3.4 Impulse and momentum

Name: _____ Class: _____ Date: _____ **Total: 14 marks**

KEY WORDS impulse • linear momentum • coefficient of restitution

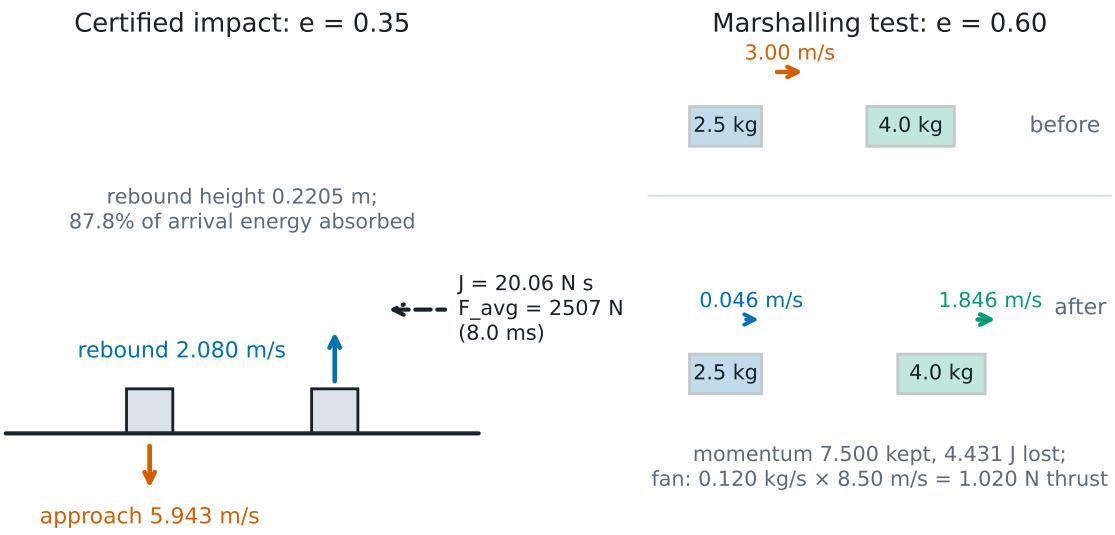
Objective

Analyse impacts by impulse and momentum: the two frozen pictures, the restitution ratio, and the steady-flow flux.

1 Key knowledge and worked examples

■ Impact bookkeeping

$\sum \mathbf{J} = \Delta\mathbf{p}$; e = separation over approach; $J = m(v + ev)$ onto a floor. Steady flow: $F = \dot{m}\Delta v$.



*Momentum keeps; kinetic energy does not

■ Worked example. The certified impact

$v = 5.943$, $e = 0.35$: rebound 2.080 m/s, $J = 20.06$ N · s, average force 2507 N over 8.0 ms ✓; carts keep 7.500 kg · m/s while 4.431 J goes ✓.

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2 Practice

A 1.8 kg controller hits the certified floor at 4.0 m/s with $e = 0.50$; the contact lasts 6.0 ms.

2.1 The rebound speed and the rebound height (three decimals, four decimals). [3]

2.2 The impulse magnitude and the average force (one decimal, nearest integer). [4]

2.3 A 3.0 kg cart at 2.5 m/s couples into a 2.0 kg cart at rest with $e = 0.80$. Both final velocities (three decimals), and the kinetic energy lost (two decimals). [5]

2.4 The test rig's fan moves 0.120 kg/s of air out at 8.50 m/s. The thrust (three decimals), and why this is a momentum-flux result rather than an impact one. [2]

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Solutions

2.1

- Rebound $= ev = 2.000$ m/s.
- Height $= v^2/2g = 0.2039$ m.

2.2

- $J = m(1+e)v = 1.8 \times 1.5 \times 4.0 = 10.8$ N $\cdot$ s.
- $F = J/\Delta t = 10.8/0.0060 = 1800$ N.

2.3

- Momentum: $7.5 = 3.0v_1 + 2.0v_2$; separation: $v_2 - v_1 = 0.80 \times 2.5$.
- $v_1 = 0.700$ m/s, $v_2 = 2.700$ m/s.
- KE: $9.375 \to 8.025$ J, loss 1.35 J.

2.4

- $F = \dot{m}v = 0.120 \times 8.50 = 1.020$ N.
- The flow is steady - momentum passes through continuously, with no frozen before/after pair.

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