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Online tutoring for Cambridge IGCSE, O Level & A Level Physics

IGCSE PHYSICS 0625 · TOPICAL PAST PAPERS

Motion (Kinematics) — Paper 2

Worked Solutions (Theory / Structured)

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Motion (Kinematics) — Paper 2 · Worked Solutions

Megalecture worked solutions — model answers with working; please verify before classroom use. These solutions cover the two topical Paper-2 (theory / structured) compilations on **Motion (Kinematics), IGCSE Physics 0625**. Every part has been solved from first principles by the Megalecture team; graph readings are taken to the nearest sensible grid value, and the acceleration of free fall is taken as g = 10 m/s^2 unless stated. Where an answer depends on reading a value off a printed graph, a small tolerance is normal — the method shown is the key thing.

Worksheet 1

Question 1 May/June 2003 · P2 · Q1

Speed–time graph for the first part of a lorry's journey (Fig. 1.1).

(a)(i) The speed of the lorry.

The speed rises from 0 and the curve gets less steep, so the lorry **speeds up (accelerates) but at a decreasing rate**. From about t = 55 s onwards the line is horizontal, so the lorry then moves at a **constant (maximum) speed of about 25 m/s**.

(a)(ii) The acceleration of the lorry.

Acceleration = gradient of the speed–time graph. The gradient is large at the start and steadily falls to zero, so the **acceleration is positive but decreasing**, becoming **zero once the lorry reaches its maximum (constant) speed**.

(b) Maximum speed in m/s and in km/h.

Reading the flat part of the graph: maximum speed = **25 m/s**.
Convert: 25 m/s × 3.6 = **90 km/h**. (×3.6 because 1 m/s = 3600/1000 km/h.)

Question 2 May/June 2005 · P2 · Q1

Earth and Venus orbiting the Sun (orbits taken as circles); data table given.

(a) Direction of the force of the Sun on the Earth.

Draw an arrow from the Earth pointing **directly towards the Sun** (along the line joining Earth to the Sun). This is the gravitational pull that keeps the Earth in orbit.

(b)(i) Show that Venus has a greater speed than Earth.

Speed = distance ÷ time = (circumference of orbit) ÷ (orbital period).
Venus: 679 ÷ 0.7 ≈ **970 million km per year**.
Earth: 942 ÷ 1.0 = **942 million km per year**.
Since 970 > 942, **Venus moves faster than Earth**.

(b)(ii) Largest possible distance between Earth and Venus.

This occurs when they are on **opposite sides of the Sun**, so the distance is the sum of the two orbit radii: 150 + 108 = **258 million km**.

Question 3 May/June 2006 · P2 · Q2

A cyclist starts from rest, accelerates, travels at constant speed, then brakes; positions photographed every 4 s (Fig. 2.1): 0 s → 0 m, 4 s → 10 m, 8 s → 22 m, 12 s → 36 m.

(a) Position of the front wheel at 16 s.

After 12 s the cyclist brakes (slows down), so the gap covered in the next 4 s is **smaller** than the previous 14 m gap. A sensible mark is at about **46–48 m** (a little beyond the 12 s position, but a shorter step).

(b) Distance–time graph for the first 16 s.

Plot the points (0, 0), (4, 10), (8, 22), (12, 36) and (16, ≈47). Join with a smooth line: **curving upward (steepening) at first as it accelerates, becoming a straight line of steady gradient while at constant speed, then bending less steeply** after 12 s as it brakes.

(c) Average speed during the first 12 s.

Average speed = total distance ÷ total time = 36 ÷ 12 = **3.0 m/s**.

Reading note: distances read from Fig. 2.1 to the nearest sensible value; small differences are acceptable.

Question 4 May/June 2007 · P2 · Q1

Distance–time graph for two athletes A and B in a 100 m race (Fig. 1.1).

(a) Motion of athlete A during the first 8 s.

The curve for A gets steadily steeper, so the speed is increasing — A **accelerates (speeds up) throughout the first 8 s**, starting from rest and covering greater distances in each successive second.

(b) Distance between the athletes as the winner passes 100 m.

B reaches 100 m first (B's curve is higher near the end). When B is at 100 m, A is at roughly 90 m, so the gap is about **10 m**.

(c) Speed of athlete A between t = 4 s and t = 15 s.

Speed = (change in distance) ÷ (change in time). Reading A's graph: ≈30 m at 4 s and ≈105 m at 15 s. Speed = (105 − 30) ÷ (15 − 4) = 75 ÷ 11 ≈ **6.8 m/s**.

