OCR
Oxford Cambridge and RSA

GCE

Mathematics B (MEI)

Unit **H640/01**: Pure Mathematics and Mechanics

Advanced GCE

Mark Scheme for June 2018

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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 a result or establishing a given result
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.

Subject-specific Marking Instructions for A Level 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 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	AOs		Guidance
1			**EITHER** $f(2)=3\times 2^3-8\times 2^2+3\times 2+2=24-32+6+2=0$ Therefore by the factor theorem $(x-2)$ is a factor	**M1** **A1** **E1** **[3]**	**1.1a** **1.1b** **2.2a**	**AG** Function notation need not be used Zero must be seen Reason required	
			OR $f(x)=(x-2)(3x^2-2x-1)$ No remainder so $(x-2)$ is a factor	**M1** **A1** **E1** **[3]**		Using algebraic division as far as $3x^2$ Correct quotient Reason required	
2			When $x=0$ $e^0-5\times 0^3=1>0$ When $x=1$ $e^1-5\times 1^3=e-5<0$ So [as the function is continuous and there is a change of sign] there is a root between 0 and 1	**M1** **E1** **[2]**	**1.1a** **2.2a**	Attempting to evaluate the function at both values Conclusion from correct values	
3			$(1+\tan^2\theta)+2\tan\theta=4$ $\tan^2\theta+2\tan\theta-3=0$ $(\tan\theta-1)(\tan\theta+3)=0$ When $\tan\theta=1,\ \theta=45°,\ 225°$ When $\tan\theta=-3,\ \theta=108.4°,\ 288.4°$	**M1** **M1** **A1** **A1** **[4]**	**3.1a** **1.1a** **1.1b** **1.1b**	**DR** Using appropriate trig identity Showing algebraic method for solving their quadratic Any two correct values for θ All correct values for θ and no extras in the interval. Ignore values outside the required interval.	Must attempt to reach an equation with only one trig function eg $20\cos^4\theta-12\cos^2\theta+1=0$ Or $\sqrt{5}\sin(2\theta-63.4°)=1$
4	(i)		$v^2=u^2+2as$ $1.2^2=2\times a\times 1.8$ $a=0.4\ \text{m s}^{-2}$	**M1** **A1** **[2]**	**3.3** **1.1b**	Using suitable suvat equation(s) leading to value for a	

Question			Answer	Marks	AOs		Guidance
	(ii)		$F-19=2.8a$ $F=20.12$ (20.1 N to 3sf)	**M1** **A1** **[2]**	**3.3** **1.1b**	Using Newton's second law. All terms present. Allow 20 N FT their *a*	
5	**(i)**		$\mathbf{v}=\frac{\mathrm{d}\mathbf{r}}{\mathrm{d}t}=(12-2\times 2t)\mathbf{i}+(2t-6)\mathbf{j}$	**M1** **A1** **[2]**	**1.1a** **2.5**	Attempt to differentiate at least one coefficient Must use vector notation	
	(ii)		When $t=3$ both components of velocity are zero, so the particle is stationary at $t=3$.	**M1** **E1** **[2]**	**3.1a** **2.2a**	Equating at least one component of their vector velocity to zero Must be argued from two zero components	Do not allow M1 for solving $12-4t=2t-6$ unless at least one zero subsequently established

Question			Answer	Marks	AOs		Guidance
6	(i)		Arithmetic sequence with $a=50,\ d=20$ $S_{24}=\frac{24}{2}\left(2\times 50+(24-1)20\right)$ = £6720	M1 A1 [2]	1.1a 1.1b	Using appropriate formula for sum of an arithmetic sequence with $a=50,\ d=20$ Allow full credit for any correct method	Allow for total written out in full
	(ii)		Each month is 12% more than the previous, so multiplied by 1.12 giving a geometric sequence with $a=50,\ r=1.12$	E1 [1]	2.4	Clear argument must include the value 1.12	
	(iii)		Geometric sequence with $a=50,\ r=1.12$ $S_{24}=\frac{50\left(1.12^{24}-1\right)}{0.12}$ = £5907.76 which is less than Aleela	M1 A1 E1 [3]	3.1a 1.1b 2.1	Using appropriate formula for sum of a geometric sequence with $a=50,\ r=1.12$ Allow any suitable rounding FT their values (dep on earning the M marks in part (i) and (iii))	Allow for total written out in full
7	(i)		$F=30+50=80\ \text{N}$	B1 [1]	1.1a	Cao	
	(ii)		Taking moments about the top of the rod $Fx=50\times 2$ $x=1.25\ \text{m}$	M1 A1 [2]	3.3 1.1b	Or any other suitable point Cao	All necessary terms must be present. Each term must be a product of a force and a length.

