**Paper 2 Option 2J**

**Further Mechanics 1 Mark Scheme (Section A)**

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **1(a)** | Using the model and *v*2 = *u*2 + 2*as* to find *v* | M1 | 3.4 |
| *v*2 = 2*as* = 2*g*  2.4 = 4.8*g* => *v = √*(4.8*g*) | A1 | 1.1b |
| Using the model and *v*2 = *u*2 + 2*as* to find *u* | M1 | 3.4 |
| 02 = *u*2 – 2*g*  0.6 => *u = √*(1.2*g*) | A1 | 1.1b |
| Using the correct strategy to solve the problem by finding the sep. speed and app. speed and applying NLR | M1 | 3.1b |
| *e* = *√*(1.2*g*)/ *√*(4.8*g*) = 0.5 \* | A1\* | 1.1b |
|  | **(6)** |  |
| **(b)** | Using the model and *e* = sep. speed / app. speed,*v*  = 0.5*√*(1.2*g*) | M1 | 3.4 |
| Using the model and *v*2 = *u*2 + 2*as* | M1 | 3.4 |
| 02 = 0.25 (1.2*g*) – 2*gh* => *h =* 0.15 (m) | A1 | 1.1b |
|  | **(3)** |  |
| **(c)** | Ball continues to bounce with the height of each bounce being a quarter of the previous one | B1 | 2.2b |
|  | **(1)** |  |
| **(10 marks)** |
| **Notes:** |
| **(a)****M1:** For a complete method to find *v***A1:** For a correct value (may be numerical)**M1:** For a complete method to find *u***A1:** For a correct value (may be numerical)**M1:** For finding both *v* and *u* and use of Newton’s Law of Restitution**A1\*:** For the given answer |
| **(b)****M1:** For use of Newton’s Law of Restitution to find rebound speed**M1:** For a complete method to find *h***A1:** For 0.15 (m) oe |
| **(c)** **B1:** For a clear description including reference to a quarter |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **2(a)** | Energy Loss = KE Loss – PE Gain | M1 | 3.3 |
|  =  0.5  252 – 0.5 *g*  20 | A1 | 1.1b |
|  = 58.25 = 58 (J ) or 58.3 (J) | A1 | 1.1b |
|  | **(3)** |  |
| **(b)** |  Using work-energy principle, 20 *R* = 58.25 | M1 | 3.3 |
|  *R* = 2.9125 = 2.9 or 2.91  | A1ft | 1.1b |
|  | **(2)** |  |
| **(c)** | Make resistance variable (dependent on speed) | B1 | 3.5c |
|  | **(1)** |  |
| **(6 marks)** |
| **Notes:** |
| **(a)****M1:** For a difference in KE and PE**A1:** For a correct expression**A1:** For either 58 (2sf) or 58.3(3sf) |
| **(b)****M1:** For use of work-energy principle**A1ft:** For either 2.9 (2sf) or 2.91 (3sf) follow through on their answer to (a) |
| **(c)****B1:** For variable resistance oe |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **3(a)** | Force = Resistance (since no acceleration) = 30 | B1 | 3.1b |
| Power = Force  Speed = 30  4 | M1 | 1.1b |
|  = 120 W | A1 **ft** | 1.1b |
|  | **(3)** |  |
| **(b)** | Resolving parallel to the slope | M1 | 3.1b |
| *F* – 60*g*sin** | A1 | 1.1b |
| *F* = 70  | A1 | 1.1b |
| Power = Force  Speed = 70  3 | M1 | 1.1b |
|  = 210 W | A1 **ft** | 1.1b |
|  | **(5)** |  |
|  **(8 marks)** |
| **Notes:** |
| **(a)****B1:** For force = 30 seen**M1:** For use of *P = Fv***A1ft:**  For 120 (W), follow through on their ‘30’ |
| **(b)****M1:** For resolving parallel to the slope with correct no. of terms and 60*g* resolved**A1:** For a correct equation**A1:** For *F* = 70**M1:** For use of *P = Fv***A1ft:** For 210 (W), follow through on their ‘70’ |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **4(a)** | Use of conservation of momentum | M1 | 3.1a |
| 3*mu* – 2*mu* = 3*mv* + *mw* | A1 | 1.1b |
| Use of NLR | M1 | 3.1a |
|  3*ue* = -*v* + *w* | A1 | 1.1b |
| Using a correct strategy to solve the problem by setting up two equations (need both) in *u* and *v* and solving for *v* | M1 | 3.1b |
|   | A1 | 1.1b |
|  | **(6)** |  |
| **(b)** |   | M1 | 3.1b |
|   | A1 | 1.1b |
|  | **(2)** |  |
| **(c)** | Solving for *w* | M1 | 2.1 |
|  \*  | A1 \* | 1.1b |
|  | **(2)** |  |
| **(d)** | Substitute  | M1 | 1.1b |
|  | A1 | 1.1b |
| Use NLR for impact with wall, *x* = *f w*  | M1 | 1.1b |
| Further collision if  | M1 | 3.4 |
|  | A1 | 1.1b |
|  1 ≥ | A1 | 1.1b |
|  | **(6)** |  |
| **(16 marks)** |
| **Notes:** |
| **(a)****M1:** For use of CLM, with correct no. of terms, condone sign errors**A1:** For a correct equation**M1:** For use of Newton’s Law of Restitution, with *e* on the correct side**A1:** For a correct equation**M1:** For setting up *two* equations and solving their equations for *v***A1:** For a correct expression for *v*  |
| **(b)****M1:** For use of an appropriate inequality**A1:** For a complete range of values of *e* |
| **(c)****M1:** For solving their equations for *w***A1:** For the given answer |

