inkMaths

ANSWER BOOK

Projectiles

Mechanics · Year 12–13

6 questions · 22 marks

NAVY EDITION

SECTION A · Warm-up

A1 The horizontal component stays constant, because no horizontal force acts on the particle. The vertical component changes at 9.8 m s^{-2} downwards, exactly as in free fall. The two motions run independently and share nothing but the clock. B1 B1 for the two components. [2]

A2 Horizontal: 20 cos 40° = 15.3 m s^{-1}. Vertical: 20 sin 40° = 12.9 m s^{-1} upwards. B1 B1 for the horizontal and vertical components. When the angle is measured from the horizontal, cosine goes with the horizontal component. Every projectile question opens here, so store both to more figures than you report; they feed everything that follows. [2]

SECTION B · Standard

B1 Vertically the stone starts from rest, so 44.1 = ½ × 9.8 × t^2, giving t^2 = 9 and t = 3 s. Horizontally the speed never changes, so the distance is 12 × 3 = 36 m. M1 for the vertical equation, A1 for the time, A1 for the distance. The vertical motion decides when the stone lands and the horizontal motion spends whatever time it is given. [3]

B2 Components: 24.5 sin 30° = 12.25 m s^{-1} up and 24.5 cos 30° = 21.2 m s^{-1} across. Take up as positive. Returning to the same level means s = 0, so 0 = 12.25t - 4.9t^2 and t = 12.25/4.9 = 2.5 s. Range = 21.2176 × 2.5 = 53.0 m. M1 for resolving, M1 for the vertical equation with s = 0, A1 for the time, A1 for the range. Resolve once, then run two one-dimensional problems that share t. The usual loss is quoting the root t = 0, which is the instant of the strike, rather than the second root. [4]

B3 At the highest point the vertical component of velocity is zero, so 0 = 12.25^2 - 2 × 9.8 × s and s = 150.0625/19.6 = 7.66 m. M1 for setting the vertical component to zero, dM1 for using $v^2 = u^2 + 2as$, A1 for 7.66 m. Only the vertical component enters the calculation. The ball is still travelling at 21.2 m s^{-1} horizontally up there, so setting the whole velocity to zero loses the method mark. [3]

SECTION C · Stretch

C1 Take up as positive, so the displacement on landing is $s = -5$. Then $-5 = 12.25t - 4.9t^2$, which rearranges to $4.9t^2 - 12.25t - 5 = 0$. The formula gives $t = (12.25 + 15.75)/9.8 = 2.86$ s. Reject the negative root, which describes a time before the strike. Horizontal distance = $21.2176 \times 2.857 = 60.6$ m. On landing the vertical velocity is $12.25 - 9.8 \times 2.857 = -15.75$ m s^{-1}, so the speed is $\sqrt{(21.2176^2 + 15.75^2)} = 26.4$ m s^{-1}. M1 for $s = -5$, A1 for the quadratic, M1 A1 for the time, A1 for the horizontal distance, M1 for the vertical velocity on landing, M1 A1 for the resultant speed. Two things earn the marks. The sign of s has to match the chosen positive direction, and the unrounded 21.2176 has to be carried through, since starting again from 21.2 shifts the final speed in the third figure. [8]