



ANSWER BOOK

Oblique impact and impact with a smooth surface

Further Mechanics 1 · Year FM

6 questions · 20 marks

NAVY EDITION

SECTION A · Warm-up

- A1** The component parallel to the surface is unchanged, because a smooth surface exerts no force along itself. The component perpendicular to the surface is reversed and multiplied by e , exactly as in a direct impact, because the impulse acts along that direction only.
- A2** Parallel component = $12\cos 40^\circ = 9.19 \text{ m/s}$, unchanged. Perpendicular component = $12\sin 40^\circ = 7.71 \text{ m/s}$, becoming $0.6 \times 7.71 = 4.63 \text{ m/s}$ the other way. Speed = $\sqrt{9.19^2 + 4.63^2} = \sqrt{105.9} = 10.3 \text{ m/s}$.

SECTION B · Standard

- B1** The angle is $\arctan(4.63/9.19) = 26.7^\circ$, shallower than the 40° it arrived at. For the energy, work with squared speeds: 105.9 remains out of 144, so the fraction lost is $1 - 105.9/144 = 0.264$, that is 26.4% . The mass cancels, so it never has to be known. [4]
- B2** Let the parallel component be p , unchanged. Before, the perpendicular component is $p \tan 45^\circ$; after, it is $p \tan 30^\circ$. Restitution applies to that component alone, so $e = \tan 30^\circ / \tan 45^\circ = 0.577$ to three decimal places. The angles alone settle it: neither speed is needed.
- B3** The tangent of the angle to the surface is the perpendicular component divided by the parallel one. The impact multiplies the numerator by e and leaves the denominator alone, so the tangent is multiplied by e . For $e < 1$ that makes the angle smaller, and only $e = 1$ leaves it unchanged, which is the mirror case.

SECTION C · Stretch

- C1** Take the two walls along the axes, so the velocity is (u, v) . The first wall reverses and scales the component perpendicular to it, giving $(-eu, v)$. The second wall does the same to the other component, giving $(-eu, -ev) = -e(u, v)$. That is a negative multiple of the original velocity, so the direction is exactly reversed, and the speed is e times the original. It is why a ball played into the corner of a court comes straight back at you. [4]