# A-LEVEL
# MATHEMATICS

## Mechanics 2B – MM2B
## Mark scheme

6360
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Version/Stage: Final V1.0

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

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**Key to mark scheme abbreviations**

| | |
|---|---|
| M | mark is for method |
| m or dM | mark is dependent on one or more M marks and is for method |
| A | mark is dependent on M or m marks and is for accuracy |
| B | mark is independent of M or m marks and is for method and accuracy |
| E | mark is for explanation |
| √or ft or F | follow through from previous incorrect result |
| CAO | correct answer only |
| CSO | correct solution only |
| AWFW | anything which falls within |
| AWRT | anything which rounds to |
| ACF | any correct form |
| AG | answer given |
| SC | special case |
| OE | or equivalent |
| A2,1 | 2 or 1 (or 0) accuracy marks |
| –*x* EE | deduct *x* marks for each error |
| NMS | no method shown |
| PI | possibly implied |
| SCA | substantially correct approach |
| c | Candidate |
| sf | significant figure(s) |
| dp | decimal place(s) |

**No Method Shown**

Where the question specifically requires a particular method to be used, we must usually see evidence of use of this method for any marks to be awarded.

Where the answer can be reasonably obtained without showing working and it is very unlikely that the correct answer can be obtained by using an incorrect method, we must award **full marks**. However, the obvious penalty to candidates showing no working is that incorrect answers, however close, earn **no marks**.

Where a question asks the candidate to state or write down a result, no method need be shown for full marks.

Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

**Otherwise we require evidence of a correct method for any marks to be awarded.**

| Q | Solution | Mark | Total | Comment |
|---|---|---|---|---|
| **1 (a)** | KE = $\frac{1}{2}\times 3\times 8^2$ | M1 | | |
| | = 96 J | A1 | 2 | |
| **(b)** | Change in PE; | | | |
| | $mgh$ = 3 × 9.8 × 13 | M1 | | |
| | = 382.2 J | A1 | 2 | |
| | = 382 J | | | SC1 380 |
| **(c)(i)** | Salmon's KE when it reaches the sea | | | (a) + (b) |
| | = 96 + 382.2J | M1 | | [both non zero] |
| | = 478 J | A1 | 2 | Ft [one correct] |
| **(ii)** | Speed of salmon is $\sqrt{\frac{478.2}{\frac{1}{2}\times 3}}$ | M1 | | |
| | = 17.8549 $ms^{-1}$ | | | |
| | = 17.9 $ms^{-1}$ | A1 | 2 | Accept 17.8,17.85,17.855, 17.86 |
| | **Total** | | **8** | |

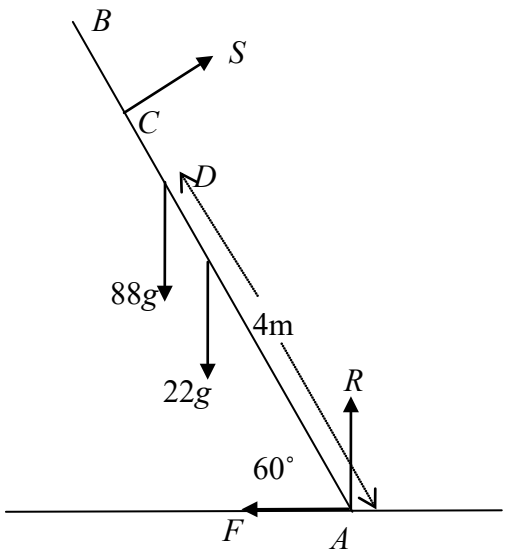
| Q | Solution | Mark | Total | Comment |
|---|---|---|---|---|
| **2 (a)** | Using $F = ma$ | M1 | | M1 either term correct oe |
| | $\boldsymbol{a} = 4e^{-2t}\,\mathbf{i} - 2t^3\mathbf{j}$ | A1 | 2 | |
| **(b)** | $v = \int a\,dt$ | M1 | | M1 for either term correct |
| | $= -2\,e^{-2t}\,\mathbf{i} - \frac{1}{2}t^4\mathbf{j} + \mathbf{c}$ | A1 | | Ft from (a) oe Condone no + **c** |
| | When t = 0, $-7\mathbf{i} - 4\mathbf{j} = -2\,\mathbf{i} + \mathbf{c}$ | m1 | | |
| | $\mathbf{c} = -5\,\mathbf{i} - 4\,\mathbf{j}$ | | | |
| | $\mathbf{v} = -(2\,e^{-2t} + 5)\mathbf{i} - (\frac{1}{2}t^4 + 4)\mathbf{j}$ | A1 | 4 | CAO |
| **(c)** | When $t = 0.5$, | | | |
| | $\mathbf{v} = -(2\,e^{-1} + 5)\mathbf{i} - (\frac{1}{2} \times 0.5^4 + 4)\mathbf{j}$ | M1A1 | | |
| | $= -5.7357\mathbf{i} - 4.03125\,\mathbf{j}$ | | | |
| | Speed is $\sqrt{5.736^2 + 4.031^2}$ | M1 | | |
| | = 7.0106... | A1 | 4 | |
| | or 7.01 $ms^{-1}$ | | | MR A0 in (a) and last part of (c) Do not accept 7 |
| | **Total** | | **10** | |

