2017 Ph H2 Q2
Section: Our Dynamic Universe
Topic: Collisions, Explosions and Impulse

Summary:
Two snooker balls of equal mass collide head-on. The velocity of one ball after the collision is known, and the velocity of the other must be determined. The collision is inelastic. In part (b), a cue hits a ball, and we must determine the average force from data involving contact time and resulting speed, and then find the percentage uncertainty in that force.

(a)(i) Calculate the velocity of the white ball immediately after the collision.

Let:

- $m = 0.180\,\text{kg}$ (mass of each ball)
- $u_w = +2.60\,\text{m/s}$ (initial velocity of white ball)
- $u_b = -1.80\,\text{m/s}$ (initial velocity of black ball)
- $v_b = +2.38\,\text{m/s}$ (final velocity of black ball)
- $v_w = ?$ (final velocity of white ball)

Using conservation of momentum:
$mu_w + mu_b = mv_w + mv_b$

$u_w + u_b = v_w + v_b$

$2.60 + (-1.80) = v_w + 2.38$

$0.80 = v_w + 2.38$

$v_w = 0.80 - 2.38 = -1.58\,\text{m/s}$

Answer:
$v_w = -1.58\,\text{m/s}$
(The negative sign indicates motion to the left.)

(a)(ii) What is meant by an inelastic collision?

An inelastic collision is one in which **kinetic energy is not conserved**, though **momentum is conserved**.

(b)(i) Calculate the average force exerted by the cue.

Given:

- Mass $m = 0.180\,\text{kg}$
- Final speed $v = 0.84\,\text{m/s}$
- Initial speed $u = 0$ (stationary)
- Time $t = 0.040\,\text{s}$

Impulse $= \Delta p = m(v - u) = Ft$

$$F = \frac{mv}{t} = \frac{0.180 \times 0.84}{0.040} = \frac{0.1512}{0.040} = 3.78\,\text{N}$$

Answer:
$3.78\,\text{N}$

(b)(ii) Determine the percentage uncertainty in the force.

% uncertainty in F
= % uncertainty in m + % uncertainty in v + % uncertainty in t

$$= \left(\frac{0.001}{0.180} + \frac{0.01}{0.84} + \frac{0.001}{0.040}\right) \times 100$$

$$= (0.00556 + 0.0119 + 0.025) \times 100 = 0.04246 \times 100 = 4.25\%$$

Answer:
4.3% (to 2 significant figures)

Guidance for Students:

- Momentum is always conserved in collisions, even if energy isn't.
- Use algebra to eliminate the masses when both are the same.
- For impulse problems, relate force, time, and change in momentum.

Revision Tips:

- ✅ In an **inelastic** collision, **kinetic energy decreases** but **momentum is conserved**.
- ✅ For conservation of momentum, cancel out masses if they're identical.
- ✅ Impulse formula: $Ft = m\Delta v$.
- ✅ When calculating **percentage uncertainties**, add relative uncertainties from each measurement.