

Y415 Mechanics b

Sample Question Paper

UPDATED August 2022

Please note that Y415 Mechanics b has now been withdrawn from AS Level Further Mathematics B (MEI) and will no longer be assessed. The final assessment opportunity for this unit was June 2022.

For further information please see the Subject Update here.

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AS Level Further Mathematics B (MEI)

Y415 Mechanics b

Sample Question Paper Version 3

Date – Morning/Afternoon

Time allowed: 1 hour 15 minutes

You must have:
- Printed Answer Booklet
- Formulae Further Mathematics B (MEI)

You may use:
- a scientific or graphical calculator

INSTRUCTIONS
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Complete the boxes provided on the Printed Answer Booklet with your name, centre number and candidate number.
- Answer **all** the questions.
- **Write your answer to each question in the space provided in the Printed Answer Booklet.** Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.
- 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
- The total number of marks for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- 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 used. You should communicate your method with correct reasoning.
- The Printed Answer Booklet consists of **12** pages. The Question Paper consists of **8** pages.

Answer **all** the questions.

1 A particle, P, has velocity v m s^{-1} at time t seconds given by $\mathbf{v} = \begin{pmatrix} 6(t^2 - 3t + 2) \\ 2(1-t) \\ 3(t^2 - 1) \end{pmatrix}$, where $0 \leq t \leq 3$.

(i) Show that there is just one time at which P is instantaneously at rest and state this value of t. **[3]**

P has a mass of 5 kg and is acted on by a single force **F** N.

(ii) Find **F** when $t = 2$. **[4]**

(iii) Find an expression for the position, **r** m, of P at time t s, given that $\mathbf{r} = \begin{pmatrix} -5 \\ 2 \\ 6 \end{pmatrix}$ when $t = 0$. **[5]**

2 A smooth wire is bent to form a circle of radius 2.5 m; the circle is in a horizontal plane. A small ring of mass 0.2 kg is travelling round the wire.

(i) At one instant the ring is travelling at an angular speed of 120 revolutions per minute.

(*A*) Calculate the angular speed in radians per second. **[1]**

(*B*) Calculate the component towards the centre of the circle of the force exerted on the ring by the wire. **[4]**

(ii) Why must the contact between the wire and the ring be smooth if your answer to part **(i)** (*B*) is also the total horizontal component of the force exerted on the ring by the wire? **[1]**

3 A young woman wishes to make a bungee jump. One end of an elastic rope is attached to her safety harness. The other end is attached to the bridge from which she will jump.

She calculates that the stretched length of the rope at the bottom of her motion should be 20 m, she knows that her weight is 576 N and the stiffness of the elastic rope is $90\,\text{N}\,\text{m}^{-1}$. She has to calculate the unstretched length of rope required to perform the jump safely.

She models the situation by assuming the following.

- The rope is of negligible mass.
- Air resistance may be neglected.
- She is a particle.
- She moves vertically downwards from rest.
- Her starting point is level with the fixed end of the rope.
- The length she calculates for the rope does not include any extra for attaching the ends.

(i) (*A*) Show that the greatest extension of the rope, *X*, satisfies the equation $X^2 = 256$. **[3]**

(*B*) Hence determine the natural length of rope she needs. **[2]**

(ii) To remain safe she wishes to be sure that, if air resistance is taken into account, the stretched length of the rope of natural length determined in part **(i)** will not be more than 20 m. Advise her on this point. **[1]**

4 Two uniform circular discs with the same radius, A of mass 1 kg and B of mass 5.25 kg, slide on a smooth horizontal surface and collide obliquely with smooth contact.

Fig. 4 gives information about the velocities of the discs just before and just after the collision.