| Q | Solution | Mark | Total | Comment |
|---|---|---|---|---|
| **3** | $\overline{X} = \frac{4\times11+3\times3+7\times5+1\times1+5\times7}{4+3+7+1+5}$ | M1 | | M1 for at least 4 correct |
| | $= \frac{124}{20}$ or 6.2 | A1 | | Accept $\frac{124}{20}$ |
| | $\overline{Y} = \frac{4\times2+3\times6+7\times9+1\times4+5\times6}{20}$ | M1 | | |
| | $= \frac{123}{20}$ or 6.15 | A1 | | |
| | ∴ Centre of mass is at (6.2, 6.15) | A1ft | 5 | Do not accept $\frac{124}{20}$ etc (6.15,6.2)M2A2 If lamina not used SC2; ie M1,M1 |
| | **Total** | | **5** | |

| Q | Solution | Mark | Total | Comment |
|---|---|---|---|---|
| **4 (a)** | 20 revolutions per minute<br>= 40π radians per minute | B1 | | or $\frac{1}{3}$ revolutions per second |
| | = $\frac{2\pi}{3}$ radians per second | B1 | 2 | Accept 2.09 |
| **(b)** | Resolve vertically<br>$T\cos 35 = 0.8g$ | M1 A1 | | M1 if Tsin35 used; need $g$ |
| | $T$= 9.5708…<br>= 9.57 N | A1 | 3 | |
| **(c)** | Resolve horizontally<br>$T \sin 35 = m\omega^2 r$ | M1 | | M1 condone Tcos35 and $m\frac{v^2}{r}$ |
| | $9.57 \sin 35 = 0.8 \times r \times \left(\frac{2\pi}{3}\right)^2$ | A1 A1 | | A1 for either side |
| | $r = 1.564\ldots$ | A1 | 4 | |
| | Radius is 1.56 m | | | Condone 1.57 |
| | **Total** | | **9** | |

| Q | Solution | Mark | Total | Comment |
|---|---|---|---|---|
| **5 (a)** | Using conservation of energy :<br>$\frac{1}{2}mv_P^2 = \frac{1}{2}mv_Q^2 + 2amg$ | M1<br>A1 | | M1 for 3 [or 4] terms 2 KE and 1[or 2] PE |
| | $v_Q^2 = 49ag - 4ag$ | M1 | | |
| | $v_Q^2 = 45ag$ | | | |
| | $v_Q = \sqrt{45ag}$ | A1 | 4 | $v_Q = 3\sqrt{5ag}$ |
| **(b)** | At Q, T + mg = $\frac{mv_Q^2}{a}$ | M1A1 | | M1 for correct 3 terms |
| | T = m. 45 g – mg<br>= 44mg | A1 | 3 | |
| | **Total** | | **7** | |

| Q | Solution | Mark | Total | Comment |
|---|---|---|---|---|
| **6 (a)** | Using F = ma | | | |
| | $-0.3mv^{\frac{1}{3}} = m\frac{dv}{dt}$ | | | |
| | $\therefore \frac{dv}{dt} = -0.3v^{\frac{1}{3}}$ | B1 | | Need substitution for a |
| | $\int v^{-\frac{1}{3}}dv = -\int 0.3dt$ | M1 | | |
| | $\frac{3}{2}v^{\frac{2}{3}} = -0.3\,t + c$ | A1A1 | | A1 for each side<br>no – sign [B0] could get M1A1 |
| | When $t = 0$, $v = 8$, | | | |
| | $\therefore c = 6$ | A1 | | |
| | $\frac{3}{2}v^{\frac{2}{3}} = -0.3\,t + 6$ | | | |
| | $v^{\frac{2}{3}} = -0.2\,t + 4$ | | | |
| | $v = (4-0.2t)^{\frac{3}{2}}$ | A1 | 6 | |
| **(b)** | When $v = 0$, $4 - 0.2\,t = 0$ | M1 | | |
| | $t = 20$ | A1 | 2 | |
| **(c)** | | | | |
| | Integrating $v = (4-0.2t)^{\frac{3}{2}}$, | | | |
| | $x = -2(4-0.2t)^{\frac{5}{2}} + d$ | M1A1 | | M1 for power of 5/2<br>A1 correct [condone no d] |
| | When t = 0 , x = 0, $\Rightarrow d = 64$ | | | |
| | $x = -2(4-0.2t)^{\frac{5}{2}} + 64$ | A1 | | |
| | When speed is 0 $ms^{-1}$, $t = 20$ | M1 | | |
| | $x = 64$ | A1 | 5 | |
| | **Total** | | **13** | |

