

General Certificate of Education

Mathematics 6360

MM2A Mechanics 2

Mark Scheme

2006 examination - January series

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

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Key To Mark Scheme And Abbreviations Used In Marking

| М | mark is for method | | | | | |
|------------|--|-----|----------------------------|--|--|--|
| m or dM | mark is dependent on one or more M marks and is for method | | | | | |
| А | mark is dependent on M or m marks and is for accuracy | | | | | |
| В | mark is independent of M or m marks and is for method and accuracy | | | | | |
| Е | mark is for explanation | | | | | |
| | | | | | | |
| or ft or F | follow through from previous | | | | | |
| | incorrect result | MC | mis-copy | | | |
| CAO | correct answer only | MR | mis-read | | | |
| CSO | correct solution only | RA | required accuracy | | | |
| AWFW | anything which falls within FW further work | | | | | |
| AWRT | anything which rounds to | ISW | ignore subsequent work | | | |
| ACF | any correct form | FIW | from incorrect work | | | |
| AG | answer given | BOD | given benefit of doubt | | | |
| SC | special case | WR | work replaced by candidate | | | |
| OE | or equivalent | FB | formulae book | | | |
| A2,1 | 2 or 1 (or 0) accuracy marks | NOS | not on scheme | | | |
| –x EE | deduct x marks for each error | G | graph | | | |
| NMS | no method shown | с | candidate | | | |
| PI | possibly implied | sf | significant figure(s) | | | |
| SCA | substantially correct approach | 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. However, there are situations in some units where part marks would be appropriate, particularly when similar techniques are involved. Your Principal Examiner will alert you to these and details will be provided on the mark scheme.

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.

MM2A

| $ \begin{array}{c c c c c c c c c c c c c c c c c c c $ | Q | Solution | Marks | Total | Comments |
|--|----------------|---|-------|-------|--------------------------------|
| $ \begin{array}{c c c c c c c c c c c c c c c c c c c $ | 1 | $5T_{1} = 20 \times 9.8 \times 1.5$ | M1 | | Moment equation. |
| MI $T + 58.8 = 20 \times 9.8$ MI A1Vertical equation with T or moments equation. Correct equationT + 58.8 = 20 \times 9.8A16Correct equationT = 137.2 NA16Correct tension2(a)T cos 30° = 2 \times 9.8MI cos 30° = 2 \times 9.8A16T = 22.6 NAGA13Correct T from correct working(b)T cos 60° = $2 \times \frac{v^2}{0.6}$ MI A1Resolving horizontally. Correct equation(b)T cos 60° = $2 \times \frac{v^2}{0.6}$ M1 