- The line XY passes through the centres of the discs at the moment of collision
- The components parallel and perpendicular to XY of the velocities of A are shown
- Before the collision, B is at rest and after it is moving at $2\,\text{m}\,\text{s}^{-1}$ in the direction XY

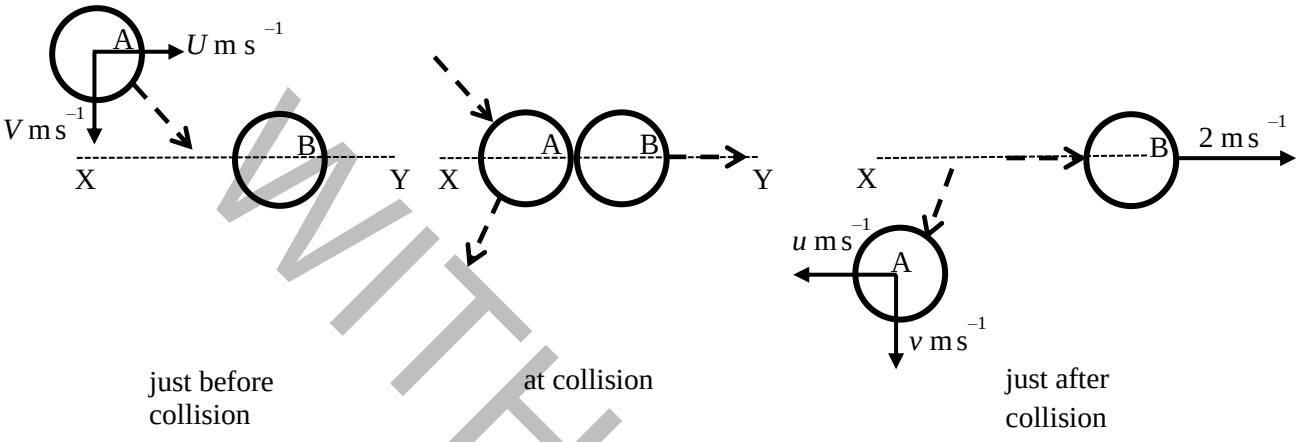

Fig. 4

The coefficient of restitution between the two discs is $\frac{2}{3}$.

(i) Find the values of U and u. **[5]**

(ii) What information in the question tells you that $v = V$? **[1]**

The speed of disc A before the collision is $8.5\,\text{m}\,\text{s}^{-1}$.

(iii) Find the speed of disc A after the collision. **[2]**

5

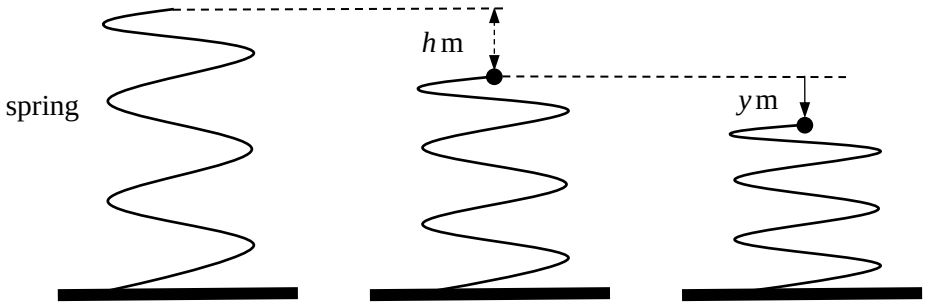

Fig. 5.1 **Fig. 5.2** **Fig. 5.3**

Fig. 5.1 shows a vertical light elastic spring. It is fixed to a horizontal table at one end. Fig 5.2 shows the spring with a particle of mass m kg attached to it at the other end. The system is in equilibrium when the spring is compressed by a distance h m.

(i) Find an expression for the stiffness of the spring, k N m^{-1}, in terms of m, h and g. **[1]**

The particle is pushed down a further distance from the equilibrium position and released from rest. At time t seconds, the displacement of the particle from the equilibrium position of the system is y m in the downward direction, as shown in Fig. 5.3. You are given that $|y| \leq h$.

(ii) Show that the motion of the particle is modelled by the differential equation $\frac{\mathrm{d}^2y}{\mathrm{d}t^2} + \frac{gy}{h} = 0$. **[4]**

(iii) Find an expression for the period of the motion of the particle. **[1]**

(iv) Would the model for the motion of the particle be valid for large values of m? Justify your answer. **[1]**

6 **In this question you must show detailed reasoning.**

As shown in Fig. 6.1, the region R is bounded by the lines $x = 1$, $x = 2$, $y = 0$ and the curve $y = 2x^2$ for $1 \leq x \leq 2$. A uniform solid of revolution, S, is formed when R is rotated through 360° about the x-axis.

