

## Solutions

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**2.1**  $0.4 \times 8 = 3.2 \text{ m s}^{-1}$ .

**2.2** The ball rebounds at  $6 \times \frac{1}{3} = 2 \text{ m s}^{-1}$ , leftward, so  $-2$  with right positive. Momentum:  $1(-2) = v_1 + 2v_2$ ; restitution with approach speed 2:  $\frac{1}{2} = \frac{v_2 - v_1}{2}$ , so  $v_2 = v_1 + 1$ . Substituting:  $-2 = v_1 + 2(v_1 + 1) = 3v_1 + 2$ , so  $v_1 = -\frac{4}{3}$  and  $v_2 = -\frac{1}{3}$ : the 2 kg ball moves off at  $\frac{1}{3} \text{ m s}^{-1}$  to the left.

**2.3** First collision (A into B):  $3u = v_A + v_B$  and  $\frac{1}{2}(3u) = v_B - v_A$ :  $v_B = \frac{9}{4}u$ ,  $v_A = \frac{3}{4}u$ . Second (B into C):  $\frac{9}{4}u = v'_B + 2v_C$  and  $\frac{1}{4} \cdot \frac{9}{4}u = v_C - v'_B$ :  $v_C - v'_B = \frac{9u}{16}$ . Adding:  $3v_C = \frac{36u}{16} + \frac{9u}{16} = \frac{45u}{16}$ , so  $v_C = \frac{15u}{16}$ .

**3.1** After the first collision:  $v_Q = \frac{2(1+\frac{1}{3})u}{3} = \frac{8}{9}u$  and  $v_P = \frac{(2-\frac{1}{3})u}{3} = \frac{5}{9}u$ . Rebound:  $f \cdot \frac{8}{9}u = \frac{5}{9}u$ , so  $f = \frac{5}{8}$ .

**3.2** First collision:  $v_P + 2v_Q = 12$  and  $v_Q - v_P = \frac{1}{2}(12) = 6$ . Adding:  $3v_Q = 18$ , so  $v_Q = 6$  and  $v_P = 0$  (P is stopped dead). Q hits the far wall and rebounds at  $6 \times \frac{1}{3} = 2$  leftward. Q (leftward at 2) now catches P (at rest): approach speed 2. Right positive, momentum:  $2(-2) = v'_P + 2v'_Q$ , i.e.  $-4 = v'_P + 2v'_Q$ . Restitution: the separation speed after is  $\frac{1}{3} \times 2 = \frac{2}{3}$  with P separating leftward faster, so  $v'_Q - v'_P = \frac{2}{3}$ , i.e.  $v'_P = v'_Q - \frac{2}{3}$ . Substituting:  $-4 = 3v'_Q - \frac{2}{3}$ , so  $3v'_Q = -\frac{10}{3}$  and  $v'_Q = -\frac{10}{9} = -1.11$ ;  $v'_P = -\frac{16}{9} = -1.78 \text{ m s}^{-1}$ . Both move leftward: P at  $1.78 \text{ m s}^{-1}$ , Q at  $1.11 \text{ m s}^{-1}$ .

Local review guidance: wall rebounds as pure speed scaling before any momentum work; each collision solved completely with a signed diagram; “same speed” conditions applied to the correct stage. This is authored classroom guidance.