**9FM0/3C: Further Mechanics 01 Mark scheme**

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **1(a)** | Driving force  (N) | B1 | 3.1b |
| No resultant force   | M1 | 3.4 |
|   is a solution\* | A1\* | 2.2a |
|   so no more real roots,   is the only solution. | A1 | 2.4 |
|  | **(4)** |  |
| **(b)** | Equation of motion:  | M1 | 3.4 |
|   | A1 | 1.1b |
|  | A1 | 1.1b |
|     | M1 | 1.1b |
|   m s-2 (0.947) | A1 | 1.1b |
|  | **(5)** |  |
| **(9 marks)** |
| **Notes:** |
| 1a | B1 | Use  to find the driving force |
|  | M1 | Use the model to form an equation in *V* |
|  | A1\* | Solve equation to obtain solution  (complex roots  ) |
|  | A1 | CSO. Justification that is the only real solution e.g. by considering determinant of quadratic factor, completing the square or stating all 3 roots and confirming that only one root is real |
| SR | A candidate who verifies that is a solution can score 2/4: |
|  | B1 | Use  to find the driving force |
|  | M1 | Complete method to show that there is no resultant force when that  |
| 1b | M1 | Use the model to form the equation of motion of the van. All terms required. Condone sign errors and sin/cos confusion |
|  | A1 | Unsimplified equation with at most one error |
|  | A1 | Correct unsimplified equation |
|  | M1 | Substitute for *v* and trig and solve for *a* |
|  | A1 | Accept 2s.f. or 3s.f. (9.8 used) |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **2** | EPE  or EPE  | B1 | 3.4 |
| Gain in GPE   | B1 | 1.1b |
| Work done against friction   | B1 | 1.1b |
| Work-Energy equation | M1 | 3.1a |
|      | A1 | 1.1b |
| Substitute trig and solve for :   |  |  |
|     | A1 | 1.1b |
|  | **[6]** |  |
| **(6 marks)** |
| **Notes:** |
| 2 | B1 | Correct unsimplified expression for EPE at *B* or at *C* |
|  | B1 | Correct unsimplified expression for GPE gained *B* to *C* |
|  | B1 | Correct unsimplified expression for WD against friction *B* to *C* |
|  | M1 | All terms required. Condone sign errors and sin/cos confusion. |
|  | A1 | Correct unsimplified equation |
|  | A1 |  or better (*g* cancels) |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **3(a)** | Impulse momentum equation | M1 | 2.1 |
|    | A1 | 1.1b |
|  Magnitude of the impulse  | M1 | 1.1b |
|   Follow their **I** | A1ft | 1.1b |
|   ,   | M1 | 2.2a |
|   (Ns)  | A1 | 1.1b |
|  | **(6)** |  |
| **3(b)** | Use of scalar product:   | M1 | 3.1a |
|   follow their   | A1ft | 1.1b |
|    | A1 | 1.1b |
|  | **(3)** |  |
| **3(b) alt** | Use trig to find 2 relevant angles:  ,  | (M1) | 3.1a |
|   or ,  | (A1) | 1.1b |
|   | (A1) | 1.1b |
|  | **(3)** |  |
| **(9 marks)** |
| **Notes:** |
| 3a | M1 | Use impulse momentum to find the impulse in terms of   |
|  | A1 | Correct unsimplified equation |
|  | M1 | Use Pythagoras and the given modulus |
|  | A1ft | Correct unsimplified expression using their **I** |
|  | M1 | Solve for ( or ) and find **I** |
|  | A1 | Correct answer |
| 3b | M1 | Complete strategy, using vectors or equivalent, to find relevant angleCould be working with velocity or momentum. |
|  | A1ft | Single trig ratio or all relevant angles. Follow their  |
|  | A1 |  or better |
| **Question** | **Scheme** | **Marks** | **AOs** |
| **4(a)** | Complete strategy to find *k*  | M1 | 3.1a |
| Resolve vertically:  | B1 | 1.1b |
| Hooke’s Law and equiibrium:   | M1 | 2.1 |
|   **\*** | A1\* | 2.2a |
|  | **(4)** |  |
| **4(b)** | Equation of motion:  | M1 | 3.1a |
|   ,   | A1 | 1.1b |
|    |  |  |
|    | A1 | 1.1b |