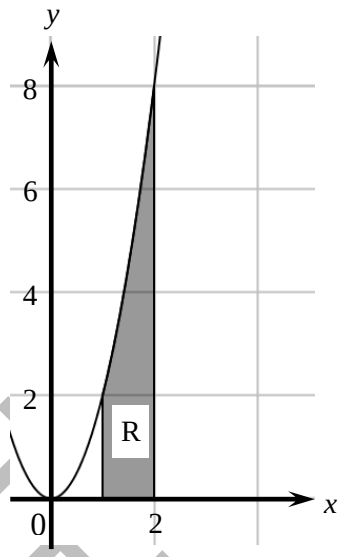

Fig. 6.1

(i) Show that the volume of S is $\frac{124\pi}{5}$. **[3]**

(ii) Show that the distance of the centre of mass of S from the centre of its smaller circular plane surface is $\frac{43}{62}$. **[5]**

Fig. 6.2 shows S placed so that its smaller circular plane surface is in contact with a slope inclined at $\alpha°$ to the horizontal. S does not slip but is on the point of tipping.

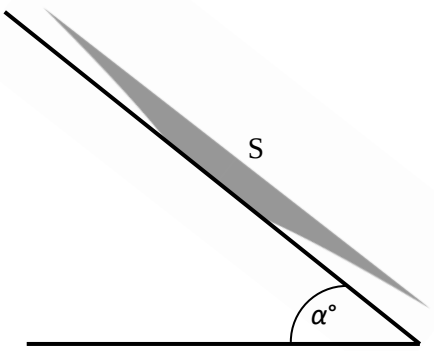

Fig. 6.2

(iii) Find the value of α, giving your answer in degrees correct to 3 significant figures. **[4]**

7 A plane is inclined at 30° above the horizontal. A particle is projected up the plane from a point C on the plane with a velocity of $14\,\text{m}\,\text{s}^{-1}$ at 40° above a line of greatest slope of the plane. The particle hits the plane at D. See Fig. 7.

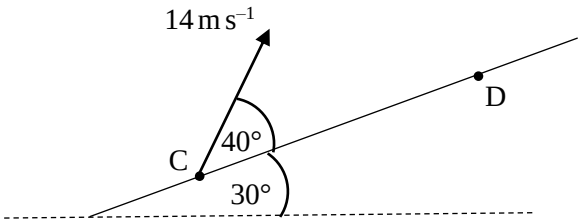

Fig. 7

(i) Using the standard model for projectile motion, show that the time of flight, T, is given by $T = \dfrac{28\sin 40°}{g\cos 30°}$. **[5]**

(ii) Calculate the distance CD. **[4]**

END OF QUESTION PAPER

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…day June 20XX – Morning/Afternoon

AS Level Further Mathematics B (MEI)

Y415 Mechanics b

SAMPLE MARK SCHEME

Duration: 1 hour 15 minutes

MAXIMUM MARK 60

This document consists of 16 pages

Text Instructions

1. **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 a result or establishing a given result
U1	Mark for correct units
G1	Mark for a correct feature on a graph
dep*	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
AG	Answer given
awrt	Anything which rounds to
BC	By Calculator
DR	This indicates that the instruction **In this question you must show detailed reasoning** appears in the question.

2. Subject-specific Marking Instructions for AS Level Further Mathematics B (MEI)

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, escalate the question to your Team Leader who will decide on a course of action with the Principal Examiner.
If you are in any doubt whatsoever 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, e.g. 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, e.g. 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, what is acceptable will be detailed in the mark scheme. If this is not the case please, escalate the question to your Team Leader who will decide on a course of action with the Principal Examiner.
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; over-specification is usually only penalised where the scheme explicitly says so. 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. Follow through should be used so that only one mark is lost for each distinct accuracy error, except for errors due to premature approximation which should be penalised only once in the examination. 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 papers. 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.

k Anything in the mark scheme which is in square brackets […] is not required for the mark to be earned on this occasion, but shows what a complete solution might look like

