

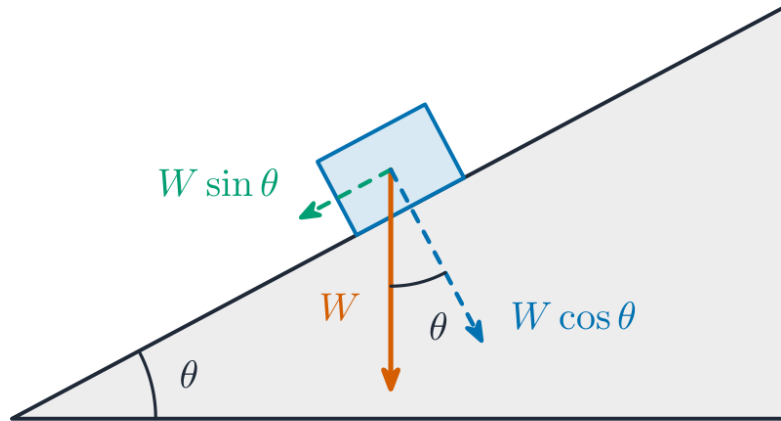
Exercise walk-through

1.7

Fluids: density, upthrust and viscous drag (statements 23–26, core practical 2)

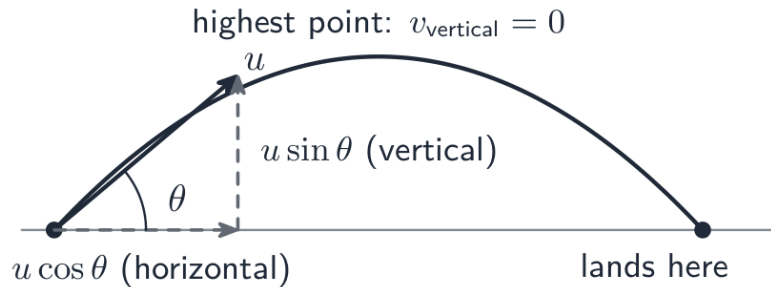
Pearson Edexcel · International A-Level · Physics

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 A block of aluminium has mass 54 g and volume 20 cm^3 . Calculate its density in kg m^{-3} . [2]

2.2 A cube displaces 0.040 kg of water. State the upthrust on the cube. (*Take $g = 9.81 \text{ N kg}^{-1}$.*) [2]

2.3 State the three conditions needed for Stokes' law to apply. [2]

Exercises 2.1·2.3

2.1 A block of aluminium has mass 54 g and volume 20 cm³. Calculate its density in kg m⁻³. [2]

$$\mathbf{2.1} \quad \rho = \frac{m}{V}: \quad \rho = \frac{0.054 \text{ kg}}{20 \times 10^{-6} \text{ m}^3} = 2.7 \times 10^3 \text{ kg m}^{-3}.$$

2.2 A cube displaces 0.040 kg of water. State the upthrust on the cube. (*Take $g = 9.81 \text{ N kg}^{-1}$.*) [2]

$$\mathbf{2.2} \quad \text{Upthrust} = \text{weight of displaced fluid} = mg = 0.040 \text{ kg} \times 9.81 \text{ N kg}^{-1} = 0.39 \text{ N}.$$

2.3 State the three conditions needed for Stokes' law to apply. [2]

2.3 Small sphere; low speed / laminar flow, no turbulence; (and viscosity depends on temperature, so the temperature must be steady).

Exercises 2.4·3.1

2.4 In the falling-ball experiment, explain why the timing must start below the surface of the oil, after the ball has reached terminal velocity. [2]

3.1 A cube of volume V placed in a liquid displaces a weight W of the liquid. What is the magnitude of the upthrust on the cube? [1]

☐

A $V \times W$

B V

C $V \times \rho$

D W

Exercises 2.4·3.1

2.4 In the falling-ball experiment, explain why the timing must start below the surface of the oil, after the ball has reached terminal velocity. [2]

2.4 Just below the surface the ball is still accelerating, so the speed is not constant; the measured time must be at constant terminal velocity, or $v = \frac{s}{t}$ gives the wrong value.

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- ☐ **A** $V \times W$
B V
C $V \times \rho$
D W

3.1 D. Upthrust equals the weight of the displaced liquid – the weight, not its volume or its mass. A and C confuse volume with weight; B is a volume, not a force.

Exercise 3.2

3.2 A student warms the oil and repeats a falling-ball measurement. The time for the ball to fall the marked distance is shorter. Which statement explains this? [1]

☐

A warm oil is more viscous, so drag increases

B warm oil is less viscous, so terminal velocity is higher

C warm oil is denser, so upthrust increases

D the ball expands, so its weight increases

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3.2 B. Viscosity falls as the oil warms, so drag is less at the same speed and the terminal velocity is higher, so the time is shorter. A reverses the temperature effect; C is wrong on density; D confuses expansion with weight.

Exercise 3.3

3.3 A ball-bearing of diameter 1.60 mm falls 25.0 cm through vegetable oil at terminal velocity in 1.8 s. The viscous drag at that speed is 8.4×10^{-5} N.

(a) Calculate the viscosity of the oil. [3]

(b) State two further measurements needed to check the force balance directly. [2]

Exercise 3.3

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(a) Calculate the viscosity of the oil.

[3]

(b) State two further measurements needed to check the force balance directly.

[2]

3.3 (a) $v = \frac{s}{t} = \frac{0.250 \text{ m}}{1.8} = 0.139 \text{ m s}^{-1}$; $F = 6\pi\eta rv \Rightarrow \eta = \frac{F}{6\pi r v}$; $\eta = \frac{8.4 \times 10^{-5}}{6\pi \times 0.8 \times 10^{-3} \times 0.139}$

Exercise 3.4

3.4 A submarine hanging from a crane cable moves upwards at constant speed, starting fully submerged and ending fully out of the water. Explain how the tension in the cable changes during the lift. Assume drag is negligible. [4]

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3.4 Fully submerged at constant speed: tension $T = W - U$, with U the upthrust. As the submarine emerges, the displaced volume falls, so the upthrust falls, and the tension rises. Once fully out of the water there is no upthrust, so $T = W$ and stays there.