GET BETTER AT PHYSICS · MARK SCHEME

# Slopes: tiered multiple choice

A-level Physics · Theme pack · questions from AQA, OxfordAQA, Edexcel, Edexcel IAL, OCR A and OCR B · 29 questions · 29 marks

1 mark per correct letter

Worked reasoning for every question

**How students did** = from AQA and Pearson examiner reports, where available

## Answer key

| Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 |
|---|---|---|---|---|---|---|---|---|---|
| A | D | B | B | A | C | C | C | D | B |
| **Q11** | **Q12** | **Q13** | **Q14** | **Q15** | **Q16** | **Q17** | **Q18** | **Q19** | **Q20** |
| B | B | B | C | B | B | D | C | B | C |
| **Q21** | **Q22** | **Q23** | **Q24** | **Q25** | **Q26** | **Q27** | **Q28** | **Q29** | |
| B | B | A | C | C | C | D | A | C | |

## Easy

Questions 1–13

**1** **A**

Reading a velocity–time graph · OCR A June 2022 · A-level Modelling physics · Q3

The gradient of a velocity–time graph is the acceleration (Δv/Δt). The area under it is the displacement (velocity × time). The slope of the ramp does not change these rules.

**2** **D**

Which force does no work · OCR A June 2017 · AS Breadth in physics · Q17

Work done = force × distance moved *in the direction of the force*. The block moves along the ramp, but the normal contact force acts at 90° to the ramp, so it has no component along the motion and does no work. Weight, friction and tension all have components along the ramp.

**Watch out:** Weight is vertical, but it still has a component down the slope, so work is done against it.

**3** **B**

Newton's third law pairs on a ramp · Edexcel IAL October 2020 · Unit 1 · Q2

A Newton's third law pair acts on two different objects and is the same type of force. Friction F and the normal contact force R are exerted by the ramp on the box, so the box exerts equal and opposite forces on the ramp. The weight W pairs with the box's pull on the Earth, and air resistance D pairs with a force on the air.

**Watch out:** W and R are not a third-law pair even though both act on the box.

**4** **B**

GPE gained going up a slope · Edexcel October 2020 · AS Paper 1 · Q2

Gain in GPE = mgΔh, where Δh is the **vertical** height gained. That is y, so ΔE = mgy. The horizontal distance x and the length along the slope do not matter.

**5** **A**

Why the speed is constant · Edexcel IAL October 2024 · Unit 1 · Q5

Constant speed means the resultant force along the slope is zero. The forces along the slope are the weight component down the slope and the resistive forces up it, so these must be equal. The perpendicular component of weight is balanced by the normal contact force, not by the resistive forces.

**6** **C**

Friction at constant speed · Edexcel IAL June 2025 · Unit 1 · Q8

At constant speed the forces along the ramp balance. The component of weight down the ramp is W sin θ, and friction F acts up the ramp, so F = W sin θ.

> **Watch out:** W cos θ is the component *into* the ramp, balanced by the normal contact force.

**7** **C**

Friction on a stationary block · OxfordAQA January 2026 · Unit 1 · Q21

The block is stationary, so the resultant force along the slope is zero. The weight component down the slope is mg sin θ (the −y direction), so friction must be mg sin θ up the slope, in the +y direction.

**8** **C**

Matching graphs to motion on ramps · Edexcel June 2016 · AS Paper 1 · Q6

The horizontal velocity falls, reaches a minimum (not zero), then rises again. The ball slows going up one ramp, then speeds up going down a second ramp. The displacement keeps increasing throughout, so the ball never comes back: it is not D, where it would return down the same ramp.

> **Watch out:** In D the displacement would decrease after the turning point.

**How students did:** 69% of students got this right in June 2016. The examiners noted that the displacement graph is what separates C from D.

**9** **D**

Efficiency of a motor on a slope · Edexcel June 2023 · AS Paper 1 · Q6

Efficiency = useful energy out ÷ total energy in. The useful output is the GPE gained, mgh (h is the vertical height, not the distance l along the slope). The energy supplied to the motor is VIt. So efficiency = mgh / VIt.

> **Watch out:** An efficiency must be less than 1, so the input energy (VIt) goes on the bottom.

**10** **B**

Components of velocity on an incline · Edexcel IAL October 2019 · Unit 1 · Q5

The velocity along the escalator, 0.5 m $s^{-1}$, is the hypotenuse of a right-angled triangle with the vertical component 0.3 m $s^{-1}$. Horizontal component = $\sqrt{(0.5^2 - 0.3^2)} = \sqrt{0.16} = 0.4$ m $s^{-1}$.