Question			Answer	Marks	AOs		Guidance
8	(i)		**EITHER** $8\sin^2 x\cos^2 x = 2(1-\cos 2x)(1+\cos 2x)$ $= 2(1-\cos^2 2x) = 2-(1+\cos 4x)$ $= 1-\cos 4x$	**M1** **M1** **E1** **[3]**	**3.1a** **3.1a** **2.1**	**AG** Using a double angle formula Second use of a double angle formula Clearly shown	
	(i)		**OR** $8\sin^2 x\cos^2 x = 2(2\sin x\cos x)^2$ $= 2\sin^2 2x$ $[= 1-\cos 2(2x)] = 1-\cos 4x$	**M1** **M1** **E1** **[3]**		Using a double angle formula Another use of a double angle formula Clearly shown	Allow any other valid sequence of identities used.
	(i)		**OR** $1-\cos 4x = 1-(1-2\sin^2 2x)$ $= 2\sin^2 2x$ $= 2(2\sin x\cos x)^2$ $= 8\sin^2 x\cos^2 x$	**M1** **M1** **E1** **[3]**		Using a double angle formula Another use of a double angle formula Clearly shown	
	(ii)		$\int \sin^2 x\cos^2 x \; dx = \frac{1}{8}\int 1-\cos 4x \; dx$ $= \frac{1}{8}x - \frac{1}{32}\sin 4x + c$	**M1** **A1** **A1** **[3]**	**1.1a** **1.1b** **1.1b**	Attempt to integrate both terms $\frac{1}{4}\sin 4x$ seen or implied All correct. Must include $+c$	

Question			Answer	Marks	AOs		Guidance
9	(i)		Vertical motion $u=0$ $s=ut+\frac{1}{2}at^2$ $-5=0-\frac{9.8}{2}t^2$ $t=\sqrt{\frac{10}{9.8}}=1.01$ s	**B1** **M1** **A1** **[3]**	**3.3** **3.4** **1.1b**	Using $u=0$ in the vertical direction to model horizontal motion soi Using suvat equation(s) to find *t*. Allow sign errors and incorrect value for *u*. Must follow from working where the signs are consistent.	
	(ii)		$x=14t$ $y=5-4.9t^2$ So cartesian equation is $y=5-4.9\left(\frac{x}{14}\right)^2\left[=5-\frac{x^2}{40}\right]$	**B1** **B1** **M1** **A1** **[4]**	**3.3** **3.3** **1.1a** **1.1b**	May be implied May be implied Attempt to eliminate *t* Any form	
	(iii)		EITHER When $y=2$ $y=5-\frac{x^2}{40}=2$ m $\frac{x^2}{40}=3$ $x=\sqrt{120}=10.9544...$ $[0<]d<11.0$ m	**M1** **A1** **E1** **[3]**	**3.4** **1.1b** **3.2a**	Using their equation of trajectory and $y=2$ Must be 11.0 or better Allow "Fence must be less than 10.95 m from the origin." FT their value	**SC2** for $d<\sqrt{80}$ $[=8.94]$ **SC1** for $d=\sqrt{80}$ $[=8.94]$
	(iii)		OR When $y=2$ $2=5-4.9t^2$ $t=0.782$ When $t=0.782$ $x=14\times0.782=10.95$ $[0<]d<11.0$ m	**M1** **A1** **A1** **[3]**		Both steps required for M1 Must be 11.0 or better Allow "Fence must be less than 10.95 m from the origin."	Allow if the origin is taken to be at window height and the top of the wall is 3m below the window. Signs must be consistent for A1