Reading note: values read off Fig. 1.1; an answer of roughly 6–7 m/s is acceptable.

Question 5 May/June 2015 · P21 · Q1

Distance–time graph for cyclists A and B in a 500 m race (Fig. 1.1).

(a)(i) Distance between A and B at t = 20 s.

At t = 20 s, A has travelled ≈220 m and B ≈180 m, so the gap is about **40 m** (read as the vertical separation of the two lines).

(a)(ii) Difference in the time taken for the race.

A reaches 500 m at about t = 38 s; B reaches 500 m at about t = 50 s. Difference ≈ 50 − 38 = **12 s** (about 10–12 s).

(b)(i) Distance–time graph for cyclist C.

For the first 200 m at 5.0 m/s, time = 200 ÷ 5.0 = 40 s. So draw a **straight line from (0, 0) to (40, 200)**, then a **curve that steepens** (accelerating) from (40, 200) up to **(60, 500)**.

(b)(ii) Average speed of C for the whole race.

Average speed = total distance ÷ total time = 500 ÷ 60 = **8.3 m/s**.

Question 6 May/June 2018 · P21 · Q1

A cyclist travels along a straight, horizontal road (Fig. 1.1).

(a) How the average speed can be measured.

Mark out a measured **distance** along the road with a tape measure (e.g. between two lines). Use a **stopwatch** to measure the **time** the cyclist takes to travel between the two marks. Then **average speed = distance ÷ time**.

(b)(i) Meaning of a negative acceleration.

A negative acceleration means the **cyclist is slowing down** — the speed is decreasing with time (deceleration).

(b)(ii) Change in speed when a = 1.8 m/s^2 for 2.5 s.

Change in speed = acceleration × time = 1.8 × 2.5 = **4.5 m/s** (a decrease of 4.5 m/s).

Question 7 Oct/Nov 2004 · P2 · Q1

Simplified speed–time graph for a train between two stations (Fig. 1.1): speed jumps to 20 m/s, stays constant from t = 20 min to t = 65 min, then returns to zero.

(a) Describe the motion.

The train is **stationary for the first 20 minutes**, then travels at a **constant speed of 20 m/s for 45 minutes** (from 20 to 65 min), and is then **stationary again** (stopped at the second station).

(b) Distance travelled between the two stations.

Distance = area under the graph = speed × time. Time at constant speed = 45 min = 45 × 60 = 2700 s. Distance = 20 × 2700 = **54 000 m (= 54 km)**.

(c) Speed–time graph for a second train (constant speed, 0 to 90 min, same distance).

Same distance in 90 min: speed = 54 000 ÷ (90×60) = **10 m/s**. Draw a **horizontal line at 10 m/s from t = 0 to t = 90 min** (so that the area below it equals 54 000 m).

Question 8 Oct/Nov 2005 · P2 · Q1

Speed–time graph of a car that slows for a town, crosses it at constant speed, then speeds up (Fig. 1.1).

(a)(i) Speed of the car in the town.

The flat (low) part of the graph reads **12 m/s**.

(a)(ii) Time taken to pass through the town.

The car is at the town speed from about t = 12 s to t = 27 s, so time taken = 27 − 12 = **15 s**.

(a)(iii) Distance travelled in the town.

Distance = speed × time (area under the flat section) = 12 × 15 = **180 m**.

(b) Acceleration after the town (with unit).

After the town the speed rises from 12 m/s at t≈27 s to ≈28 m/s at t≈34 s.
a = (v − u) ÷ t = (28 − 12) ÷ (34 − 27) = 16 ÷ 7 ≈ **2.3 m/s^2**.

Reading note: graph values read to the nearest grid line; ≈2 m/s^2 is acceptable.

Question 9 Oct/Nov 2010 · P21 · Q1

A window cleaner drops a sponge at t = 0; speed–time graph given (Fig. 1.1). The speed rises, levels off at ≈12 m/s by about t = 1.7 s.

(a)(i) t when moving at uniform (constant) speed.

Any value where the line is horizontal, e.g. **t = 2.0 s** (any t between about 1.7 s and 2.5 s).

(a)(ii) t when accelerating at a non-uniform rate.

Where the line is curved (gradient changing), e.g. **t = 1.0 s** (any t in the region where the curve is bending, about 0.8–1.6 s).

(a)(iii) t when decelerating.

At **t = 2.5 s** the line drops vertically (the sponge is caught/stopped), so the sponge is decelerating there.