**How students did:** 90% of students got this right in October 2019.

**11** **B**

Component of weight into the slope · OCR B October 2021 · A-level Fundamentals of physics · Q10

F is drawn perpendicular to the slope, so it is the component of the weight into the hill: F = mg cos 25° = 1100 × 9.81 × cos 25° ≈ 9780 N ≈ 9800 N.

> **Watch out:** A (4600 N) is mg sin 25°, the component *down* the slope. Check which way F is drawn.

**12** **B**

Work done by gravity down a hill · OCR B October 2020 · AS Foundations of physics · Q10

Work done by gravity = mg × vertical drop. The car falls 50 sin 8° = 6.96 m, so W = 500 × 9.81 × 6.96 ≈ 34 000 J = 34 kJ. Or: weight component along the slope × distance = (500 × 9.81 × sin 8°) × 50, which gives the same answer.

> **Watch out:** D (250 kJ) uses the full 50 m as if the car fell vertically.

**13** **B**

Acceleration along a slope with an angled force · AQA June 2024 · A-level Paper 1 · Q18

Resolve along the slope. The component of F along the slope is F cos β (β is measured from the slope). The weight component down the slope is mg sin α. Resultant force = F cos β − mg sin α, so a = (F/m) cos β − g sin α.

**How students did:** Over 70% of students got this right in June 2024.

## Medium

Questions 14–26

**14** **C**

Effect of doubling the mass · AQA June 2023 · A-level Paper 1 · Q24

With no friction, the accelerating force is the weight component mg sin θ, so doubling m doubles the force (A and B are wrong). Then a = mg sin θ / m = g sin θ, which does not depend on mass. The acceleration is unchanged.

> **Watch out:** A bigger mass means a bigger accelerating force *and* more inertia, and the two cancel.

**15** **B**

Triangle of forces for a block at rest · OCR A June 2016 · AS Breadth in physics · Q7

The block is in equilibrium, so W, F and N form a closed triangle with the arrows following each other head to tail. W points down, F points up the slope, and N is perpendicular to the slope. In B the arrows go round the triangle in one direction. In A the N arrow points the wrong way, and in C and D F does not start where W ends.

> **Watch out:** Check the arrows go round the triangle the same way; the shape alone is not enough.

**16** **B**

Triangle of forces with the slope angle · OCR A October 2020 · A-level Modelling physics · Q8

W, N and F must form a closed triangle with the arrows head to tail. N is perpendicular to the slope and W is vertical, so the angle between W and N equals the slope angle, 30°. F (up the slope) is at 90° to N. Only B has the 30° between W and N and the arrows head to tail. In A, F points the wrong way; in C and D the 30° is between W and F.

> **Watch out:** The angle between the vertical and the normal to a slope is the same as the slope angle.

**17** **D**

Work done along a slope · Edexcel IAL June 2022 · Unit 1 · Q9

Work done = F × distance moved along the slope. The distance along the slope is the hypotenuse: Δh = d sin θ, so d = Δh / sin θ. Work done = F Δh / sin θ.

> **Watch out:** Draw the right-angled triangle: Δh is the side opposite θ.

**18** **C**

Efficiency of a ramp · Edexcel IAL January 2019 · Unit 1 · Q4

Useful work = GPE gained = weight × height = 200 × 4. Energy supplied = pushing force × distance along the ramp = 90 × 10. Efficiency = (200 × 4) / (90 × 10) ≈ 0.89.

> **Watch out:** The work done by the push already includes the GPE gained, so do not add the two (B and D).

**19** **B**

Work done against resistive forces · Edexcel June 2024 · A-level Paper 1 · Q3

Energy supplied by the motor = P × t = 5.2 × 1.1 J. The speed is constant, so there is no gain in KE. The energy goes into GPE (0.40 J) and work against resistive forces. Work against resistive forces = (5.2 × 1.1) − 0.40.

**20** **C**

Speed at the bottom of a frictionless slope · Edexcel IAL June 2023 · Unit 1 · Q8

Acceleration down a frictionless slope a = g sin 23°. From rest, $v^2 = 2as = 2 \times 9.81 \times \sin 23° \times 20$, so $v = \sqrt{(2 \times 9.81 \times 20 \times \sin 23°)}$. (Energy gives the same: the height dropped is 20 sin 23°.)

> **Watch out:** cos 23° gives the component of g into the slope, which does not accelerate the object.