A1A14Correct value Correct equation(b)T cos 60° = $2 \times \frac{v^2}{0.6}$ MI A1A14Correct value Correct equation(b)T cos 60° = $2 \times \frac{v^2}{0.6}$ MI A1A14Correct value Correct equation(b)T cos 60° = $2 \times \frac{v^2}{0.6}$ MI A1A14Correct curve Correct equation(ii) $2 < a \le 14$ B1,B1T B1Correct curve For 2, For 14(ii) $2 < a \le 14$ B1,B13Correct inequalities(b) $s = t^2 + 12e^{-t} + c$ M1 A12Differentiating, with at least one term correct. Correct inequalities(b) $s = t^2 + 12e^{-t} + c$ M1 A12Correct inequalities(ii) $s = 0, t = 0 \Rightarrow c = -12$ $s = 0, t = 0 \Rightarrow c = -12$ $s = 0, t = 0 \Rightarrow c = -12$ $s = 0, t = 0 \Rightarrow c = -12$ $s = 0, t = 0 \Rightarrow c = -12$ $s = 0, t = 0 \Rightarrow c = -12$ $s = 0, t = 0 \Rightarrow c = -12$ $s = 0, t = 0 \Rightarrow c = -12$ $s = 0, t = 0 \Rightarrow c = -12$ $s = 0, t = 0 \Rightarrow c = -12$ $s = 0, t = 0 \Rightarrow c = -12$ $s = 0, t = 0 \Rightarrow$ | | $51_A - 20 \times 7.6 \times 1.5$ | A1 | | Correct equation |
| T + 58.8 = 20×9.8MI A1equation. Correct equationT = 137.2 NA16T = 302 SP.8M1 A16T cos 30° = 2×9.8M1 A17T = $\frac{2 \times 9.8}{\cos 30°}$ A13T = 22.6 NAGA1A177T cos 60° = 2× $\frac{v^2}{0.6}$ M1 A1A1A14Correct T from correct working(b)T cos 60° = 2× $\frac{v^2}{0.6}$ M1 A1Correct equation $v = 1.84 \text{ ms}^{-1}$ A14Correct quation73(a)(i) $a = 2 + 12e^{-t}$ M1A1 B1,B1 $v = 1.84 \text{ ms}^{-1}$ A14Correct inequalitiesFor 2, For 14 B1(b) $s = t^2 + 12e^{-t} + c$ M1 A1 $s = 0, t = 0 \Rightarrow c = -12$ $s = t^2 + 12e^{-t} - 12$ A14(a) $P = (30 \times 42) \times 42$ $= 52920 W$ M1A1 A1 $s = 0, t = 0 \Rightarrow c = -12$ $s = t^2 + 12e^{-t} - 12$ A14(a) $P = (30 \times 42) \times 42$ $= 52920 W$ M1 A1(b) $F = 1200 \times 9.8 \sin 5° + 30v$ M1A1 A1 $v = -392 \sin 5° v - 1764 = 0$ A1 A14(ii) $v = -392 \sin 5° v - 1764 = 0$ A1 A1(iii) $v = -392 \sin 5° + 30v$ /bitM1A1 $= 2v$ (b) $v = -392 \sin 5° + \sqrt{(392 \sin 5°)^2 - 4 \times 1 \times (-1764)} \\ 2 \times 1 \\ v = 28.3 \text{ or } -62.4 \\ v = 28.3 \text{ or } -62.4$ | | $T_A = \frac{20 \times 9.8 \times 1.5}{5} = 58.8 \text{ N}$ | A1 | | Correct tension |
| $T + 58.8 = 20 \times 9.8$ A1equation. Correct equation $T = 137.2 \text{ N}$ A16Correct tension2(a) $T \cos 30^\circ = 2 \times 9.8$ M1 A16Resolving vertically with two terms Correct equation $T = 22.9 \text{ N}$ A13Correct T from correct working $T = 22.6 \text{ N}$ AGA13Correct T from correct working(b) $T \cos 60^\circ = 2 \times \frac{v^2}{0.6}$ M1 A1A14Correct equation $v = 1.84 \text{ ms}^{-1}$ A14Correct equation3(a)(i) $a = 2 + 12e^{-r}$ M1A1 $2 < a \le 14$ 2Differentiating, with at least one term correct. Correct velocity(ii) $2 < a \le 14$ B1,B1 B13Correct inequalities(b) $s = r^2 + 12e^{-r} + c$ M1 A12Differentiating, with at least one term correct. Correct inequalities(b) $s = r^2 + 12e^{-r} + c$ M1 A12Differentiating c $s = 0, t = 0 \Rightarrow c = -12$ $s = 0, t = 0 \Rightarrow c = -12$ $s = 1/2 + 12e^{-t} - 12$ A14Correct inequalities(b)(i) $F = 1200 \times 9.8 \sin 5^\circ + 30v$ M1A1 $A1$ 2Finding force Correct answer from $P = Fv$ (b)(i) $F = 1200 \times 9.8 \sin 5^\circ + 30v$ M1A1 2×1 2Finding force Correct equation from correct working AG(ii) $v = \frac{-392 \sin 5^\circ t + \sqrt{(392 \sin 5^\circ)^2 - 4 \times 1 \times (-1764)}}{2 \times 1}$ M14Solving quadratic(iii) $v = \frac{-392 \sin 5^\circ t + \sqrt{(392 \sin 5^\circ)^2 - 4 \times 1 \times (-1764)}}{2 \times 1}$ M142(iii) $v = -392 \sin$ | | | M1 | | |
| $\begin{array}{c c c c c c c c c c c c c c c c c c c $ | | $T + 58.8 = 20 \times 9.8$ | | | |
| Total62(a) $T \cos 30^\circ = 2 \times 9.8$ M1 A1Resolving vertically with two terms Correct equation $T = \frac{2 \times 9.8}{\cos 30^\circ}$ A13Correct T from correct working(b) $T \cos 60^\circ = 2 \times \frac{v^2}{0.6}$ A13Correct τ from correct working(b) $T \cos 60^\circ = 2 \times \frac{v^2}{0.6}$ A14Correct τ $v = 1.84 \text{ ms}^{-1}$ A14Correct v $v = 1.84 \text{ ms}^{-1}$ A12Differentiating, with at least one term correct. Correct velocity For 2. For 14(ii) $2 < a \le 14$ B1,B1 B13Correct equatities(b) $s = t^2 + 12e^{-t} + c$ M1Integrating, with at least one term correct. Correct expression with or without c Finding c $s = 0, t = 0 \Rightarrow c = -12$ A14Correct final expression(b) $F = 120^{-1} - 12$ A12Correct final expression $s = t^2 + 12e^{-t} - 12$ A12Correct answer from $P = Fv$ $f(a)$ $P = (30 \times 42) \times 42$ $a \le 20 \text{ W}$ AGA12 $s = 2220 \text{ W}$ AGA12Correct answer from $P = Fv$ (b)(i) $F = 1200 \times 9.8 \sin 5^\circ + 30v$ M1AUsing $P = Fv$ $v^2 + 392 \sin 5^\circ v - 1764 = 0$ A14Correct equation from correct working AG(ii) $v = -392 \sin 5^\circ \pm \sqrt{(392 \sin 5^\circ)^2 - 4 \times $ | | | | | Correct equation |
| 2(a) $T \cos 30^\circ = 2 \times 9.8$ M1 A1Resolving vertically with two terms Correct equation $T = \frac{2 \times 9.8}{\cos 30^\circ}$ $T = 22.6$ N AGA13Correct T from correct working(b) $T \cos 60^\circ = 2 \times \frac{v^2}{0.6}$ M1 A1A13 $v = 1.84 \text{ ms}^{-1}$ A14Correct v $v = 1.84 \text{ ms}^{-1}$ A14Correct v (ii) $a = 2 + 12e^{-t}$ M1A2Differentiating, with at least one term correct. Correct velocity For 2, For 