

Further Mechanics 1 Unit Test 4: Momentum and impulse (part 2)

- 1** A gas particle of mass 3×10^{-6} kg is moving with velocity $((t^2 - 7t)\mathbf{i} + 2\mathbf{j}) \text{ m s}^{-1}$. When $t = 8$ seconds it instantaneously collides directly with a second particle of the same mass but moving with constant velocity $(4\mathbf{i} + \mathbf{j}) \text{ m s}^{-1}$. At the point of collision, the two particles coalesce and this new larger particle begins to move immediately after impact with constant velocity \mathbf{v} .
- a** Find the speed of the new larger gas particle immediately after the collision. **(4 marks)**
- b** A third gas particle has velocity $(2\mathbf{i} - 3\mathbf{j}) \text{ m s}^{-1}$. Find the angle between the directions of motion of this third particle and the new larger particle. **(5 marks)**
- 2** A ball of mass 200 g is propelled from rest, from position vector $\mathbf{r} = (2\mathbf{i} + \mathbf{j}) \text{ m}$, so that it rolls with constant velocity $\mathbf{v} = (3\mathbf{i} + 4\mathbf{j}) \text{ m s}^{-1}$. The surface on which the ball rolls is assumed to offer no resistance to its motion. After 3 seconds this ball reaches a player holding a bat.
- The player immediately strikes the ball with the bat, which causes the ball to change its velocity such that the ball rolls along the floor at an exact constant speed of $5\sqrt{2} \text{ m s}^{-1}$ and collides with a skittle which is at position vector $\mathbf{r}_s = (15\mathbf{i} + 9\mathbf{j}) \text{ m}$.
- a** Find, in vector form, the impulse given to the ball by the bat. **(6 marks)**
- The mass of the skittle is 1 kg. The base of the skittle is such that the skittle will resist motion with a force due to friction. When the ball in part **a** collides with the skittle the collision lasts 0.8 seconds. Directly after impact the ball moves with velocity $(-2\mathbf{i} + 2\mathbf{j}) \text{ m s}^{-1}$. The maximum possible force due to friction is just enough to cause the skittle to remain at rest.
- b** Find the coefficient of friction, μ , between the skittle and the floor. **(5 marks)**