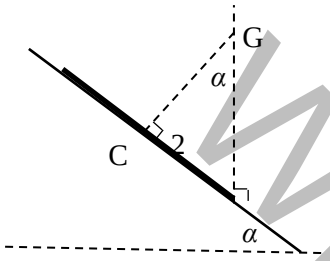
Question			Answer	Marks	AOs	Guidance	
1	(i)		All 3 components zero at same time	M1	1.1a	This may be implied	
			The only possible time is $t = 1$ (from **j** cpt)	A1	1.1	This may be obtained by factorising **i** and **j** cpts	
			This gives **i** cpt 0 and **k** cpt 0. So $t = 1$ is the only time.	E1 [3]	2.1	Complete argument	**SC1** for $t = 1$ www.
1	(ii)		$\mathrm{a} = \frac{\mathrm{d}v}{\mathrm{d}t}$	M1	1.2	Differentiate w.r.t. t to find **a**	
			$\mathbf{a} = \begin{pmatrix} 12t-18 \\ -2 \\ 6t \end{pmatrix}$ so $\mathbf{a}(2) = \begin{pmatrix} 6 \\ -2 \\ 12 \end{pmatrix}$	A1	1.1a	cao	
			Using $\mathbf{F} = m\mathbf{a}$ $\quad \mathbf{F} = 5\begin{pmatrix} 6 \\ -2 \\ 12 \end{pmatrix}$	M1 A1 [3]	1.1 1.1	Use of $\mathbf{F} = m\mathbf{a}$ All correct Accept any format. cao	
1	(iii)		$\mathbf{r}(t) = \begin{pmatrix} 2t^3 - 9t^2 + 12t + C \\ 2t - t^2 + D \\ t^3 - 3t + E \end{pmatrix}$	M1 A1	1.1a 1.1	Attempt at integration $\leq$ 2 errors. Accept no arb constants	
			Use $\mathbf{r}(0) = \begin{pmatrix} -5 \\ 2 \\ 6 \end{pmatrix}$	M1	1.1	At least one equation attempted	
			$C = -5, D = 2, E = 6$ $\quad \mathbf{r}(t) = \begin{pmatrix} 2t^3 - 9t^2 + 12t - 5 \\ 2t - t^2 + 2 \\ t^3 - 3t + 6 \end{pmatrix}$	A1 A1 [4]	1.1 1.1	2 correct All correct. Full expression given.	

Question			Answer	Marks	AOs	Guidance	
2	(i)	(*A*)	120 rev min $^{-1}$ gives $\omega = 120 \times 2 \times \pi \times \frac{1}{60} = 4\pi$ rad s $^{-1}$ (12.566…)	B1 [1]	1.1		
2	(i)	(*B*)	Accn towards centre so $2.5 \times (4\pi)^2 = 40\pi^2$ m s $^{-2}$ (394.78…) Using N2L Radial force is $0.2 \times 40\pi^2 = 8\pi^2$ N (78.95…) [towards the centre]	M1 A1 M1 A1 [4]	1.1a 1.1 3.4 1.1	Use $(m)r\omega^2$ (m not required) May be implied Use of N2L cao	
2	(ii)		Otherwise there would be a tangential (transverse) force as well as the central force	E1 [1]	3.5b		
3	(i)	(*A*)	$20 \times 576 = \frac{1}{2} \times 90X^2$ $X^2 = \frac{2 \times 20 \times 576}{90}$ $X^2 = 256$ AG	M1 A1 E1 [3]	3.1b 1.1 1.1	Equating GPE lost to EPE gained For one side correct All correct and convincing working	
3	(i)	(*B*)	Natural length required is $20 - X$ = 4 m.	M1 A1 [2]	1.1 3.2a	For $20 - X$ For this mark answer must refer to natural length	
3	(ii)		The EPE term would be less than the GPE term because of the air resistance. This would mean that when natural length is 4 m, the stretched length would be less than 20 [so she would be safe].	E1 [1]	3.2b		