14(iii) $2 < a \le 14$ B1,B1 B1B13(b) $s = t^2 + 12e^{-t} + c$ M1 A1Correct inequalities Integrating, with at least one term correct. Correct expression with or without c Finding c $s = 0, t = 0 \Rightarrow c = -12$ $s = t^2 + 12e^{-t} - 12$ A14(b) $r = (30 \times 42) \times 42$ $s = t^2 + 12e^{-t} - 12$ A14(a) $P = (30 \times 42) \times 42$ $s = 52920$ WM1A1 A12(b)(i) $F = 1200 \times 9.8 \sin 5^\circ + 30v$ M1A1 A12(b)(ii) $F = 1200 \times 9.8 \sin 5^\circ + 30v$ M1A1 A12(iii) $v = \frac{-392 \sin 5^\circ v - 1764 = 0}{2 \times 1}$ A14(iii) $v = \frac{-392 \sin 5^\circ \pm \sqrt{(392 \sin 5^\circ)^2 - 4 \times 1 \times (-1764)}}{2 \times 1}$ M1 $v = 28.3 \text{ or } -62.4$ $v = 28.3 \text{ or } -62.4$ A12Correct solutionCorrect solution | | | A1 | | Correct tension |
| $\begin{array}{c c c c c c c c c c c c c c c c c c c $ | | | | 6 | |
| $ \begin{array}{c c c c c c c c c c c c c c c c c c c $ | 2(a) | $T\cos 30^\circ = 2 \times 9.8$ | | | |
| $ \begin{array}{c ccccccccccccccccccccccccccccccccccc$ | | 2 × 0 8 | AI | | Correct equation |
| $ \begin{array}{c ccccccccccccccccccccccccccccccccccc$ | | $T = \frac{2 \times 9.8}{2002}$ | | | |
| (b) $T \cos 60^{\circ} = 2 \times \frac{v^2}{0.6}$ (b) $T \cos 60^{\circ} = 2 \times \frac{v^2}{0.6}$ (c) $\frac{M1}{A1}$ (d) $\frac{M1}{A1}$ (d) $\frac{M1}{A1}$ (e) $\frac{N1}{A1}$ (f) $\frac{v = 1.84 \text{ ms}^{-1}}{v = 1.84 \text{ ms}^{-1}}$ (f) $\frac{v = 1.84 \text{ ms}^{-1}}{2 \times a \le 14}$ (g) $\frac{1}{a = 2 + 12e^{-t}}$ (g) $\frac{1}{2 < a \le 14}$ (h) $\frac{1}{a = 2 + 12e^{-t}}$ (g) $\frac{1}{2 < a \le 14}$ (h) $\frac{1}{a = 2 + 12e^{-t}} + c$ (h) $\frac{1}{B1}$ (h) $\frac{1}{a = 2 + 12e^{-t}} + c$ (h) $\frac{1}{a = 2 + 12e^{-t}} + c$ (h) $\frac{1}{B1}$ (h) $\frac{1}{a = 2 + 12e^{-t}} + c$ (h) $\frac{1}{a = 1 + 12e^{-t}} + c$ (h) $\frac{1}{a = 2 + 12e^{-t}} + c$ (h) $\frac{1}{a = 2 + 12e^{-t}} + c$ (h) $\frac{1}{a = 1 + 12e^{-t}} + 2a + 3e^{-t} + 3e^{-t}$ (h) $\frac{1}{a = 1 + 12e^{-t}} + 2a + 3e^{-t} + 3e^{-t}$ (h) $\frac{1}{a = 1 + 2e^{-t}} + 2a + 3e^{-t} + 3e^{-t}$ (h) $\frac{1}{a = 1 + 2e^{-t}} + 2a + 3e^{-t} + 3e^{-t}$ (h) $\frac{1}{a = 1 + 2e^{-t}} + 2a + 3e^{-t} + 3e^{-t}$ (h) $\frac{1}{a = 1 + 2e^{-t}} + 2a + 3e^{-t} + 3e^{-t}$ (h) $\frac{1}{a = 1 + 2e^{-t}} + 2a + 3e^{-t} + 3e^{$ | | $T = 22.6 \text{ N} \qquad \text{AG}$ | A1 | 3 | Correct T from correct working |
| $\begin{array}{c c c c c c c c c c c c c c c c c c c $ | | | | 2 | |
| $\begin{array}{c c c c c c c c c c c c c c c c c c c $ | (b) | $ v^2$ | | | |
| $\begin{array}{c c c c c c c c c c c c c c c c c c c $ | | $T\cos 60^\circ = 2 \times \frac{1}{0.6}$ | | | A |
