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| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **1a** | When *t* = 8, *u*1 = (8**i**+ 2**j**) m s−1 | **M1** | 1.1a | 4th  Extend the definition of momentum and impulse to two dimensions |
| Also given: *u*2 = (4**i** + **j**) m s−1  States that the combined particle has mass 2(3 × 10−6) = 6 × 10−6 and a single velocity, *v*. | **M1** | 3.1a |
| Use the vector form of the conservation of momentum:  (3 × 10−6)(*u*1 + *u*2) = (6 × 10−6)*v* gives *v* = 6**i** + 1.5**j** | **M1** | 1.1b |
| Speed of new larger particle m s−1 (3 s.f.) | **A1** | 1.1a |
|  | **(4)** |  |  |
| **1b** |  | **M1** | 2.2a | 4th  Extend the definition of momentum and impulse to two dimensions |
| above **i** | **A1** | 3.2a |
|  | **M1** | 2.2a |
| below **i** | **A1** | 3.2a |
| Angle between two particles after collision = 14.04 + 56.31  = 70.4°(3 s.f.) | **A1** | 1.1b |
|  | **(5)** |  |  |
| (9 marks) | | | | |
| Notes | | | | |

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| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **2a** | Position of player with bat = 2**i** + **j** + 3(3**i** + 4**j**) = 11**i** + 13**j** | **M1** | 1.1a | 6th  Use the impulse/momentum principle in vector form |
| Displacement player to skittle = 15**i** + 9**j** − (11**i** + 13**j**) = 4**i** − 4**j** | **M1** | 1.1b |
| Velocity of ball after being struck by bat in order to hit the skittle is of the form *a***i** − *a***j** | **M1** | 3.1b |
| This velocity has magnitude  Magnitude of *a***i** − *a***j** =  Hence *a* = 5 | **M1** | 1.1b |
| Use impulse−momentum principle in vector form.  Impulse = 0.2((5**i** − 5**j**) − (3**i** + 4**j**)) | **M1** | 1.1a |
| Impulse = 0.4**i** − 1.8**j** | **A1** | 1.1b |
|  | **(6)** |  |  |
| **2b** | Impulse given to ball from skittle = 0.2((−2**i** + 2**j**) − (5**i** − 5**j**))  = −1.4**i** + 1.4**j** | **M1** | 3.1a | 6th  Use the impulse/momentum principle in vector form |
| Use Newton’s Third Law:  Impulse given to skittle from ball = 1.4**i** − 1.4**j**  0.8 × Force = 1.4**i** − 1.4**j** | **M1** | 3.2a |
| Force on skittle due to collision = 1.75**i** − 1.75**j**  Magnitude of force on skittle = 2.475 N | **M1** | 1.1b |
| Maximum resistant force on skittle due to friction = *μm*g N  = *μ* × 1 × 9.8 | **M1** | 1.1b |
| 9.8*μ* = 2.475  *μ* = 0.253 | **A1** | 1.1b |
|  | **(5)** |  |  |
| (11 marks) | | | | |
| Notes | | | | |