(b) Distance travelled between t = 0 and t = 0.75 s.

Up to 0.75 s the graph is almost a straight line through the origin, reaching ≈9 m/s at 0.75 s. Distance = area under the graph ≈ ½ × base × height = ½ × 0.75 × 9 ≈ **3.4 m**.

Reading note: distance found as the area under the curve; ≈3–3.5 m is acceptable.

Worksheet 2

Question 1 May/June 2004 · P2 · Q1

A free-fall parachutist falls vertically; speed–time graph rises and levels off (points A then B).

(a)(i) Downward force on the parachutist.

Weight (the gravitational pull of the Earth).

(a)(ii) One upward force.

Air resistance (drag).

(b)(i) Initial value of the acceleration (with unit).

At the very start the speed is zero, so air resistance is zero and the only force is weight. The acceleration is therefore the acceleration of free fall: **10 m/s^2**.

(b)(ii) Why the acceleration decreases from A to B.

As the speed increases, the **air resistance increases**. This reduces the **resultant downward force** (weight − air resistance), and since a = F/m, the **acceleration gets smaller**.

(b)(iii) Why the parachutist falls at constant speed after B.

By B the **air resistance has grown until it equals the weight**, so the **resultant force is zero**. With no resultant force there is no acceleration, so the speed stays constant (terminal velocity).

Question 2 May/June 2009 · P2 · Q1

A piece of paper falls from 4.0 m; height–time graph (h against t) given (Fig. 1.1).

(a) What happens to the speed of the paper as it falls.

The graph of height gets steeper with time, so the paper **speeds up (accelerates)** as it falls (it covers more height in each successive interval).

(b) Speed of the paper at t = 1.5 s.

Speed = magnitude of the gradient (slope) of the height–time graph at t = 1.5 s. Drawing a tangent there, the height falls by about 3.0 m over about 0.9 s:
speed ≈ 3.0 ÷ 0.9 ≈ **3.3 m/s** (about 3 m/s).

(c) Main energy change between t = 1.0 s and t = 2.0 s.

Gravitational potential energy → kinetic energy (as the paper falls and speeds up).

Reading note: the tangent gradient depends on how it is drawn; roughly 3 m/s is acceptable.

Question 3 May/June 2010 · P21 · Q1

Speed–time graph of a dropped ball; it accelerates then reaches a constant speed of 1.5 m/s after t = 0.20 s (Fig. 1.1).

(a) Why the speed is constant after t = 0.20 s.

The **air resistance has increased until it equals the weight**, so the **resultant force is zero**; with no resultant force there is no acceleration and the speed stays constant.

(b)(i) Value of the acceleration of free fall.

10 m/s^2 (9.8 m/s^2).

(b)(ii) Speed of the second ball at t = 0.20 s.

Until 0.20 s this ball has a = g = 10 m/s^2 from rest.
v = u + a·t = 0 + 10 × 0.20 = **2.0 m/s**.

(b)(iii) Draw the speed–time graph for the second ball (0 to 0.28 s).

Draw a **straight line from (0, 0) to (0.20 s, 2.0 m/s)** (constant acceleration = free fall, steeper than the first ball), then a **curve that bends over** (acceleration decreasing) from 0.20 s to 0.28 s.

Question 4 May/June 2011 · P21 · Q2

A sky-diver falls at terminal velocity; arrows X (down) and Y (up) are the two main forces (Fig. 2.1).

(a)(i) Name forces X and Y.

X (downwards) = **weight**. Y (upwards) = **air resistance (drag)**.

(a)(ii) Why force Y acts upwards.

The sky-diver moves **downwards through the air**, so the air pushes back on him in the **opposite direction to his motion** — i.e. upwards.

(b)(i) Effect of the unbalanced forces at the start.

At first the speed is low so Y (air resistance) is small and **weight is greater than air resistance**. There is a **resultant downward force**, so the sky-diver **accelerates (speeds up) downwards**.

(b)(ii) What happens to the sizes of X and Y as terminal velocity is reached.

X (weight) stays the same; **Y (air resistance) increases** with speed until it **equals X**, giving zero resultant force (terminal velocity).

Question 5 May/June 2012 · P21 · Q1

A stone is thrown vertically upwards on the Moon at t = 0; the velocity–time line falls from ≈4.8 m/s at t = 0 to ≈1.6 m/s at t = 2.0 s (Fig. 1.1). No air resistance.

(a)(i) Complete the graph up to t = 6.0 s.