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| **Question 4 notes continued:** |
| **(d)****M1:** For substituting  into their *v* and *w***A1:** For correct expressions for *v* and *w***M1:** For use of Newton’s Law of Restitution, with *e* on the correct side**M1:** For use of appropriate inequality**A1:** For a correct inequality**A1:** For a correct range |

**Further Mechanics 2 Mark Scheme (Section B)**

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **5 (a)** | Multiply out and differentiate wrt *t*  | M1 | 1.1b |
|  | A1 | 1.1b |
|  | **(2)** |  |
| **(b)** | Multiply out and integrate wrt *t* | M1 | 1.1b |
|  | A1 | 1.1b |
|  => *C* = 0 | A1  | 1.1b |
|  | **(3)** |  |
| **(c)** |  and  | M1 | 2.1 |
| Explanation to show that *t*2 – 8*t* + 20 > 0 for all *t*. | M1 | 2.4 |
| So *s* = 0 has no non-zero solutions, so *s* is never zero again, so never returns to *O* \* |  A1\* | 3.2a |
|  | **(3)** |  |
| **(8 marks)** |
| **Notes:**  |
| **(a)** **M1:** For multiplying out and differentiating (powers decreasing by 1)**A1:** For a correct expression for *a* |
| **(b)****M1:** For multiplying out and integrating (powers increasing by 1)**A1:** For a correct expression for *s*  with or without *C***A1:** For *C* = 0 and correct final answer |
| **(c)****M1:** For equating their *s* to 0 and producing a quadratic**M1:** For clear explanation that *t*2 – 8*t* + 20 > 0 for all *t* (e.g. completing the square or another  complete method)**A1\*:** For a correct conclusion in context |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **6(a)** |  | B1 | 1.1b |
|    | B1 | 1.1b |
| Resolving vertically  | M1 | 3.1b |
|  | A1  | 1.1b |
| Resolving horizontally  | M1 | 3.1b |
|  | A1  | 1.1b |
|  | A1 | 1.1b |
| Solving for either tension | M1 | 2.1 |
|   \*  | A1\*  | 1.1b |
|  \*  |  A1\* | 1.1b |
|  |  **(10)** |  |
| **(b)** |  |  M1 | 2.1 |
|  |  M1 | 2.1 |
|  or  |  A1 | 2.2a |
|  |  M1 | 1.1b |
|  \*  |  A1\* | 1.1b |
|  |  **(5)** |  |
| **(c)** | String being light implies that the tension is constant in both portions of the string |  B1 | 3.5b |
|  |  **(1)** |  |
| **(16 marks)** |
| **Notes:** |
| **(a)** **B1:** For correct trig. ratio seen**B1:** For a correct radius expression seen**M1:** For resolving vertically with correct no. of terms and tensions resolved**A1:** For a correct equation**M1:** For resolving horizontally with correct no. of terms and tensions resolved**A1A1:** For a correct equation**M1:** For solving their two equations to find either tension**A1\*:** For the given answer**A1\*:** For the given answer |

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| **Question 6 notes continued:** |
| **(b)****M1:** For use of **M1:** For using *T*2 > 0**A1:** For a correct inequality (either) for **M1:** For use of with either critical value**A1\*:** For given answer |
| **(c)****B1:** For a clear explanation |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **7(a)** | Rel. Mass: 2 5 1 8 | B1 | 1.2 |
|  *y* : 2 0.5 1.5  | B1 | 1.2 |
|  *x* : 0.5 2.5 4.5  | B1 | 1.2 |
|  (2  2) + (5  0.5) + (11.5) = 8 | M1 | 2.1 |
|  = 1 \*  | A1\* | 1.1b |
|  (2  0.5) + (5  2.5) + (1  4.5) = 8 | M1 | 2.1 |
|  *=* 2.25 | A1  | 1.1b |
|  | **(7)** |  |
| **(b)** |  Use of correct strategy to solve the problem by use of ‘moments equation’ | M1 | 3.1b |
|  (8  2.25) - (2*πr*2  0.5) = (8 - 2*πr*2)2.5 | A1ft | 1.1b |
|  Solving for *r*  | M1 | 1.1b |
|  *r*  = *=* 0.399  | A1  | 1.1b |
|  | **(4)** |  |
| **(c)**  | Since for original plate is 1, holes must be symmetrically placed about the line *y* = 1 | B1 | 2.4 |
|  *a =* 1.5 | B1  | 2.2a |
|  | **(2)** |  |
| **(d)** | Use of tan from an appropriate triangle | M1 | 1.1a |
|  | A1ft | 1.1b |
|  ** | A1  | 1.1b |
|  | **(3)** |  |
| **(16 marks)** |
| **Notes:** |
| **(a)****B1:** For correct relative masses**B1:** For correct *y* values**B1:** For correct *x* values**M1:** For a moments equation, correct no. of terms, condone sign errors**A1\*:** For a correct given answer (1)**M1:** For a moments equation, correct no. of terms**A1:** For 2.25 |
| **(b)****M1:** For a moments equation, correct no. of terms, condone sign errors**A1ft:** For a correct equation, follow through on their **M1:** For solving for *r***A1:** For 0.399 or 0.40 |
| **Question 7 notes continued:** |
| **(c)****B1:** For consideration of symmetry about *y* = 1**B1:** For *a* = 1.5 |
| **(d)****M1:** For use of tan from an appropriate triangle**A1ft:** For a correct equation, follow through on their *a***A1:** For a correct angle  |