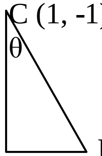
Question			Answer	Marks	AOs		Guidance
10			Curve crosses the x-axis when $y=0$ $y=(k-x)\ln x=0$	M1	3.1a	Attempt to solve $y=0$	
			Either $k-x=0$ or $\ln x=0$ $x=k$ or 1	A1	1.1b	Both roots required	
			EITHER Area = $\int_1^k (k-x)\ln x \, dx$ Let $u=\ln x$, $\frac{dv}{dx}=k-x$, $\frac{du}{dx}=\frac{1}{x}$, $v=kx-\frac{1}{2}x^2$	M1	2.1	Using integration by parts with $u=\ln x$, $\frac{dv}{dx}=k-x$ clearly argued	
			Area = $\left[\left(kx-\frac{1}{2}x^2\right)\ln x\right]_1^k-\int_1^k \frac{1}{x}\left(kx-\frac{1}{2}x^2\right) dx$	A1	1.1b	Allow without limits	
			$\left[\left(kx-\frac{1}{2}x^2\right)\ln x\right]_1^k-\int_1^k \left(k-\frac{1}{2}x\right) dx$	M1	3.1a	Simplifying the integrand	
			$\left[\left(kx-\frac{1}{2}x^2\right)\ln x-\left(kx-\frac{1}{4}x^2\right)\right]_1^k$	A1	1.1b	Second part correct	
			$\left(\left(k^2-\frac{1}{2}k^2\right)\ln k-\left(k^2-\frac{1}{4}k^2\right)\right)-\left(\left(k-\frac{1}{2}\right)\ln 1-\left(k-\frac{1}{4}\right)\right)$	M1dep	1.1a	Using limits. Dependendent on M mark for integration by parts	
			$=\frac{1}{2}k^2\ln k-\frac{3}{4}k^2+k-\frac{1}{4}$	A1 [8]	1.1b	Cao	

Question			Answer	Marks	AOs		Guidance
10			OR Integral split into two separate integrals $\int_1^k k\ln x \, dx$ Let $u=\ln x,\ \frac{dv}{dx}=k,\ \frac{du}{dx}=\frac{1}{x},\ v=kx$	M1		Using integration by parts with $u=\ln x,\ \frac{dv}{dx}=k$ or $u=\ln x,\ \frac{dv}{dx}=\pm x$ clearly argued	
			$=\left[kx\ln x\right]_1^k-\int_1^k \frac{1}{x}kx \, dx$	M1		Simplifying the integrand	
			$\left[kx\ln x\right]_1^k-\int_1^k k \, dx=\left[kx\ln x-kx\right]_1^k$ $\left(k^2\ln k-k^2\right)-\left(k\ln 1-k\right)=k^2\ln k-k^2+k$ And Area = $\int_1^k x\ln x \, dx$ Let $u=\ln x,\ \frac{dv}{dx}=x,\ \frac{du}{dx}=\frac{1}{x},\ v=\frac{1}{2}x^2$	M1dep		Substituition of limits seen in at least one integral. Dependendent on M mark for integration by parts	
			$=\left[\frac{1}{2}x^2\ln x\right]_1^k-\int_1^k \frac{1}{x}\times \frac{1}{2}x^2 dx$ $\left[\frac{1}{2}x^2\ln x\right]_1^k-\int_1^k \frac{1}{2}x \, dx$	A1		Both integrals correct at this stage Allow without limits	
			$\left[\frac{1}{2}x^2\ln x-\frac{1}{4}x^2\right]_1^k$ $\left(\frac{1}{2}k^2\ln k-\frac{1}{4}k^2\right)-\left(\frac{1}{2}\ln 1-\frac{1}{4}\right)=\frac{1}{2}k^2\ln k-\frac{1}{4}k^2+\frac{1}{4}$ Area $=\left(k^2\ln k-k^2+k\right)-\left(\frac{1}{2}k^2\ln k-\frac{1}{4}k^2+\frac{1}{4}\right)$	A1		Both integrals fully correct Allow without limits	
			$=\frac{1}{2}k^2\ln k-\frac{3}{4}k^2+k-\frac{1}{4}$	A1		Cao	