| Total73(a)(i) $a = 2 + 12e^{-t}$ M1A12Differentiating, with at least one term correct. Correct velocity(ii) $2 < a \le 14$ B1,B1For 2, For 14B13Correct inequalities(b) $s = t^2 + 12e^{-t} + c$ M1Integrating, with at least one term correct. Correct expression with or without c $s = 0, t = 0 \Rightarrow c = -12$ dM1Finding c $s = 0, t = 0 \Rightarrow c = -12$ A14Correct final expression $s = t^2 + 12e^{-t} - 12$ A14Correct final expression(b) $F = (30 \times 42) \times 42$ $= 52920$ WM1Sinding force Correct answer from $P = Fv$ (b)(i) $F = 1200 \times 9.8 \sin 5^{\circ} + 30v$ M1A12Finding force Correct answer from $P = Fv$ (b)(i) $F = 1200 \times 9.8 \sin 5^{\circ} + 30v$ M1A14Correct equation from correct working AG $v^2 + 392 \sin 5^{\circ}v - 1764 = 0$ A14Correct equation from correct working AG(ii) $v = \frac{-392 \sin 5^{\circ} \pm \sqrt{(392 \sin 5^{\circ})^2 - 4 \times 1 \times (-1764)}}{2 \times 1}$ M14Solving quadratic $v = 28.3$ or -62.4 $v = 28.3$ or s^{-1} A12Correct solution | | | | | - |
| 3(a)(i) (ii) $a = 2 + 12e^{-t}$ M1A12Differentiating, with at least one term correct. Correct velocity For 2, For 14 Correct inequalities(ii) $2 < a \le 14$ B1,B1B13Correct inequalities(b) $s = t^2 + 12e^{-t} + c$ M1A1Correct expression with or without c $s = 0, t = 0 \Rightarrow c = -12$ M1A1Gorrect final expression(b) $s = t^2 + 12e^{-t} - 12$ A14Correct final expression(b) $p = (30 \times 42) \times 42$ $= 52920$ WAGM1 A12Finding force Correct answer from $P = Fv$ (b)(i) $F = 1200 \times 9.8 \sin 5^{\circ} + 30v$ M1A12Finding force Correct answer from $P = Fv$ (b)(i) $F = 1200 \times 9.8 \sin 5^{\circ} + 30v$ M1A14Solving quadratic(ii) $v = \frac{-392 \sin 5^{\circ} t \sqrt{(392 \sin 5^{\circ})^2 - 4 \times 1 \times (-1764)}}{2 \times 1}$ M14Solving quadratic(iii) $v = \frac{-392 \sin 5^{\circ} t \sqrt{(392 \sin 5^{\circ})^2 - 4 \times 1 \times (-1764)}}{2 \times 1}$ M12Correct solution | | | Al | | Correct v |
| (ii) $2 < a \le 14$ $(ii) 2 < a \le 14$ $(b) s = t^2 + 12e^{-t} + c$ $s = 0, t = 0 \Rightarrow c = -12$ $s = t^2 + 12e^{-t} - 12$ $(b) s = t^2 + 12e^{-t} - 12$ (c) = texpression with or without c $s = t^2 + 12e^{-t} - 12$ (c) = texpression with or without c (c) = texpression texpression with or without c (c) = texpression texpression with or without c (c) = texpression texpress | 2(a)(i) | Total | | | |
