

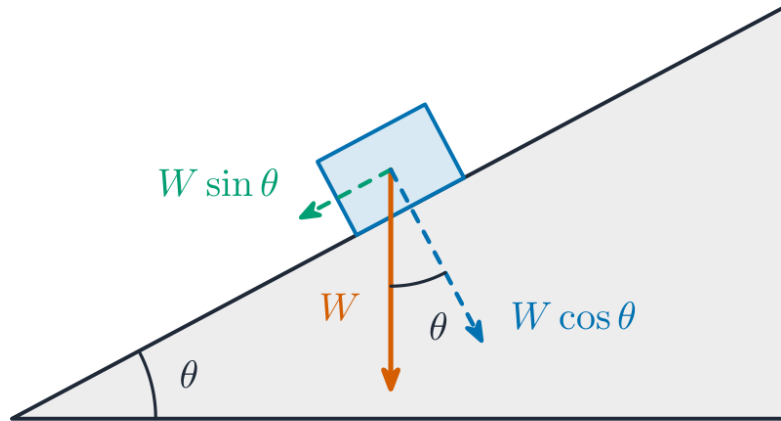
Exercise walk-through

1.4

Momentum and its conservation (statements 13–14)

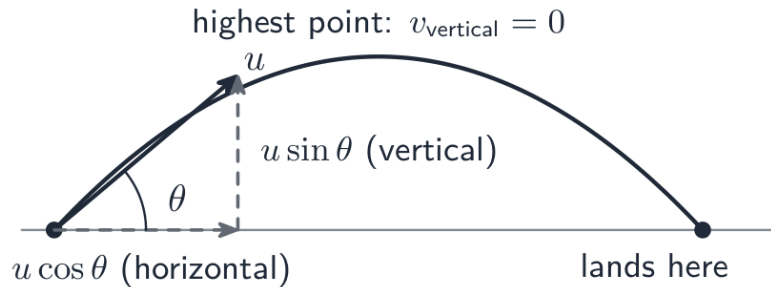
Pearson Edexcel · International A-Level · Physics

Resolve from the marked angle



- Draw a right triangle: the adjacent component uses cosine, the opposite uses sine.
- For a slope at angle θ :
 $W_{\parallel} = W \sin \theta$, $W_{\perp} = W \cos \theta$.
- Combine perpendicular components with Pythagoras and give a direction.

One projectile, two motions



- Neglect drag: horizontal acceleration is zero; vertical acceleration is $-g$ upward-positive.
- $u_h = u \cos \theta$, $u_v = u \sin \theta$; time links the two directions.
- At the highest point only the vertical velocity is zero.

Core practical 3: Young modulus of a wire

- Measure original length; measure diameter at several positions and orientations with a micrometer.
- Add loads in steps; measure extensions and plot stress against strain in the proportional region.
- Use the gradient for E ; repeat/unload to check elastic behaviour and control zero errors.

Exercises 2.1·2.3

2.1 Calculate the momentum of a 1200 kg car moving at 18 m s^{-1} . [1]

2.2 A 60 kg skater at rest pushes a 3.0 kg ball away at 4.0 m s^{-1} . Calculate the skater's recoil velocity. [2]

2.3 State the condition needed for the total momentum of a system to be conserved in a collision. [1]

Exercises 2.1·2.3

2.1 Calculate the momentum of a 1200 kg car moving at 18 m s^{-1} . [1]

2.1 $p = mv = 1200 \text{ kg} \times 18 \text{ m s}^{-1} = 2.2 \times 10^4 \text{ kg m s}^{-1}$.

2.2 A 60 kg skater at rest pushes a 3.0 kg ball away at 4.0 m s^{-1} . Calculate the skater's recoil velocity. [2]

2.2 The system starts at rest, so $0 = m_{\text{skater}}v_{\text{skater}} + m_{\text{ball}}v_{\text{ball}}$: $v_{\text{skater}} = -\frac{3.0 \text{ kg} \times 4.0 \text{ m s}^{-1}}{60 \text{ kg}}$
 $-0.20 \text{ m s}^{-1} - 0.20 \text{ m s}^{-1}$ backwards.

