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| **Question** | **Scheme** | **Marks** | **AOs** |
| **1(a)**  **(b)** | Use of *P* = *Fv*: *F* = | B1 | 3.3 |
| Using the model to set up an equation of motion | M1 | 3.4 |
|  | A1 | 1.1b |
| = 15 \* | A1\* | 1.1b |
|  | **(4)** |  |
| Using the model to set up equation of motion | M1 | 3.3 |
|  | A1 | 1.1b |
| 3 term quadratic and solve: | M1 | 1.1b |
| *U* = 25 | A1 | 2.2a |
|  | **(4)** |  |
| **(8 marks)** | | | |
| **Notes:** | | | |
| **(a)**  **B1:** Use of *P* = *Fv*  **M1:** Correct number of terms with weight resolved**.**  **A1:** Correct equation  **A1\*:** Given answer | | | |
| **(b)**  **M1:** Correct number of terms  **A1:** Correct equation  **M1:** This mark can be implied by a correct value of *U*  **A1:** *U* = 25 | | | |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **2(a)**  **(b)** |  | B1 | 1.2 |
|  |  | B1 | 2.2a |
|  |  | **(2)** |  |
|  | Using work-energy principle to solve the problem | M1 | 3.4 |
|  | **OR**: | A1 | 1.1b |
|  |  | A1 | 1.1b |
|  |  | A1 | 1.1b |
|  |  | **(4)** |  |
| **(c)** | e.g. Include air resistance in the model. | B1 | 3.5c |
|  |  | **(1)** |  |
| **(7 marks)** | | | |
| **Notes:** | | | |
| **(a)**  **B1:** Correct expression for max friction  **B1:** Correct deduction from comparing weight component with *F*max | | | |
| **(b)**  **M1:** Using the work-energy principle with correct no. of terms ( either start to finish or descent only)  **A1**: Correct equation, condone 1 error  **A1**: Correct equation  **A1**: 4.9 or 4.95 (m) | | | |
| **(c)**  **B1:** Other refinements e.g. allow for spin of box, dimensions of box, more accurate value of *g* | | | |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **3** | Use impulse-momentum principle | M1 | 3.1a |
|  | A1 | 1.1b |
|  | A1 | 1.1b |
| Use of change in KE to set up quadratic equation in only. | M1 | 2.1 |
|  | A1**ft** | 1.1b |
| Simplifying to and solving | M1 | 1.1b |
| **I** = | A1 | 2.2a |
|  | **(7)** |  |
| **(7 marks)** | | | |
| **Notes: Allow column vectors throughout** | | | |
| **M1:** Allow **I =** …but must be a *difference* in momentaand dimensionally correct  **A1:** For LHS (This may be awarded later)  **A1:** For RHS  **M1:** All terms present but allow difference reversed  **A1ft:** Follow through their **v**  **M1:** Attempt to solve a 3 term quadratic  **A1:** 4**i –** 2**j** only | | | |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **4(a)**  **(b)**  **(c)** | Using CLM | M1 | 3.1b |
|  | A1 | 1.1b |
| Using NIL | M1 | 3.4 |
|  | A1 | 1.1b |
| Overall strategy for setting up two equations and solving for or | M1 | 3.1b |
| Speed of *A* is | A1 | 1.1b |
| Speed of *B* is | A1 | 1.1b |
|  | **(7)** |  |
| Direction of motion of *A* is reversed by the collision, since  is positive when | B1 | 2.4 |
|  | **(1)** |  |
| Speed of *A* =  Speed of *B* = | B1**ft** | 1.1b |
| Calculation of KE loss with all terms; condone ‘increase’ | M1 | 2.1 |
| = | A1**ft** | 1.1b |
| = | A1 | 1.1b |
|  | **(4)** |  |
| **(12 marks)** | | | |
| **Notes:** | | | |
| **(a)**  **M1:** Correct no.of appropriate terms, condone sign errors  **A1:** Correct equation  **M1:** Need *e* on the correct side of the equation  **A1:** Correct equation  **M1:** Solving for either  **A1:** Correct speed of *A*  **A1:** Correct speed of *B* | | | |
| **(b)**  **B1:** Correct direction with appropriate justification | | | |
| **(c)**  **B1ft:** Follow through their answers for (a)  **M1:** All terms but condone a negative loss  **A1ft:** Follow their speeds  **A1:** cao | | | |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **5(a)**  **(b) (i)**  **(ii)**  **(c)** | CLM parallel to line of centres (loc) | M1 | 3.1a |
|  | A1 | 1.1b |
| Correct use of NIL | M1 | 3.4 |
|  | A1 | 1.1b |
| Solve for | M1 | 1.1b |
|  | A1 | 1.1b |
| Velocity component of *Q* perp to loc = *u* | B1 | 3.4 |
|  | M1 | 3.1a |
|  | M1 | 1.1b |
| \* | A1\* | 2.1 |
|  | **(10)** |  |