Question			Answer	Marks	AOs	Guidance	
4	(i)		AB → PCLM $U + 0 = -u + 2\times5.25$ so $U = -u + 10.5$ NEL $\frac{2-(-u)}{0-U} = -\frac{2}{3}$ so $6 + 3u = 2U$ Solving $u = 3$, $U = 7.5$	**M1** **A1** **M1** **A1** **A1** **[5]**	**3.4** **1.1** **3.4** **1.1** **1.1**	 Any form Must be right way up. Accept sign errors. Any form BC	
4	(ii)		Contact is smooth	**B1** **[1]**	**3.3**		
4	(iii)		For disc A, initial speed of 8.5 m s^{-1} gives $V = \sqrt{8.5^2 - 7.5^2} = 4$ m s^{-1} final speed is $\sqrt{(-3)^2 + 4^2} = 5$ m s^{-1}	**M1** **A1** **[2]**	**3.1b** **1.1**	FT their U and u	
5	(i)		Using HL $mg = kh$ so $k = \frac{mg}{h}$	**B1** **[1]**	**3.4**		
5	(ii)		N2L ↓ $mg - \frac{mg}{h}(h + y) = m\ddot{y}$ so $g - \frac{g}{h}\times h - \frac{g}{h}\times y = \ddot{y}$ and $\ddot{y} + \frac{g}{h}y = 0$ AG	**M1** **B1** **A1** **A1** **[4]**	**3.4** **3.3** **1.1** **1.1**	Using N2L with HL Use of $h + y$ All correct Some working seen.	

Question			Answer	Marks	AOs	Guidance	
5	(iii)		Period is $2\pi\sqrt{\frac{h}{g}}$	B1 [1]	2.2a	oe	
5	(iv)		No. Too large *m* would lead to spring being too compressed.	E1 [1]	3.5a		
6	(i)		DR $V = \pi\int_1^2 \left(2x^2\right)^2 \mathrm{d}x$ $= \pi\int_1^2 \left(4x^4\right) \mathrm{d}x = \pi\left[\frac{4}{5}x^5\right]_1^2$ $\frac{4}{5}\pi(32-1)$ $= \frac{124\pi}{5}$ AG	 M1 A1 A1 [3]	 1.1a 1.1 1.1	Allow use of surface density = 1 without comment At least 2 terms correct. Allow no limits.	

Question			Answer	Marks	AOs	Guidance	
6	(ii)		$V\bar{x} = \pi\int_1^2 x\left(2x^2\right)^2 \mathrm{d}x$	M1	3.1b	Limits not required	
			$= \pi\int_1^2 \left(4x^5\right) \mathrm{d}x = \pi\left[\frac{2x^6}{3}\right]_1^2$	A1	1.1	At least 2 terms correct. Allow no limits.	
			$= 42\pi$	A1	1.1	Any form	
			Need $\bar{x} - 1 = \frac{42\pi}{\left(\frac{124\pi}{5}\right)} - 1$	M1	2.2a	Must involve expression with their $\bar{x}$	
			$= \frac{210}{124} - 1$	E1	2.1	Clearly established	
			$\frac{43}{62}$ AG				
				[5]			

Question			Answer	Marks	AOs	Guidance	
6	(iii)		DR  C is the centre of the base of S and G its CoM Radius of the base is 2 G is vertically above a point on the circumference of the base of S $\tan\alpha = \frac{2}{CG}$ where CG is $\frac{43}{62}$ from **(i)** so angle is 70.87477… so 70.9° (to 3 s. f.)	**B1** **B1** **M1** **A1** **[4]**	**3.1b** **2.2a** **1.1** **1.1**	May be implicit e.g. from obtaining the correct angle	

Question			Answer	Marks	AOs	Guidance	
7	(i)		Take x and y horiz and vert; take X and Y parallel and perp to slope				
			Method 1				
			$\ddot{Y} = -g\cos 30$ (and $\ddot{X} = -g\sin 30$)	**B1**	**1.1a**	$\ddot{X}$ not needed here	
			In Y direction				
			$Y = 14\sin 40t - \frac{1}{2}g\cos 30t^2$	**M1**	**3.4**	Must have correct signs and attempt to resolve g	
				A1	**1.1**	g need not be substituted until final ans	
			$Y = 0$ gives	**M1**	**1.1**	Must use Y not y.	
			$14\sin 40t = \frac{1}{2}g\cos 30t^2$				
			$T = \frac{28\sin 40}{g\cos 30}$ AG	**A1**	**2.2a**		
			Method 2				
			$x = 14\cos 70t$	**B1**			
			$y = 14\sin 70t - \frac{1}{2}gt^2$	**B1**			
			$y = x\tan 30$	**M1**		Including substitution	
			$14\sin 70T - \frac{1}{2}gT^2 = 14\cos 70T \times \tan 30$	**A1**		Substitution correct	
			so $T = \frac{28}{g}(\sin 70 - \cos 70\tan 30)$				
			$= \frac{28}{g\cos 30}\sin(70-30)$	**A1**			
			$T = \frac{28\sin 40}{g\cos 30}$ AG				
				[5]			

