**Paper 3C/4C: Further Mechanics 1 Mark Scheme**

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **1** | Use Impulse-momentum principle | M1 | 2.1 |
|  | A1 | 1.1b |
|  (m s-1) | A1 | 1.1b |
| Use of KE =  | M1 | 2.1 |
|   | A1 | 1.1b |
|  (J) \* | A1\* | 1.1b |
|  | **(6)** |  |
| **(6 marks)** |
| **Notes:** |
| **M1:** Difference of terms & dimensionally correct**A1:** Correct unsimplified equation**A1:** cao**M1:** Must be a difference of two terms  Must be dimensionally correct**A1:** Correct unsimplified equation**A1\*:** Complete justification of given answer |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **2(a)** |   | M1 | 3.4 |
| Force due to friction =  | M1 | 3.4 |
| Work-Energy equation | M1 | 3.4 |
|   | A1 | 1.1b |
|    | A1 | 1.1b |
|  | **(5)** |  |
| **(b)** | Appropriate refinement | B1 | 3.5c |
|  | **(1)** |  |
| **(6 marks)** |
| **Notes:** |
| **(a)****M1:** Condone sin/cos confusion**M1:** Use of  their R**M1:** Must be using work-energy. Requires all terms  Condone sin/cos confusion, sign errors and their *R***A1:** Correct in **A1:** Accept 0.0913 **or**  0.091 |
| **(b)****B1:** e.g.  - do not model the parcel as a particle and therefore take air resistance into account - take into account the dimensions/uniformity of the parcel |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **3(a)** | Use NEL to find the speed of particle after the first impact  | B1 | 3.4 |
| Impulse =   | M1 | 3.1b |
|  | A1 | 1.1b |
|  | **(3)** |  |
| **(b)** | Use NEL to find the speed of the particle after the second impact  | B1 | 3.4 |
| Use of  to find total time | M1 | 3.1b |
|   | A1 | 1.1b |
| Solve for *u*:  | M1 | 1.1b |
|   | A1 | 1.1b |
|  | **(5)** |  |
| **(8 marks)** |
| **Notes:** |
| **(a)****B1:** Using Newton's experimental law as a model to find the speed after the first impact**M1:** Must be a difference of two terms, taking account of the change in direction of motion**A1:** cao |
| **(b)****B1:** Using NEL as a model to find the speed after the second impact**M1:** Needs to be used for at least one stage of the journey**A1:** Ur equivalent**M1:** Solve their linear equation for *u***A1:** Accept 1.56 or better |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **4(a)** | Complete strategy to find the kinetic energy after the second impact | M1 | 3.1b |
| Parallel to *AB* after collision:   | M1 | 3.1b |
| Perpendicular to *AB* after collision:  | M1 | 3.4 |
| Components of velocity after first impact:   | A1 | 1.1b |
| Parallel to *BC* after collision:    | M1 | 3.1b |
| Perpendicular to *BC* after collision:   | M1 | 3.4 |
| Components of velocity after second impact:  | A1 | 1.1b |
| Final KE =  |  |  |
| Fraction of initial KE   **\*** | A1\* | 2.2a |
|   | **(8)** |  |
| **(b)** | The answer is too large - rough surface means resistance so final speed will be lower | B1 | 3.5a |
|  | **(1)** |  |
| **(9 marks)** |
| **Notes:** |
| **(a)****M1:** Use of CLM parallel to the wall. Condone sin/cos confusion**M1:** Use NEL as a model to find the speed perpendicular to the wall. Condone sin/cos confusion**A1:** Both components correct with trig substituted (seen or implied)**M1:** Use of CLM parallel to the wall. Condone sin/cos confusion**M1:** Use NEL as a model to find the speed perpendicular to the wall. Condone sin/cos confusion**A1:** Both components correct with trig substituted (seen or implied)**M1:** Correct expression for total KE using their components after 2nd collision**A1\*:** Obtain **given answer** with sufficient working to justify it |
| **(b)** **B1:** Clear explanation of how the modelling assumption has affected the outcome |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **5(a)** | Use of  :  | B1 | 3.3 |
| Equation of motion: *F* – (200 + 2*v*) = 600*a* | M1 | 3.4 |
|  600 – 240 = 600*a* | A1ft | 1.1b |
| 360 = 600*a*, *a* = 0.6 (m s-2) | A1 | 1.1b |
|  | **(4)** |  |
| **(b)** | Equation of motion: | M1 | 3.3 |
|   | A1 A1 | 1.1b1.1b |
| 3 term quadratic and solve:  | M1 | 1.1b |
| (m s-1) | A1 | 1.1b |
|  | **(5)** |  |
| **(9 marks)** |
| **Notes:** |
| **(a)****B1:** 600 or equivalent**M1:** Use the model to form the equation of motion Must include all terms .Condone sign errors**A1ft:** Correct for their *F***A1:** cao |
| **(b)****M1:** Use the model to form the equation of motion All terms needed. Condone sign errors and sin/cos confusion**A1:** All correct A1A1 One error A1A0**M1:** Dependent on the preceding M1. Use the equation of motion to form a 3-term quadratic  in *w* only**A1:** Accept 19. Do not accept more than 3 s.f. |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **6(a)** |  |  |  |
| Overall strategy to find   | M1 | 3.1a |
| Velocity of *A* perpendicular to loc after collision  (m s-1) | B1 | 3.4 |
| CLM parallel to loc  | M1 | 3.1a |
|   (−9 = 3*w*-2*v*) | A1 | 1.1b |
| Correct use of impact law | M1 | 3.1a |
|   (= 2) | A1 | 1.1b |
|  Solve for *w*   |  |  |
|   (m s-1),  | A1ft | 1.1b |
|  | **(7)** |  |
| **(b)** |  | M1 | 3.1a |
|  (nearest degree) | A1 | 1.1b |
| Alternative method:  (nearest degree) |  |  |
|  | **(2)** |  |
| **(9 marks)** |
| **Notes:** |
| **(a)****M1:** Correct overall strategy to form sufficient equations and solve for **B1:** Use the model to find the component of  perpendicular to the line of centres**M1:** Use CLM to form equation in *v* and *w*. Need all 4 terms, dimensionally correct**A1:** Correct unsimplified**M1:** Must be used the right way round**A1:** Correct unsimplified**A1ft:** **v***B* correct. Follow their  |
| **(b)****M1:** Complete method for finding the required angle. Follow their **v***B***A1:** cao |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **7(a)** | In equilibrium  no resultant vertical force | M1 | 2.1 |
|   | A1 | 1.1b |
|  ,  \* | A1\* | 2.2a |
|  | **(3)** |  |
| **(b)** | Equation of motion: | M1 | 3.1a |
|    | A1 | 1.1b |
|   | A1 | 1.1b |
|  | **(3)** |  |
| **(c)** | Max speed at equilibrium position | B1 | 3.1a |
| Work energy & use of  | M1 | 3.1a |
|  | A1A1 | 1.1b1.1b |
|  ,   | A1 | 1.1b |
|  | **(5)** |  |
| **(d)** | At max ht. KE = 0. EPE lost = GPE gained | M1 | 3.1a |
|  | A1 | 1.1b |
|  | A1 | 1.1b |
|  | **(3)** |  |
| **(14 marks)** |