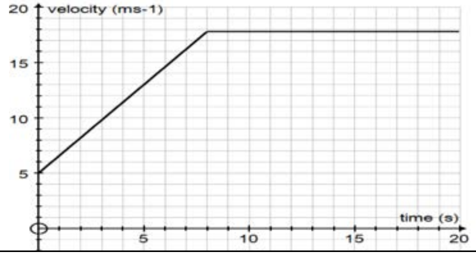
Question			Answer	Marks	AOs		Guidance
11	(i)		Component of weight down the plane $4.7g\sin 60°$ Equilibrium equation $T = 4.7g\sin 60°$ $= 39.889...$ so $T = 39.9$ to 3 sf	**B1** **E1** **[2]**	**2.1** **3.3**	**AG** Award if seen Must be clear that 39.9 N is the tension and not just component of weight	
	(ii)		Resolve perpendicular to the slope N is the normal reaction between plane and block B $N = 4g\cos 25°$ Resolve up the slope $T - F - 4g\sin 25° = 0$ On the point of sliding so $F = \mu N = \mu \times 4g\cos 25°$ $\mu = \frac{4.7g\sin 60° - 4g\sin 25°}{4g\cos 25°} = 0.656$ to 3sf	**B1** **M1** **A1** **M1** **A1** **[5]**	**1.1a** **3.3** **1.1b** **3.1b** **1.1b**	Need not be evaluated here $[\approx 35.5]$ Allow only sign errors F need not be evaluated here $[\approx 23.3]$ Do not allow for $F \le \mu N$ unless = used subsequently. FT their values. FT (notice this answer is 0.657 if 39.9 used for T)	If only values are seen used, it must be clear that the values used are friction and normal reaction.

Question			Answer	Marks	AOs		Guidance
12	(i)		C is (1, -1)	**B1** **[1]**	**1.1a**	Cao	
	(ii)	A	EITHER Substitute $y=\frac{3}{4}x-8$ into the equation of the circle $(x-1)^2+\left(\frac{3}{4}x-8+1\right)^2=25$ $x^2-8x+16=0$ EITHER $(x-4)^2=0$ OR Discriminant = $(-8)^2-4\times1\times16=0$ So the equation has a repeated root so the line is a tangent	**M1** **M1** **A1** **A1** **[4]**	**3.1a** **1.1a** **1.1b** **2.2a**	**AG** Attempt to eliminate one variable Attempt to expand and collect terms to obtain 3 term quadratic expression A correct 3 term quadratic Clearly argued	
	(ii)	A	OR Substitute $x=\frac{4}{3}y-\frac{32}{3}$ into the equation of the circle $\left(\frac{4}{3}y-\frac{32}{3}-1\right)^2+(y+1)^2=25$ $y^2+10y+25=0$ EITHER $(y+5)^2=0$ OR Discriminant = $10^2-4\times1\times25=0$ So the equation has a repeated root so the line is a tangent	**M1** **M1** **A1** **A1** **[4]**	**3.1a** **1.1a** **1.1b** **2.2a**	**AG** Attempt to eliminate one variable Attempt to expand and collect terms to obtain 3 term quadratic expression A correct 3 term quadratic Clearly argued	
		B	$x=4$ and $y=-5$ so B is (4, -5)	**B1** **[1]**	**1.1a**	Cao	