Question			Answer	Marks	AOs	Guidance	
7	(ii)		**Either** In time T, the particle travels a horizontal distance CQ and a distance				
			CD up the slope where $\text{CD} = \frac{\text{CQ}}{\cos 30}$	**M1**	**3.1b**	Complete method	
			$\text{CQ} = 14\cos 70T$	**B1**	**1.1**		
			so $\text{CD} = \frac{14\cos 70}{\cos 30} \times \frac{28\sin 40}{9.8\cos 30}$	**M1**	**1.1**	Or substitute numerical value for T (2.120649)	
			$= 11.725136\ldots$ so 11.7 m (to 3 s. f.)	**A1**	**1.1**	cao	
			or				
			Use $X = 14\cos 40T - \frac{1}{2} \times 9.8 \times \sin 30T^2$	**M1**		Must attempt to resolve g in X direction	
				A1			
			$= 14\cos 40 \times \frac{28\sin 40}{g\cos 30} - \frac{1}{2} \times 9.8 \times \sin 30\left(\frac{28\sin 40}{g\cos 30}\right)^2$	**M1**		Or substitute numerical value for T (2.120649)	
			so CD is 11.725136… so 11.7 m (to 3 s. f.)	**A1**		cao	
				[4]			

Question	AO1	AO2	AO3(PS)	AO3(M)	Total
1i	2	1	0	0	3
1ii	4	0	0	0	4
1iii	5	0	0	0	5
2i	4	0	0	1	5
2ii	0	0	0	1	1
3iA	2	0	1	0	3
3iB	1	0	1	0	2
3ii	0	0	1	0	1
4i	3	0	0	2	5
4ii	0	0	0	1	1
4iii	1	0	1	0	2
5i	0	0	0	1	1
5ii	2	0	0	2	4
5iii	0	1	0	0	1
5iv	0	0	0	1	1
6i	3	0	0	0	3
6ii	2	2	1	0	5
6iii	2	1	1	0	4
7i	3	1	0	1	5
7ii	3	0	1	0	4
Totals	37	6	7	10	60

Summary of Updates

Date	Version	Change
October 2019	2	Amendments to the front cover rubric instructions to candidates
August 2022	3	Unit Y415 WITHDRAWN FROM ASSESSMENT

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AS Level Further Mathematics B (MEI)

Y415 Mechanics b

Printed Answer Booklet Version 2

Date – Morning/Afternoon

Time allowed: 1 hour 15 minutes

You must have:
- Question Paper Y415 (inserted)
- Formulae Further Mathematics B (MEI)

You must have:
- a scientific or graphical calculator

First name	
Last name	
Centre number	
Candidate number	

INSTRUCTIONS
- The Question Paper will be found inside the Printed Answer Booklet.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Complete the boxes provided on the Printed Answer Booklet with your name, centre number and candidate number.
- Answer **all** the questions.
- **Write your answer to each question in the space provided in the Printed Answer Booklet.** Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.
- 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 m s^{-2}. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.

INFORMATION
- 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 used. You should communicate your method with correct reasoning.
- The Printed Answer Booklet consists of **12** pages. The Question Paper consists of **8** pages.

1 (i)	
1 (ii)	

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1 (iii)

2 (i)(*A*)	
2 (i)(*B*)	
2 (ii)	

3 (i) (*A*)

3 (i) (*B*)

3 (ii)

4 (i)

4 (ii)

4 (iii)

5 (i)

5 (ii)

(answer space continued on next page)

5 (ii)	**(continued)**
5 (iii)	
5 (iv)	

6 (i)	
6 (ii)	

6 (iii)

7 (i)

(answer space continued on next page)

7 (i) **(continued)**

7 (ii)

PLEASE DO NOT WRITE IN THIS SPACE