| Q | Solution | Mark | Total | Comment |
|---|---|---|---|---|
| **7(a)** |  | B2 | 2 | Need 5 forces correct<br>ignore labels<br><br>B1 for 4 forces correct |
| **(b)** | Resolve horizontally<br>F = S cos 30 | B1 | | |
| | Resolve vertically<br>R = 88g + 22g – S sin 30 | B1 | | |
| | Moments about A<br>22g . 3 cos 60 + 88g. 4 cos 60 = 5 S<br>5S = 209g | M1 | | M1 for correct moments about any point<br><br>Resolve once B1 moments twice is M1A1, B1 |
| | S = 41.8g [409.64] | A1 | | |
| | Using F = μR;<br>S cos 30 = μ(110g – S sin 30) | M1 | | R =873.18<br>F =354.758 |
| | $\mu = \frac{S\sqrt{3}}{220g-S}$<br>$= \frac{41.8\sqrt{3}}{220-41.8}$<br>$= \frac{41.8\sqrt{3}}{178.2}$<br>$= \frac{19\sqrt{3}}{81} = 0.406$ | A1 | 6 | Accept 0.407, 0.4063..,0.41<br>not 0.4 |
| | | | | |
| | If S is horizontal, B1 in (a)<br>In (b) M1 [moments], M1 for friction,B1 [2 resolve] 0.439 SC3 | | | |
| | | | | |
| | **Total** | | **8** | |

PMT

| Q | Solution | Mark | Total | Comment |
|---|---|---|---|---|
| **8 (a)** | Resolve perpendicular to plane | | | |
| | $R = mg\cos 20$ | M1 | | |
| | $F = \mu R = \mu mg\cos 20$ | m1 | | |
| | $= 0.8 \times 4 \times g\cos 20$ | | | or 0.8 x 36.8359 |
| | $= 29.468..$ | A1 | 3 | |
| | $= 29.5$ N | | | |
| **(b)(i)** | As particle moves from C to B; Constant friction acts. | | | |
| | Work done by friction is $(x + 2) \times 29.468$ | B1 | | |
| | Change in PE is $mg(x+2)\sin 20$ | B1 | | |
| | Initial EPE $= \frac{\lambda x^2}{2l}$ | | | |
| | $= \frac{120\times(x-1.5)^2}{2\times1.5}$ | | | |
| | $= 40\,(x - 1.5)^2$ | B1 | | |
| | Final EPE $= \frac{120\times(0.5)^2}{2\times1.5} = 10$ | B1 | | |
| | $(x + 2) \times 29.468 + mg(x+2)\sin 20$ | M1A1 | | M1 for 4 of these terms at least 2 correct |
| | $= 40\,(x - 1.5)^2 - 10$ | A1 | | A1for 3 terms correct with correct signs<br>A1 for equation totally correct |
| | $40x^2 - 162.875x - 5.75 = 0$ | | | |
| | $x = 4.1069$ or $-0.035$ | | | |
| | $\therefore\ x = 4.11$ | A1 | 8 | condone 4.10, 4.12, and anything in between, |
| **(ii)** | Using $T = \frac{\lambda x}{l}$ | | | |
| | Tension when particle is at B is $\frac{120\times0.5}{1.5}$ | | | |
| | $= 40$ | B1 | | |
| | Frictional force is 29.468 | | | |
| | Gravitational force is $mg\sin 20$ | | | |
| | $= 13.407$ | B1 | | For both 29.4. and 13.4. |
| | Using $F = ma$ | | | |
| | $4a = 40 + 13.407 - 29.468$ | M1 | | Need all terms & correct |
| | $= 23.938$ | | | |
| | Acceleration is 5.984 | | | |
| | $= 5.98\ ms^{-2}$ | A1 | 4 | condone 5.99,5.984..,5.985 |
| | **Total** | | **15** | |
| | **TOTAL** | | **75** | |