|  | **(3)** |  |
| **4(c)** | Conservation of energy:  | M1 | 3.1a |
|   | A1 | 1.1b |
|    | A1 | 1.1b |
|  | **(3)** |  |
| **4(d)** | Any sensible reason in context | B1 | 3.5b |
|  | **(1)** |  |
| **(11 marks)** |
| **Notes:** |
| 4a | M1 | Complete strategy e.g. resolve vertically to find *T* and use Hooke’s law |
|  | B1 | Correct substituted equation in *T* |
|  | M1 | Correct use of Hooke’s law and equilibrium to find the tension in the string |
|  | A1\* | Draw the information together to deduce the **given result** |

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| 4b | M1 | Use the model to form the equation of motion of *P*. Need all terms. Dimensionally correct. Condone sign errors and sin/cos confusion. |
| A1 | Correct substituted unsimplified. |
| A1 | 25 or 25.0 m s-2 if 9.8 used. |
| 4c | M1 | Use the model to write down the equation for conservation of energy: EPE lost = GPE gained + KE gained |
| A1 | Any unsimplified equivalent |
| A1  | Accept any equivalent simplified form or   |
| 4d | B1 | e.g. The pebble has dimensions, so the instant of crossing *AB* is not well- defined Some of the string could be taken up attaching the pebble Accuracy of the measurement of the speed |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **5** |  |  |  |
| After first impact: parallel to *AB*  2**i** | B1 | 2.1 |
|  Use of impact law perpendicular to *AB*  | M1 | 3.4 |
|     | A1 | 1.1b |
| Strategy to find final velocity  | M1 | 3.1b |
| Second impact: parallel to *BC*  | M1 | 3.1b |
|   follow their **v** | A1ft | 1.1b |
|  Component of velocity   | A1 | 1.1b |
| Vector perpendicular to the wall   | B1 | 3.1b |
| Use of impact law:  | M1 | 3.4 |
|    Follow their velocity and their perpendicular vector | A1ft | 1.1b |
|  Component of velocity  | A1 | 1.1b |
|   (sum of their components) |  |  |
|   (m s-1) **\*** | A1\* | 2.2a |
|  | **(12)**  |  |
| **5 alt** | ***For the last 9 marks*** |  |  |
| Strategy to find final velocity  | M1 |  |
| Perpendicular to  is  | B1 |  |
| Find components of the initial velocity parallel and perpendicular to :   | M1 |  |
|    | A1 |  |
|  ,  | A1 |  |
| Impact law perpendicular to plane:   | M1 |  |
|  Follow their perpendicular component | A1ft |  |
| Parallel component: Follow their parallel component | A1ft |  |
| Final velocity  \* | A1\* |  |
|  |  |  |  |
| **(12 marks)** |
| **Notes:** |
| 5 | B1 | Conservation of component parallel to the first wall |
| M1 | Use the impact law on the model to find the component of the velocity perpendicular to *AB* after the impact |
| A1 | Correct value |
| M1 | Complete strategy to find final velocity: find components parallel and perpendicular to *BC* and add. |
| M1 | Scalar product of their velocity with a vector parallel to *BC* . Condone missing modulus. |
| A1 | Correct unsimplified (follow their ) |
| A1 | Correct parallel component |
| B1 | Any parallel vector |
| M1 | Correct use of the model and the impact law to find the magnitude of the perpendicular component. Condone missing modulus. |
| A1ft | Correct unsimplified. Follow their  and their perpendicular vector |
| A1 | Correct perpendicular component |
| A1\* | Combine the components to deduce the **given answer** |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **6(a)** |  |  |  |
| Two correct possibilities identified | B1 | 2.1 |
| Form and solve a pair of simultaneous equations in *k* and *e* | M1 | 3.1a |
| Use of CLM:  | M1 | 3.1a |
|   or  | A1 | 1.1b |