| (ii) $2 < a \le 14$ (b) $s = t^2 + 12e^{-t} + c$ $s = 0, t = 0 \Rightarrow c = -12$ $s = t^2 + 12e^{-t} - 12$ (b) $P = (30 \times 42) \times 42$ s = 52920 W (c) $P = 1200 \times 9.8 \sin 5^\circ + 30v$ $V^2 + 392 \sin 5^\circ t - 1764 = 0$ (ii) $v = \frac{-392 \sin 5^\circ \pm \sqrt{(392 \sin 5^\circ)^2 - 4 \times 1 \times (-1764)}}{2 \times 1}$ (iii) $v = \frac{-392 \sin 5^\circ \pm \sqrt{(392 \sin 5^\circ)^2 - 4 \times 1 \times (-1764)}}{2 \times 1}$ (iv) $v = 28.3 \text{ or } -62.4$ v = 28.3 or -62.4 v = 28.3 or -62.4 | S(a)(1) | $a = 2 + 12e^{-t}$ | MIAI | 2 | |
| $\begin{array}{c ccccccccccccccccccccccccccccccccccc$ | (ii) | $2 < a \leq 14$ | R1 R1 | | |
| (b) $s = t^2 + 12e^{-t} + c$ $s = 0, t = 0 \Rightarrow c = -12$ $s = t^2 + 12e^{-t} - 12$ 41 4 4 5 4 4 4 4 5 5 4 4 4 5 5 4 4 5 5 4 5 4 5 5 4 5 4 4 5 5 4 5 4 5 4 4 4 5 5 4 4 4 5 5 4 4 4 4 4 5 5 4 4 4 4 4 4 5 5 4 4 4 4 4 4 4 4 4 4 4 4 4 | (11) | 2 < u = 14 | - | 3 | |
| A1 s = 0, t = 0 \Rightarrow c = -12 s = t^2 + 12e^{-t} - 12A1 dM1A1 Finding c Correct expression with or without c Finding c Correct final expression4(a) $P = (30 \times 42) \times 42$ = 52920 WAG AGM1 A12Finding force Correct answer from $P = Fv$ (b)(i) $F = 1200 \times 9.8 \sin 5^{\circ} + 30v$ M1A12Finding force. Correct answer from $P = Fv$ (b)(i) $F = 1200 \times 9.8 \sin 5^{\circ} + 30v$ M1A14Correct equation from correct force $v^2 + 392 \sin 5^{\circ}v - 1764 = 0$ A14Correct equation from correct working AG(ii) $v = \frac{-392 \sin 5^{\circ} \pm \sqrt{(392 \sin 5^{\circ})^2 - 4 \times 1 \times (-1764)}}{2 \times 1}$ M1Solving quadratic $v = 28.3 \text{ or } -62.4$ $v = 28.3 \text{ or } -62.4$ A12Correct solution | (b) | $s = t^2 + 12e^{-t} + c$ | M1 | | * |
| $\begin{array}{c c c c c c c c c c c c c c c c c c c $ | | | A1 | | |
| Total94(a) $P = (30 \times 42) \times 42$ $= 52920$ WAGM1 A12Finding force Correct answer from $P = Fv$ (b)(i) $F = 1200 \times 9.8 \sin 5^{\circ} + 30v$ M1A12Finding force. Correct force $52920 = (1200 \times 9.8 \sin 5^{\circ} + 30v)v$ dM1Using $P = Fv$ $v^2 + 392 \sin 5^{\circ}v - 1764 = 0$ A14Correct equation from correct working AG(ii) $v = \frac{-392 \sin 5^{\circ} \pm \sqrt{(392 \sin 5^{\circ})^2 - 4 \times 1 \times (-1764)}}{2 \times 1}$ M1Solving quadratic $v = 28.3$ or -62.4 $v = 28.3$ ms ⁻¹ A12Correct solution | | $s = 0, t = 0 \Longrightarrow c = -12$ | | | Finding <i>c</i> |
| Total94(a) $P = (30 \times 42) \times 42$ $= 52920$ WAGM1 A12Finding force Correct answer from $P = Fv$ (b)(i) $F = 1200 \times 9.8 \sin 5^{\circ} + 30v$ M1A12Finding force. Correct force $52920 = (1200 \times 9.8 \sin 5^{\circ} + 30v)v$ dM1Using $P = Fv$ $v^2 + 392 \sin 5^{\circ}v - 1764 = 0$ A14Correct equation from correct working AG(ii) $v = \frac{-392 \sin 5^{\circ} \pm \sqrt{(392 \sin 5^{\circ})^2 - 4 \times 1 \times (-1764)}}{2 \times 1}$ M1Solving quadratic $v = 28.3$ or -62.4 $v = 28.3$ ms ⁻¹ A12Correct solution | | $s = t^2 + 12e^{-t} - 12$ | A1 | 4 | Correct final expression |
