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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) |