2.3 State the condition needed for the total momentum of a system to be conserved in a collision. [1]

2.3 No external force acts on the system (the system is isolated).

Exercises 2.4·3.1

2.4 A 2.0 kg trolley at 1.5 m s^{-1} catches up with a 1.0 kg trolley at 0.50 m s^{-1} moving

3.1 A truck of mass $2m$ moving at speed v meets a car of mass m moving at speed v in the opposite direction. They collide and move off together. Which expression gives their common speed? [1]

☐

A $\frac{v}{3}$

B $\frac{v}{2}$

C v

D $\frac{2v}{3}$

Exercises 2.4·3.1

2.4 A 2.0 kg trolley at 1.5 m s^{-1} catches up with a 1.0 kg trolley at 0.50 m s^{-1} moving

2.4 $p_{\text{before}} = p_{\text{after}}$: $2.0 \times 1.5 + 1.0 \times 0.50 = 3.0 V$, so $V = \frac{3.5 \text{ kg m s}^{-1}}{3.0 \text{ kg}} = 1.2 \text{ m s}^{-1}$ forwards.

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- ☐ **A** $\frac{v}{3}$
B $\frac{v}{2}$
C v
D $\frac{2v}{3}$

3.1 A. Take the truck's direction as positive: $2mv - mv = 3mV$, so $V = \frac{v}{3}$. B forgets the mass ratio; C keeps the speed unchanged; D adds the momenta wrongly.

Exercise 3.2

3.2 In which situation is the total momentum of the two trolleys conserved? [1]

☐

A a trolley rolling to a stop on a rough track

B two trolleys colliding on a frictionless air track

C a trolley accelerating down a sloped track

D a trolley pulled by a falling mass

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3.2 B. Only on the frictionless track is there no external horizontal force on the pair. A, C and D each have an external force (friction, a component of weight, the falling mass's pull).

Exercise 3.3

3.3 On an air track, glider P (mass 0.25 kg) moves at 0.20 m s^{-1} towards glider Q (mass 0.15 kg), which moves towards P at 0.40 m s^{-1} . The gliders collide and move apart after the collision.

(a) Explain how Newton's third law applies to the gliders during the collision. [1]

(b) The collision separates the gliders. State what is conserved in the collision and the condition for it. [2]

(c) After the collision, P moves back at 0.10 m s^{-1} . Calculate the velocity of Q after the collision. [3]

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Full solution 3.3

3.3 (a) P exerts a force on Q and Q exerts an equal and opposite force on P. (b) Total momentum, because no external force acts on the two gliders. (c) Right positive, P's initial direction: $0.25 \times 0.20 + 0.15 \times (-0.40) = 0.25 \times (-0.10) + 0.15 v_Q$: $0.050 - 0.060 = -0.025 + 0.15 v_Q$, so $v_Q = \frac{0.015}{0.15} = 0.10 \text{ m s}^{-1}$ to the right.

Exercise 3.4

3.4 In a Newton's cradle, sphere A is pulled aside and released. A strikes the resting row and stops; sphere E leaves the other end.

(a) State what happens to the total momentum of the five spheres during the collision, with a reason. [2]

(b) Explain, using conservation of momentum and of energy, why the collision sends out **one** sphere rather than two spheres at lower speed. [*Assume the collision conserves kinetic energy.*] [3]

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3.4 (a) It is conserved: the forces between the spheres are internal to the system, and no external horizontal force acts. (b) Momentum conservation requires the outgoing momentum to equal A's incoming momentum. Kinetic energy conservation then requires $\frac{1}{2}mv^2$ to match as well; two equal spheres at half the speed would conserve momentum but carry only half the kinetic energy, so the only solution satisfying both is one sphere leaving at (almost) the same speed.