Because there is no air resistance, the acceleration is constant, so the graph is a **single straight line**. Extend the same line: it crosses v = 0 at t = 3.0 s and continues straight down to **v = −4.8 m/s at t = 6.0 s** (the stone returns to the hand with the same speed it left, but moving downwards).

(a)(ii) Time when the stone is at its highest point.

At the highest point the velocity is zero. The line reaches v = 0 at **t = 3.0 s**.

(b) Acceleration between t = 0 and t = 2.0 s.

a = (v − u) ÷ t = (1.6 − 4.8) ÷ 2.0 = −3.2 ÷ 2.0 = **−1.6 m/s^2** (i.e. 1.6 m/s^2 directed downwards — the Moon's gravity).

(c) Two ways the Earth graph would differ.

1. The line would be **steeper** — a larger (downward) acceleration of about 10 m/s^2 instead of 1.6 m/s^2.
2. The stone would **reach its highest point and return in a shorter time** (so it would cross v = 0 much sooner).

Question 6 May/June 2013 · P22 · Q1

A ball rolls down a slope; a metre rule shows its position at t = 0, 1.0 s, 2.0 s, 3.0 s (Fig. 1.1): ≈10 cm, ≈20 cm, ≈50 cm, ≈85 cm.

(a) How Fig. 1.1 shows the ball is accelerating.

The ball travels a **greater distance in each successive 1 second interval** (the gaps between positions get larger), so its speed is increasing — it is accelerating.

(b) Average speed between t = 1.0 s and t = 3.0 s.

Distance = 85 − 20 = 65 cm = 0.65 m; time = 3.0 − 1.0 = 2.0 s.
Average speed = 0.65 ÷ 2.0 = **0.33 m/s** (≈33 cm/s).

(c) What happens to air resistance and weight as the ball accelerates.

Air resistance: increases (it grows as the speed increases).
Weight: stays the same (it does not depend on speed).

(d) Why a long enough slope gives a constant speed.

As speed rises, the air resistance (and other resistive forces) increase until the total force up the slope **balances the component of weight down the slope**. The **resultant force becomes zero**, so there is no acceleration and the speed stays constant.

Reading note: positions read from the metre rule to the nearest sensible value; ≈0.3 m/s is acceptable.

Question 7 May/June 2016 · P21 · Q1

A sky-diver (mass 60 kg, weight 600 N) jumps with initial downward acceleration 10 m/s^2. Fig. 1.2 shows air resistance against speed.

(a) Why the initial downward acceleration is 10 m/s^2.

At the instant he jumps his speed is zero, so the **air resistance is zero** and the only force is the weight, 600 N.
a = F ÷ m = 600 ÷ 60 = **10 m/s^2**.

(b) Why he experiences an upward acceleration when the parachute opens.

Opening the parachute **greatly increases the air resistance**, so it becomes **larger than the weight**. The resultant force now acts **upwards**, which causes an upward acceleration (he slows down).

(c)(i) Terminal velocity from Fig. 1.2.

At terminal velocity the air resistance equals the weight, 600 N. Reading Fig. 1.2 where air resistance = 600 N gives a speed of about **5.0 m/s**.

(c)(ii) Resultant force at speed 5.5 m/s.

From Fig. 1.2, at 5.5 m/s the air resistance is about 700 N (upwards), and the weight is 600 N (downwards).
Resultant = 700 − 600 = **100 N upwards**.

Reading note: values read from Fig. 1.2; ≈5 m/s and ≈100 N are acceptable.

Question 8 May/June 2018 · P22 · Q1

A metal object dropped into oil; positions recorded at 1.0 s intervals (Fig. 1.1): 0 s → 0 cm, 1.0 s → 0.5 cm, 2.0 s → 1.5 cm, 3.0 s → 3.0 cm, 4.0 s → 5.0 cm, 5.0 s → 7.0 cm.

(a) Plot the distance–time graph.

Plot the points (0, 0), (1, 0.5), (2, 1.5), (3, 3.0), (4, 5.0), (5, 7.0) and join with a smooth line. It **curves upward (steepening) at first as the object accelerates, then becomes a straight line** (constant gradient) once the speed is steady — the last two steps are both 2.0 cm, so the final gradient is **2.0 cm/s**.

(b)(i) How a distance–time graph shows constant speed.

The graph is a **straight line** (constant gradient). A straight line means equal distances are covered in equal times, so the speed is constant.

(b)(ii) Why it can fall at constant speed (in terms of forces).