Question			Answer	Marks	AOs		Guidance
	(iii)		$\angle CAD = \angle CBD = 90°$ (radius is perpendicular to the tangent) Gradient of AC $= \frac{2-(-1)}{5-1} = \frac{3}{4}$ Gradient of BC $= \frac{(-1)-(-5)}{1-4} = -\frac{4}{3}$ So AC is perpendicular to BC so $\angle ACB = 90°$ So ADBC is a rectangle Either AC = BC radius [=5] Or AD = BD equal tangents so ADBC is a square.	**B1** **B1** **B1** **[3]**	**2.1** **3.1a** **2.1**	Allow for one or other of these angles Complete proof **AG**	Allow up to B1, B1 for any two of these three pieces of evidence. Allow the final B1 only when the proof is complete and clearly argued.
			$\angle CAD = \angle CBD = 90°$ (radius is perpendicular to the tangent) Gradient of AC $= \frac{2-(-1)}{5-1} = \frac{3}{4}$ Gradient of BD is $\frac{3}{4}$ So AC is parallel to BD So ADBC is a rectangle AC = BC = radius so ADBC is a square.	**B1** **B1** **B1**		Allow for one or other of these angles Complete proof **AG**	
			$\angle CAD = 90°$ (radius is perpendicular to the tangent) AC = BC radius [=5] Gradient of AC $= \frac{2-(-1)}{5-1} = \frac{3}{4}$ Equation of AD is $y-2 = -\frac{4}{3}(x-5)$ So coordinates of D are (8, -2) Hence BD = 5 and AD = 5 So ABCD is a rhombus	**B1** **B1** **B1**		 Gradient of AD must be found from the coordintes of A and C Complete proof	

Question		Answer	Marks	AOs		Guidance
	(iv)	E is the point (1, -6)	B1	2.1	May be implied	
		EITHER 	M1	3.1a	Right-angled triangle formed and use of arctan	
		$\theta = \arctan\left(\frac{3}{4}\right) = 0.6435$	A1	3.1a	oe	
		OR $BE = \sqrt{(4-1)^2 + (-5-(-6))^2} = \sqrt{10}$ Cosine rule in triangle BCE $\cos BCE = \frac{5^2+5^2-10}{2\times5\times5}\left[=\frac{40}{50}\right]$	(M1)		Using distance BC and the cosine rule	
		$\angle BCE = 0.6435...$	(A1)		oe	
		OR M is the midpoint of BE M is (2.5, -5.5) $BM = \sqrt{(4-2.5)^2 + (-5-(-5.5))^2} = \frac{1}{2}\sqrt{10}$ $\angle BCM = \arcsin\left(\frac{\frac{1}{2}\sqrt{10}}{5}\right) = 0.32175...$	(M1)		Using trig in triangle BCM or ECM Allow for $\angle BCM$	
		$\angle BCE = 0.6435...$	(A1)		Oe. Must be $\angle BCE$	
		Area sector $= \frac{1}{2}r^2\theta = \frac{1}{2}\times25\times2\times0.32175...$	M1dep	1.1a	Using the sector area formula	
		$= 8.04376$	A1 [5]	1.1b	FT their $\angle BCM$	

Question			Answer	Marks	AOs		Guidance
13	(i)		$f'(x)=\frac{1}{3}\left(27-8x^3\right)^{-2/3}\times(-24x^2)$ $\left[=\frac{-8x^2}{\left(27-8x^3\right)^{2/3}}\right]$ $f'(1.5)=-\frac{8\times1.5^2}{0}$ and dividing by zero zgives the error.	M1 A1 E1 [3]	1.1a 1.1 2.4	Using the chain rule Allow unsimplified Sufficient to say "can't divide by zero" oe	
	(ii)		$\left(27-8x^3\right)^{1/3}=27^{1/3}\left(1-\frac{8}{27}x^3\right)^{1/3}$ $=3\left(1+\left(\frac{1}{3}\right)\left(-\frac{8x^3}{27}\right)+\frac{\left(\frac{1}{3}\right)\left(-\frac{2}{3}\right)}{2!}\left(-\frac{8x^3}{27}\right)^2+\ldots\right)$ $=3-\frac{8x^3}{27}-\frac{64x^6}{2187}+\ldots$	B1 M1 A1 [3]	3.1a 1.1a 1.1b	Dealing with the 27 correctly Using the Binomial expansion substantially correctly Cao	
	(iii)		The binomial expansion is valid for $\left\|-8\frac{x^3}{27}\right\|<1$ $\|x\|<1.5$ and the limits of the integral are completely in this interval.	B1 E1 [2]	2.4 2.3	Allow unsimplified but must use correct modulus notation or equivalent Must indicate that the limits of the integral lie in their interval for which the expansion is valid.	
	(iv)		$\frac{0.25}{2}\left(3+2.6684+2\left(2.9954+2.9625+2.8694\right)\right)$ $=\frac{0.25}{2}\times23.3224=2.9153$	B1 M1 A1 [3]	1.1a 1.1b 1.1b	$h=0.25$ used For sum in the bracket – condone one slip. Allow for 2.92 or better	Values from candidates own calculators may differ in the last decimal place.
	(v)		There is area between the curve and the top of the trapezia, so some area is missing from the estimate.	E1 [1]	2.4	Allow for any sensible explanation eg the trapezia are under the curve	"The curve is concave downwards" on its own is not quite enough