| $\begin{array}{c ccccccccccccccccccccccccccccccccccc$ | | | | | ^ |
| $= 52920 \text{ W}$ $F = 1200 \times 9.8 \sin 5^{\circ} + 30v$ $F = 1200 \times 9.8 \sin 5^{\circ} + 30v)v$ $V^{2} + 392 \sin 5^{\circ} v - 1764 = 0$ $V = \frac{-392 \sin 5^{\circ} \pm \sqrt{(392 \sin 5^{\circ})^{2} - 4 \times 1 \times (-1764)}}{2 \times 1}$ $W = \frac{-392 \sin 5^{\circ} \pm \sqrt{(392 \sin 5^{\circ})^{2} - 4 \times 1 \times (-1764)}}{2 \times 1}$ $M1$ $V = \frac{-392 \sin 5^{\circ} \pm \sqrt{(392 \sin 5^{\circ})^{2} - 4 \times 1 \times (-1764)}}{2 \times 1}$ $M1$ $Solving quadratic$ $V = 28.3 \text{ or } -62.4$ $V = 28.3 or$ | 4(a) | $P = (30 \times 42) \times 42$ | | | e |
| (ii) $52920 = (1200 \times 9.8 \sin 5^{\circ} + 30v)v$ $v^{2} + 392 \sin 5^{\circ}v - 1764 = 0$ $M1$ $A1$ 4 $Using P = Fv$ $Correct equation from correct working AG$ G $V = \frac{-392 \sin 5^{\circ} \pm \sqrt{(392 \sin 5^{\circ})^{2} - 4 \times 1 \times (-1764)}}{2 \times 1}$ $V = 28.3 \text{ or } -62.4$ $v = 28.3 \text{ ms}^{-1}$ $A1$ 2 $Correct solution$ | | = 52920 W | A1 | 2 | Correct answer from $P = Fv$ |
| (ii) $v^{2} + 392 \sin 5^{\circ} v - 1764 = 0$ $A1$ $A1$ $Correct equation from correct working AG$ $V = \frac{-392 \sin 5^{\circ} \pm \sqrt{(392 \sin 5^{\circ})^{2} - 4 \times 1 \times (-1764)}}{2 \times 1}$ $V = 28.3 \text{ or } -62.4$ $V = 28.3 \text{ ms}^{-1}$ $A1$ $Correct equation from correct working AG$ $Correct solution$ | (b)(i) | $F = 1200 \times 9.8 \sin 5^\circ + 30v$ | M1A1 | | Finding force. Correct force |
| (ii) $v = \frac{-392 \sin 5^{\circ} \pm \sqrt{(392 \sin 5^{\circ})^{2} - 4 \times 1 \times (-1764)}}{2 \times 1}$ M1 Solving quadratic $v = 28.3 \text{ or } -62.4$ $v = 28.3 \text{ ms}^{-1}$ A1 2 Correct solution | | $52920 = (1200 \times 9.8 \sin 5^\circ + 30v)v$ | dM1 | | Using $P = Fv$ |
| $v = \frac{-392 \sin 3 \pm \sqrt{(392 \sin 3)^2 - 4 \times 1 \times (-1764)}}{2 \times 1}$ M1 v = 28.3 or -62.4 v = 28.3 ms ⁻¹ A1 2 Correct solution | | $v^2 + 392\sin 5^\circ v - 1764 = 0$ | A1 | 4 | |
| $v = 28.3 \text{ ms}^{-1}$ A1 2 Correct solution | (ii) | <i>v</i> =2×1 | M1 | | Solving quadratic |
| | | | Δ1 | 2 | Correct solution |
| Total 8 | | | AI | | |

| Q | Solution | Marks | Total | Comments |
|------|--|-------|-------|---|
| 5 | | M1 | | Applying Newton's second law with $40v$ |
| | $1 \cos dv$ to | | | and $\frac{dv}{dt}$. |
| | $1600\frac{dv}{dt} = -40v$ | A 1 | | <i>dt</i> Correct equation |
| | | A1 | | Concer equation |