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| **Question 7 notes:** |
| **(a)****M1:** Use to form equation for equilibrium**A1:** Correct unsimplified equation**A1\*:** Requires sufficient working to justify given answer plus a 'statement' that the required result has been achieved |
| **(b)****M1:** Use  to form equation of motion Need all 3 terms. Condone sign errors**A1:** Correct unsimplified equation**A1:** cao |
| **(c)****B1:** Seen or implied**M1:** Form work-energy equation. All 4 terms needed  Condone sign errors**A1:** Correct unsimplified equation A1A1 One error in the equation A1A0**A1:** cao |
| **(d)****M1:** Form energy equation**A1:** Correct unsimplified equation**A1:** cao |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **8(a)** |  |  |  |
| Complete overall strategy to find *v*  | M1 | 3.1a |
| Use of CLM  | M1 | 3.1a |
|  ,  | A1 | 1.1b |
| Use of Impact law: | M1 | 3.1a |
|   | A1 | 1.1b |
| Solve for *v*:  |  |  |
|    | A1 | 1.1b |
|  Direction of *Q* reversed:   | M1 | 3.4 |
|   | A1 | 1.1b |
|   | **(8)** |  |
| **(b)** |    ,  | B1 | 2.1 |
| Equation for KE lost  | M1 | 2.1 |
|  | A1A1 | 1.1b1.1b |
|  **\*** | A1\* | 2.2a |
|  | **(5)** |  |
| **(c)** | Increase *e*  more elastic less energy lost | B1 | 2.2a |
|  | **(1)** |  |
| **(14 marks)** |

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| **Question 8 notes:** |
| **(a)****M1:** Complete strategy to form sufficient equations in *v* and *w* and solve for *v***M1:** Use CLM to form equation in *v* and *w* Needs all 4 terms & dimensionally correct**A1:** Correct unsimplified equation**M1:** Use NEL as a model to form a second equation in *v* and *w*. Must be used the right way round**A1:** Correct unsimplified equation**A1:** for *v* or 7*v* correct**M1:** Use the model to form a correct inequality for their *v* **A1:** Both limits required |
| **(b)****B1:** Or equivalent statements**M1:** Terms of correct structure combined correctly**A1:** Fully correct unsimplified A1A1 One error on unsimplified expression A1A0**A1\*:** cso. plus a 'statement' that the required result has been achieved |
| **(c)****B1:** "less energy lost" or equivalent |