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| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **1a** | States or uses *I* = *F* × *t* | **M1** | 1.2 | 2nd  Understand the definitions of momentum and impulse |
| *I* = 5 × 0.4 = 2 N s  Answer must include units. | **A1** | 1.1b |
|  | **(2)** |  |  |
| **1b** | Starts with *F* = *m* × *a* and *v* = *u* + *at*  Substitutes to get *Ft* = *m*(*v* − *u*) | **M1** | 2.1 | 3rd  Derive the formulae for momentum and impulse |
| Cue ball begins at rest | **M1** | 2.1 |
| Speed of ball after impact is  States final conclusion: snooker player is correct. | **A1** | 2.3 |
|  | **(3)** |  |  |
| **1c** | States or uses *I* = *mv* − *mu* | **B1** | 1.1b | 2nd  Understand the definitions of momentum and impulse |
| Momentum = *mv* = 0.25 × 8 = 2 kg m s−1 | **B1** | 1.1b |
|  | **(2)** |  |  |
| **(7 marks)** | | | | |
| Notes | | | | |

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| Q | Scheme | | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **2a** |  | Well labelled diagram. | **M1** | 3.3 | 5th  Use the principle of the conservation of momentum in simple one dimensional problems |
| States conservation of momentum equation  *m*1*u*1 + *m*2*u*2 = *m*1*v*1 + *m*2*v*2 | | **M1** | 3.1a |
| 0.01 − 0.03 = 0.02*v* − 0.015 | | **M1** | 1.2 |
| So *v* = −0.25 = 0.25 m s−1 in opposite direction to initial motion. | | **A1** | 3.2a |
|  | | **(4)** |  |  |
| **2b** | *I* = *mv* − *mu* | | **M1** | 1.1a | 2nd  Understand the definitions of momentum and impulse |
| Impulse on lighter marble = 0.02 × 0.5 − (0.02 × −0.25)  = 0.015 N s | | **A1** | 1.1b |
|  | | **(2)** |  |  |
| **2c** | Allow any valid assumption. For example, assume that there is no resistance to forward motion due to friction. | | **B1** | 3.5b | 2nd  Understand the definitions of momentum and impulse |
|  | | **(1)** |  |  |
| (7 marks) | | | | | |
| Notes  2b Allow calculation of impulse on heavier marble if student states that magnitude of impulse is the same because of Newton’s Third Law. (M1) | | | | | |

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| Q | Scheme | | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **3a** |  | Diagram modelling situation. | **M1** | 3.3 | 2nd  Understand the definitions of momentum and impulse |
| States or implies conservation of momentum.  *m*1*u*1 + *m*2*u*2 = *m*1*v*1 + *m*2*v*2 | | **M1** | 3.1a |
| Substitutes correctly to find  *m* × 0.8 + (*m* + 0.025) × 0 = *m* × 0 + (*m* + 0.025) × *v* | | **M1** | 1.2 |
| Rearranges to get | | **A1** | 1.1b |
|  | | **(4)** |  |  |
| **3b** | States or implies that only force is constant resistive force so constant acceleration formulae apply. | | **M1** | 2.4 | 2nd  Understand the definitions of momentum and impulse |
| *s* < 0.1 because lighter car stopped when string taut at 10 cm.    *v* = 0 because heavier car comes to rest  using *F* = *ma* for heavier car | | **M1** | 3.3 |
| Substitutes into *v*2 = *u*2 + 2*as*  Rearranges to 0.64*m*2 − 4*m* − 0.1 < 0 | | **M1** | 1.1b |
| Uses quadratic formula to get *m* < 6.27 kg (3 s.f.) | | **A1** | 3.2 |
|  | | **(4)** |  |  |
| (8 marks) | | | | | |

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| Notes  Alternative method  Separate impulse diagrams for lighter and heavier cars. **(M1)**  Impulse on lighter car = 0 − (*m* × 0.8) = −0.8*m* **(M1)**  States or implies that impulse on heavier car is equal and opposite.  Impulse on heavier car = 0.8*m* = (*m* + 0.025) × *v* (**M1**)  Rearranges to get  (**A1**) |

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| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **4a** | Ball thrown upwards under gravity only so *u* = 7, *s* = 1.8, *a* = −9.8  Uses *v*2 = *u*2 + 2*as* to get *v* = 3.704 | **M1** | 3.1b | 2nd  Understand the definitions of momentum and impulse |
| Magnitude of impulse on apple = magnitude of impulse on ball  = (0.1 × 3.704) − (0.1 × −1)  = 0.4704 N s | **M1** | 1.1b |
| Substitutes values for *I* and *t* into *I* = *F* × *t*  0.4704 = *F* × 0.8 | **M1** | 1.1b |
| Calculates *F* = 0.588 N  States that the force is greater than 0.5 N so the apple will be dislodged. | **A1** | 3.2 |
|  | **(4)** |  |  |
| **4b** | Conservation of momentum.  (0.1 × 3.704) + (0.25 × 0) = (0.1 × −1) + 0.25*v*  Solve to get *v* = 1.8816 | **M1** | 3.1b | 5th  Use the principle of the conservation of momentum in simple one dimensional problems |
| *u* = 1.8816, *v* = 0, *a* = −9.8  Find *s* | **M1** | 1.2 |
| Uses  19.6*s* = (1.8816)2  *s* = 0.1806… | **M1** | 1.1b |
| Hence *x* = 18 cm | **A1** | 3.2a |
|  | **(4)** |  |  |
| (8 marks) | | | | |
| Notes  **4b** Could also use impulse–momentum principle with answer from part **a**. 0.4704 = 0.25*v* − (0.25 × 0) | | | | |