| Perp to loc   = 0 *e* = | B1 | 2.2a |
|  | B1 | 1.1b |
|  | M1 | 3.1a |
| = 76o or better (1.3c) to the line of centres oe | A1 | 1.1b |
|  | **(4)** |  |
| Impulse between spheres acts horizontally i.e. parallel to the plane momentum conserved horizontally | B1 | 2.4 |
|  | **(1)** |  |
|  |  |  |
| **(15 marks)** | | | |
| **Notes:** | | | |
| **(a)**  **M1:** Need all four terms  **A1:** Correct unsimplified equation  **M1:** *e* must be on the correct side of the equation  **A1:** Correct unsimplified equation  **M1:** Solve for  **A1:** Correct unsimplified equation  **B1:** Use the model to find the velocity component perpendicular to loc  **M1:** Overall strategy to find tan  **M1:** Sub forand simplify  **A1\*:** Given answer | | | |
| **(b)(i)**  **B1:** Clear explanation. May use = 90 => = 0 *e* =  **(b)(ii)**  **B1:** Use  to find *vP*  **M1:** Complete method to solve the problem and find the angle  **A1:**  Answers in degrees (76o) or rads (1.3) or better, are acceptable. | | | |
| **(c)**  **B1:** Clear explanation | | | |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **6(a)**  **(b)** | Overall strategy to set up an equation in one unknown using equilibrium condition and resolving vertically: | M1 | 3.1a |
|  | A1 | 1.1b |
| Use of Hooke’s Law | M1 | 3.1a |
| **OR** | A1 | 1.1b |
| \* | A1\* | 1.1b |
|  | **(5)** |  |
| Max speed is at equilibrium position | B1 | 3.1a |
| Use of EPE = | M1 | 3.1a |
| Use of conservation of energy principle | M1 | 3.1a |
|  | A1 | 1.1b |
| A1 | 1.1b |
|  | A1 | 1.1b |
|  | **(6)** |  |
| **(11 marks)** | | | |
| **Notes:** | | | |
| **(a)**  **M1:** Correct no. of terms with *T* resolvedand correct equation in *T* only  **A1:** Correct tension  **M1:** Use of Hooke’s Law  **A1:** Correct unsimplified equation  **A1\*:** Given answer | | | |
| **(b)**  **B1:** Use of max speed at equilm to solve the problem  **M1:** Use of EPE formula  **M1:** Use of Conservation of energy to solve the problem  **A1:** Correct unsimplified equation with one error  **A1:** Correct unsimplified equation  **A1:** cao oe | | | |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **7(a)**  **(b)**  **(c)**  **(d)**  **(e)**  **(f)** | At *A*1: Horiz component = 14cos | B1 | 3.4 |
| At *A*1: Vert component = .14sin | B1 | 3.4 |
| t ( =) | M1 | 3.1b |
|  | A1 | 1.1b |
|  | **(4)** |  |
| Since no air resistance, motion symmetrical so vertical component down at *A*1 is equal to vertical component up at *O* , | B1 | 2.4 |
|  | **(1)** |  |
|  | M1 | 3.4 |
|  | A1 | 1.1b |
|  | A1 | 1.1b |
| Total time = 2.6 or 2.57 (s) | A1 | 1.1b |
|  | **(4)** |  |
| At *An*: Horiz component = 14cos | B1 | 3.4 |
| At *An*: Vert component = | B1 | 3.4 |
| oe | B1 | 3.1b |
|  | **(3)** |  |
| Ball continues to bounce with the size of the angle to the ground decreasing | B1 | 3.2a |
|  | **(1)** |  |
| After hitting the ground at *A*1, the ball moves along the ground  at a constant speed of 11.2 . | B1 | 2.4 |
| B1 | 2.4 |
|  |  | **(2)** |  |
| **(15 marks)** | | | |
| **Notes:** | | | |
| **(a)**  **B1:** Using NIL as a model to obtain the horiz component at *A*1  **B1:** Using NIL as a model to obtain the vert component at *A*1  **M1:** Using the components found above and tan to solve the problem – allow reciprocal for this mark  **A1:** Accept degrees or radians | | | |
| **(b)**  **B1:** No air resistance means motion is symmetrical | | | |
| **(c)**  **M1:** Using the model and vert motion to find the time from *O* to *A*1  **A1:** sin does not need to be substituted  **A1:** sin does not need to be substituted  **A1:** Either 2 or 3 sf answers only | | | |
| **(d)**  **B1:** Using NIL as the model to obtain the horiz component at *An*  **B1:** Using NIL to obtain the vert component at *An*  **B1:** Solving the problem to produce any equivalent form | | | |
| **(e)**  **B1:** A clear explanation | | | |
| **(f)**  **B1:** Clear description  **B1:** Constant speed and 11.2 (m s-1) | | | |