| | $\begin{bmatrix} 1 \\ d \end{bmatrix} = \begin{bmatrix} 1 \\ d \end{bmatrix} = \begin{bmatrix} 1 \\ d \end{bmatrix}$ | dM1 | | Separating variables |
| | $\int \frac{1}{v} av = \int \frac{1}{40} at$ | GIVII | | Separating variables |
| | $\int \frac{1}{v} dv = \int -\frac{1}{40} dt$ $\ln v = -\frac{t}{40} + c$ $v = Ae^{-\frac{t}{40}}$ | dM1 | | integrating to get lnv term. |
| | $\frac{t}{40}$ | A1 | | Correct integral with or without <i>c</i> |
| | $v = Ae^{-40}$ $t = 0, v = 20 \Longrightarrow c = 20$ | dM1 | | Finding constant |
| | $v = 20e^{-\frac{t}{40}}$ | Al | 7 | Correct final result |
| | | | | |
| | Total | M1 | 7 | Three term energy equation |
| 6(a) | $\frac{1}{2}mv^2 = \frac{1}{2}m \times 2^2 + mg(3 - 3\cos\theta)$ $v^2 = 4 + 6g(1 - \cos\theta) \text{ AG}$ | Al | | Correct equation |
| | | dM1 | 4 | Solving for v^2 . |
| | $v^2 = 4 + 6g(1 - \cos\theta) \text{ AG}$ | | 4 | Correct result from correct working |
| | | A1 | | Concernes in tom concer working |
| (b) | $mg\cos\theta = m\frac{v^2}{3}$ | M1 | | Resolving towards the centre |
| | $mg\cos\theta - m\frac{1}{3}$ | A1 | | Correct equation |
| | $3g\cos\theta = 4 + 6g - 6g\cos\theta$ | dM1 | | Solving for $\cos\theta$ |
| | | | | |
| | $\cos\theta = \frac{4+6g}{9g}$ | A1 | | Correct $\cos \theta$ |
| | $\theta = 44.6^{\circ}$ | A1 | 5 | Correct angle |
| | Total | | 9 | |

MM2A (cont)

| Q | Solution | Marks | Total | Comments |
|--------|---|----------------|-------|---|
| 7(a) | $\frac{100}{0.4} e = 10 \times 9.8$ | M1 | | Use of Hookes law and equilibrium |
| | e = 0.392 m | A1 | 2 | Correct length |
| (b) | $EPE = \frac{1}{2} \times \frac{100}{0.4} \times 0.6^2 = 45 \text{ J}$ AG | M1 A1 | 2 | Use of EPE formula Correct value from correct working |
| (c)(i) | $45 = \frac{1}{2} \times \frac{100}{0.4} (x - 0.4)^2 + \frac{1}{2} \times 10v^2 + 10 \times 9.8(1 - x)$ | M1 A1 M1 | | Expression for EPE with $(x \pm 0.4)^2$ Correct EPE Four term energy equation |
| | $45 = 125(x - 0.4)^2 + 5v^2 + 98(1 - x)$ | B1 | | Correct GPE |
| | | A1 | | Correct equation |
| | $5v^{2} = 98x - 98 + 45 - 125x^{2} + 100x - 20$ $v^{2} = 39.6x - 25x^{2} - 14.6 \text{ AG}$ | dM1 A1 | 7 | Solving for v^2 Correct result from correct working |
| (ii) | $39.6x - 25x^2 - 14.6 = 0$ $25x^2 - 39.6x + 14.6 = 0$ | | 1 | |
| | $x = \frac{39.6 \pm \sqrt{39.6^2 - 4 \times 25 \times 14.6}}{2 \times 25}$ | M1 | | Solving quadratic |
| | =1 or 0.584 | A1 | | Correct solutions |
| | <i>x</i> = 0.584 | A1 | 3 | Appropriate value selected SC Only correct answers given, award M1A1. |
| | Total | | 14 | |
| | TOTAL | | 60 | |