InkMaths

ANSWER BOOK

# Impulse and momentum as vectors

Further Mechanics 1 · Year FM

6 questions · 20 marks

NAVY EDITION

## SECTION A · Warm-up

**A1** Momentum is a vector, so it changes if the direction changes even when the magnitude does not. The impulse equals the vector change mv - mu, which is non-zero whenever v and u point different ways. Working with speeds rather than velocities loses that information entirely. [2]

**A2** The change in velocity is the impulse divided by the mass: (2i + 3j) m/s. So the new velocity is (2i - 5j) + (2i + 3j) = (4i - 2j) m/s, with speed √(16 + 4) = √20 = 4.47 m/s. [3]

## SECTION B · Standard

**B1** Impulse = 0.4(-i + 6j) - 0.4(5i + 2j) = 0.4(-6i + 4j) = (-2.4i + 1.6j) N s. Its magnitude is √(5.76 + 2.56) = √8.32 = 2.88 N s. The speed changed from √29 = 5.39 to √37 = 6.08, so quoting the mass times that difference would have given 0.28 N s: an order of magnitude wrong. [4]

**B2** Momenta: 4(2i + 3j) = 8i + 12j and 6(-3i + j) = -18i + 6j. Total = (-10i + 18j) N s. Dividing by the combined 10 kg gives v = (-i + 1.8j) m/s, with speed √(1 + 3.24) = 2.06 m/s. [4]

**B3** Since |v| = |u|, the vectors mu and mv have the same length, so the triangle they form with the impulse is isosceles. The impulse is therefore perpendicular to the bisector of the angle between the old and new velocities, and in particular it is never along either of them. [3]

## SECTION C · Stretch

**C1** The final velocity is 6i m/s, so the final momentum is 12i and the initial momentum is 2(3i + 4j) = 6i + 8j. The impulse is 12i - (6i + 8j) = (6i - 8j) N s, of magnitude √(36 + 64) = 10 N s. The j component had to be removed entirely, which is why the impulse is not along the direction of travel. [4]