**21** **B**

Finding the slope angle · AQA June 2025 · A-level Paper 1 · Q23

Constant speed, so the forces along the ramp balance: push up = weight component down + friction (friction opposes motion up the ramp). 25.0 = 240 sin θ + 3.0, so sin θ = 22.0/240 = 0.0917 and θ = 5.3°.

**Watch out:** Adding friction instead of subtracting gives 6.7° (D); ignoring it gives 6.0° (C).

**22** **B**

Work done up a slope with friction · OCR B June 2023 · A-level Fundamentals of physics · Q16

At constant speed the pulling force = mg sin 20° + friction = 2.0 × 9.81 × sin 20° + 20 = 6.71 + 20 = 26.7 N. Work done = 26.7 × 9.0 ≈ 240 J. (Or GPE gained, 2.0 × 9.81 × 9.0 sin 20° = 60 J, plus work against friction, 20 × 9.0 = 180 J.)

**Watch out:** A (180 J) counts only the friction.

**23** **A**

Average resistive force from an energy loss · OCR A June 2017 · AS Breadth in physics · Q13

Energy lost to resistive forces = 100 − 60 = 40 J. This work is done along the length of the ramp, 5.0 m (not the 3.0 m height). Average resistive force = 40 / 5.0 = 8.0 N.

**Watch out:** Divide by the distance the force acts over, along the ramp, not the vertical height.

**24** **C**

Frictional force from energy · OxfordAQA January 2024 · Unit 1 · Q19

GPE lost = 12 × 9.81 × 2.0 = 235 J. KE gained = ½ × 12 × $1.5^2$ = 13.5 J. Work against friction = 235 − 13.5 = 222 J, done over 3.5 m along the ramp. Friction = 222 / 3.5 ≈ 63 N.

**Watch out:** B (67 N) forgets the KE; A (220 N) is the energy, not the force.

**25** **C**

Speed from power on a hill · AQA June 2018 · AS Paper 2 · Q21

With no resistive forces, the driving force at steady speed equals the weight component down the hill: mg sin 12° = 950 × 9.81 × sin 12° = 1940 N. P = Fv, so v = $6.5 \times 10^4$ / 1940 ≈ 34 m $s^{-1}$.

**Watch out:** Using the whole weight mg instead of mg sin 12° gives 7.0 m $s^{-1}$ (A).

**How students did:** 41% of students got this right in June 2018.

**26** **C**

Extra power needed up a hill · AQA June 2025 · AS Paper 2 · Q34

On the level at constant speed, resistive forces = thrust = 3800 N. Up the hill the engine must also balance the weight component: 12 000 sin 10° = 2080 N. Driving force = 3800 + 2080 = 5880 N. P = Fv = 5880 × 15 ≈ 88 kW.

**Watch out:** B (57 kW) is the power on the level; A (31 kW) is only the extra power needed for the hill.

**How students did:** The examiners reported that the correct answer was the most popular choice in June 2025.

## Hard

Questions 27–29

**27** **D**

Power output on and off a hill · Edexcel IAL January 2024 · Unit 1 · Q4

On the level at constant speed, the cyclist must still work against resistive forces, so P is constant and not zero. On the hill at the same constant speed, she must also supply mg sin θ, so the force, and so P = Fv, jumps to a new, higher constant value. The gradient is constant, so P does not keep rising.

**Watch out:** A and B show power rising steadily, which would need a steadily steepening hill or increasing speed.

**28** **A**

Average friction from an energy loss · AQA June 2017 · AS Paper 2 · Q5

GPE lost = 2.5 × 9.81 × 3.0 = 73.6 J. KE gained = ½ × 2.5 × 5.0² = 31.3 J. Work against friction = 73.6 − 31.3 = 42.3 J, over 5.0 m of ramp. Friction = 42.3 / 5.0 ≈ 8.5 N.

> **Watch out:** 10.6 N divides by the 4.0 m base instead of the 5.0 m ramp; 14.7 N forgets the KE gained.

**How students did:** 27% of students got this right in June 2017.

**29** **C**

Resistive force from power on a slope · OxfordAQA June 2024 · Unit 1 · Q21

Driving force F = P/v = 150 000 / 20 = 7500 N. At constant velocity, F = weight component + resistive forces. Weight component = 1200 × 9.81 × sin 15° = 3050 N. Resistive forces = 7500 − 3050 ≈ 4500 N.

> **Watch out:** A (3000 N) is close to the weight component itself, so read which force the question wants.

**End of mark scheme.** Answers from the exam boards' published mark schemes; explanations written for this pack. © AQA, OxfordAQA, Pearson Education Ltd and OCR. More free packs and 1-to-1 tuition: **www.getbetteratphysics.co.uk**

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