

# Elastic and inelastic collisions with centre of mass

AP Physics 1 (algebra-based) · Lab answers

Model values are calculated from the sample times. Your own results will differ slightly, but the conclusions about conserved momentum, lost kinetic energy and the likely sources of error should be the same.

**Level:** AP Physics 1 (algebra-based) · **Curriculum:** AP P1 Unit 4

## Question 1 Momentum before and after

$p = m v$ . Trial 1: before  $0.50 \times 0.800 = 0.400$  kg m/s; after  $0.75 \times 0.526 = 0.395$  kg m/s. Trial 2: before 0.500; after 0.492 kg m/s. Trial 3: before 0.625; after 0.612 kg m/s. **Values agree to within about 2 %.**

## Question 2 Percentage difference

Difference =  $(p_{\text{after}} - p_{\text{before}}) \div p_{\text{before}} \times 100$ : **-1.3 %, -1.6 % and -2.0 %**. These are within the timing uncertainty and the small friction loss, so momentum is conserved.

## Question 3 Energy retained

Before: 0.160, 0.250, 0.391 J. After: 0.104, 0.161, 0.250 J. Fraction retained: 0.65, 0.64, 0.64. Theory:  $0.50 \div 0.75 = \mathbf{0.67}$ . The measured fractions are close to the theory and slightly lower because of friction.

## Question 4 Graph of momentum

Plot  $p_{\text{after}}$  on the vertical axis. The points lie on a straight line through the origin with a gradient close to **1**. The intercept is zero because no motion before means no motion after.

## Question 5 Timing uncertainty

Percentage uncertainty in  $t = 0.01 \div 0.50 \times 100 = 2 \%$ . Since  $u = 0.40 \div t$ , the percentage uncertainty in  $u$  is also 2 %, and the momentum before ( $m \times u$ ) has about **2 %** uncertainty, because the mass uncertainty is negligible.

## Question 6 Why is $p$ after slightly low?

Friction and air drag act on the carts after the collision and slow them before they pass the second gate. The effect is reduced by **raising the track end very slightly to**

**compensate for friction**, using an air track, or timing a short distance just after the collision.

### Question 7 Centre of mass check

$v_{\text{cm}} = (0.50 \times 0.800 + 0.25 \times 0) \div 0.75 = \mathbf{0.533 \text{ m/s}}$ . The measured speed of the joined carts is 0.526 m/s. They agree to within 1.3 %, as expected because the centre of mass velocity stays constant.