| Use of impact law:  | M1 | 3.1a |
|   or  | A1 | 1.1b |
|  ,  | A1 | 1.1b |
|   |  |  |
| Second pair of simultaneous equations | M1 | 3.4 |
|  Both equations correct | A1 | 1.1b |
|  |  |  |
|   impossible since max   | M1 | 1.1b |
| Convincing argument to support just one possible value for *k***\***. | A1\* | 2.2a |
|  |  |  |
| ***Alternative for last 4 marks:*** |  |  |
| Second CLM equation | M1 | 3.4 |
|  | A1 | 1.1b |
| both particles gain KE, which is impossible | M1 | 1.1b |
| Convincing argument to support just one possible value for *k***\***. | A1\* | 2.2a |
|  | **(11)** |  |

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| **6(b)** | KE lost = difference of two KEs | M1 | 3.1a |
|     | A1ft | 1.1b |
|  = or equivalent | A1 | 1.1b |
|  | **(3)** |  |
| **(14 marks)** |
| **Notes:** |
| 6a | B1 | Identify all possible options from given information |
| M1 | Complete strategy to find a pair of values for *k* and *e* |
| M1 | Correct use of CLM. All terms needed. Condone sign errors. Dimensionally correct |
| A1 | Correct unsimplified equation (for either option) |
| M1 | Correct use of impact law. |
| A1 | Correct unsimplified equation (for the same option) |
| A1 | Correct solution for one pair of *k* and *e* |
| M1 | Form second pair of simultaneous equations to fit the model. |
| A1 | Both equations correct unsimplified |
| M1 | Correct reasoning for elimination of one pair of values |
| A1\* | CSO. Deduce the **given result** having considered all the options. |
| 6b | M1 | Complete strategy to find an expression in *m*, (*k*) and *u* for the KE lost. |
| A1ft | Correct unsimplified expression in *k* or their *k* |
| A1 |  or better |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **7(a)** |  |  |  |
| Complete strategy to find impulse | M1 | 3.1a |
| CLM parallel to line of centres | M1 | 3.1a |
|   | A1 | 1.1b |
| Use of impact law parallel to line of centres | M1 | 3.1a |
|   | A1 | 1.1b |
| Solve for *v* or *w*:    | A1 | 1.1b |
| Correct trig ratio used   | B1 | 1.1b |
| Magnitude of impulse   | M1 | 3.1a |
|   | A1 | 1.1b |
|   **\*** | A1\* | 2.2a |
|  | **(10)** |  |
| **7(b)** | Component of velocity perpendicular to line of centres   | B1 | 3.4 |
| Speed  for their *w* | M1 | 2.1 |
|    | A1 | 1.1b |
|  | **(3)** |  |

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| **7(c)** | Impulse only acts along the line of centres | B1 | 3.5b |
|  | **(1)** |  |
| **(14 marks)** |
| **Notes:** |
| 7a | M1 | Over all strategy: form and solve simultaneous equations and use impulse/momentum. |
| M1 | Use of CLM parallel to l of c. All terms needed. Condone sign errors and sin/cos confusion. |
| A1 | Correct unsimplified equation |
| M1 | Must be used the right way round. Follow their components of *u* and 2*u*. |
| A1 | Correct unsimplified equation |
| A1 | *v* or *w* correct in terms of *u* and   |
| B1 | Correct trig ratio seen or implied |
| M1 | Magnitude of impulse on either particle. Must be using change in component of velocity. |
| A1 | Correct unsimplified in terms of *m*, *u* and   |
| A1\* | Substitute trig values and deduce the **given result** |
| 7b | B1 | Use conservation of component of velocity perpendicular to line of centres |
| M1 | Use of Pythagoras to combine the components parallel and perpendicular to the line of centres. Follow their *w*. |
| A1 | Any equivalent simplified form |
| 7c | B1 | Any valid modelling assumption – no spin, no friction, no change perpendicular to the line of centres |