Question			Answer	Marks	AOs		Guidance
14	(i)		$u=5,\ v=11.4,\ t=4$ $a=\frac{v-u}{t}=\frac{11.4-5}{4}=1.6$ $v=5+1.6t$	M1 A1 A1 [3]	3.1b 1.1b 3.3	Using *suvat* equation(s) leading to value for *a* Any form FT their *a*	
	(ii)		The car would not be able to accelerate indefinitely – the velocity would become too large	E1 [1]	3.5b		
	(iii)		When $v=17.8$ $t=\frac{17.8-5}{1.6}=8$ 	B1 G1 G1 [3]	1.1a 1.1a 3.5c	Calculation or point on graph labelled at *t* = 8 Two line segments with one horizontal Axes labelled. (0, 5) and constant speed 17.8 clear on vertical scale	Mark intent for 17.8 – allow for a linear scale beyond 17.8
	(iv)		Dividing area into sections Area under trapezium = $\frac{1}{2}(5+17.8)\times 8=91.2$ Area rectangle $12\times 17.8=213.6$ Total displacement = 304.8 m	M1 A1 A1 [3]	3.1b 1.1a 1.1b	May be found as sum of areas. May be implied by correct total FT their distance found for first 8s	FT their graph if linear for M1 A0 for a triangle or trapezium area 213.6 must be added to another distance
	(v)		When $t=4\ \ v=5+0.3\times 4^2-0.05\times 4^3=11.4\ \text{m s}^{-1}$ Which matches the given value	B1 [1]	3.4	Allow without comment	
	(vi)		$\frac{\text{d}v}{\text{d}t}=0.6\times 2t-0.05\times 3t^2\ \left[=1.2t-0.15t^2\right]$ When $t=8\ \ v=1.2\times 8-0.15\times 64=0$ Acceleration is zero at $t=8$ which means that the car reaches its maximum speed without the sudden change in acceleration in model A.	M1 A1 E1 [3]	1.1a 3.2a 3.2a	Need not be simplified Must mention acceleration Must compare with model A	Final mark can be awarded independently for a statement about change in acceleration as long as supported by some numerical evidence

Question			Answer	Marks	AOs		Guidance
	(vii)		EITHER $\int_0^8 \left(5+0.6t^2-0.05t^3\right) dt = \left[5t+0.2t^3-0.0125t^4\right]_0^8$ =91.2 m which is same as model A for the first 8 s Distance is the same for the remainder of the time So this is the same as model A at t = 20	M1 A1 E1 [3]	2.1 1.1b 2.1	 BC Must consider to t = 20	Allow for correct definite integral stated and calculator used. Also allow M1A1 for $5\times8-0.2\times8^3-0.0125\times8^4$ seen
			OR $\int_0^8 \left(5+0.6t^2-0.05t^3\right) dt = \left[5t+0.2t^3-0.0125t^4\right]_0^8$ =91.2 m Distance at 17.8 ms^{-1} 213.6 Total distance 304.8m [which is the same as model A]	 M1 A1 A1		 BC Must consider to t = 20	Allow for correct definite integral stated and calculator used.

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