InkMaths

ANSWER BOOK

Momentum and impulse

Further Mechanics 1 · Year FM

6 questions · 20 marks

NAVY EDITION

SECTION A · Warm-up

A1 Impulse is force times the time it acts, measured in newton seconds, and equals the change in momentum. Stopping a body removes its momentum; reversing it removes that momentum and supplies the same again the other way, so the change is the sum of the two speeds rather than just the first. [2]

A2 Taking the outgoing direction as positive, u = -12 and v = 18. Impulse = 0.2(18) - 0.2(-12) = 3.6 + 2.4 = 6 N s. Average force = 6/0.03 = 200 N. [3]

SECTION B · Standard

B1 Momentum before = 5(3) + 4(1) = 19 N s. After: 5(1.8) + 4v = 19, so 4v = 19 - 9 = 10 and v = 2.5 m/s. The struck sphere has sped up and the striking one slowed, which is what must happen if they are not to pass through each other. [4]

B2 Total momentum before is zero, since nothing is moving. After: 3(6) + 5v = 0, so 5v = -18 and v = -3.6 m/s: the 5 kg piece moves at 3.6 m/s in the opposite direction. An explosion is conservation of momentum with the masses grouped the other way round. [4]

B3 The change in momentum is fixed by the speeds before and after, so the impulse is fixed. Since impulse is force times time, spreading the same impulse over a longer contact reduces the average force in proportion. Crumple zones, airbags, thick landing mats and bending the knees on landing all work this way. [3]

SECTION C · Stretch

C1 Speed on landing = $\sqrt{(2 \times 9.8 \times 5)} = 9.90$ m/s downwards. Rebound speed = $\sqrt{(2 \times 9.8 \times 1.8)} = 5.94$ m/s upwards. Taking upwards as positive, the impulse is 2(5.94) - 2(-9.90) = 11.88 + 19.80 = 31.7 N s upwards. Momentum is not conserved for the ball alone here, because the ground is an external body. [4]