The **upward forces (drag from the oil + upthrust) have increased until they equal the weight**, so the **resultant force is zero**. With no resultant force there is no acceleration and the object falls at constant speed.

Reading note: positions read from the ruler in Fig. 1.1 to the nearest sensible value.

Question 9 Oct/Nov 2003 · P2 · Q1

Beagle 2 spacecraft landing on Mars; speed–time axes given. Mass 65 kg, Mars gravitational field strength 3.0 N/kg, total upward force 500 N at one point.

(a) Complete the speed–time graph.

After the parachutes open at t_1 the friction increases, so the craft **slows down to a steady (constant) speed**: draw the line **decreasing from 1600 km/h after t_1 to a constant value**, then a **horizontal line** until it hits the surface at t_2 (where the line stops).

(b)(i) Weight of the spacecraft.

Weight = mass × gravitational field strength = 65 × 3.0 = **195 N**.

(b)(ii) Resultant force on the spacecraft.

Upward force 500 N, downward weight 195 N.
Resultant = 500 − 195 = **305 N upwards**.

(b)(iii) Deceleration of the spacecraft.

a = F ÷ m = 305 ÷ 65 = **4.7 m/s^2** (deceleration, since the resultant force opposes the downward motion).

Question 10 Oct/Nov 2006 · P2 · Q2

A coin and a piece of paper fall in a tube of air; Fig. 2.2 shows their force arrows (weight and air resistance).

(a) Initial value of the acceleration of the coin.

At the start the speed is zero, so air resistance is zero and the only force is weight: acceleration = **10 m/s^2** (the acceleration of free fall).

(b)(i) How Fig. 2.2 shows the paper falls at constant speed.

For the paper the **two arrows (air resistance and weight) are equal in length**, so the forces are balanced and the **resultant force is zero** — therefore no acceleration, i.e. constant speed.

(b)(ii) How Fig. 2.2 shows the coin accelerates.

For the coin the **weight arrow is longer than the air-resistance arrow**, so there is a **resultant downward force**, which makes the coin accelerate.

(c) Two differences when the air is removed (vacuum).

1. With no air resistance, **both objects accelerate at the same rate** (the acceleration of free fall).
2. **They fall together / take the same time to reach the bottom** (the paper no longer lags behind and neither reaches a terminal speed).

Question 11 Oct/Nov 2007 · P2 · Q1

A parachutist jumps; vertical speed–time graph (Fig. 1.1). Speed rises to ≈50 m/s by t = 20 s, then drops sharply to ≈5 m/s and stays constant until t = 55 s.

(a) What happens at t = 20 s and at t = 55 s.

At 20 s: the **parachute opens** (the speed falls rapidly).
At 55 s: the parachutist **lands / reaches the ground** (speed becomes zero).

(b) Describe the motion between t = 0 and t = 20 s.

The parachutist **accelerates (speeds up)**, but the curve flattens, so the **acceleration decreases** and the speed approaches a **terminal velocity of about 50 m/s**.

(c) Why the speed is constant between t = 25 s and t = 55 s.

With the parachute open, the large **air resistance now equals the weight**, so the **resultant force is zero**; no resultant force means no acceleration, so the speed stays constant.

(d) Distance travelled between t = 25 s and t = 55 s.

Constant speed ≈5 m/s for (55 − 25) = 30 s.
Distance = area under the graph = speed × time = 5 × 30 = **150 m**.

Reading note: the constant speed is read as ≈5 m/s; an answer near 150 m is acceptable.

Question 12 Oct/Nov 2016 · P22 · Q1

A skier sets off from rest and accelerates uniformly at 3.4 m/s^2 for 5.0 s, then travels at constant speed for a further 10.0 s.

(a) Speed of the skier after 5.0 s.

v = u + a·t = 0 + 3.4 × 5.0 = **17 m/s**.

(b)(i) Resultant force during the 10.0 s at constant speed.

Constant speed means no acceleration, so the resultant force is **0 N (zero)**.

(b)(ii) Sketch the speed–time graph for the whole 15.0 s.

Draw a **straight line from (0, 0) up to (5 s, 17 m/s)** (uniform acceleration), then a **horizontal line at 17 m/s from 5 s to 15 s** (constant speed).

(b)(iii) How distance is found from the speed–time graph.

The **distance travelled equals the area under the speed–time graph**.

Question 13 Oct/Nov 2018 · P21 · Q1

A girl on a bicycle (total mass 35 kg) accelerates from rest down a constant slope without pedalling (Fig. 1.1).

(a) Resultant force when accelerating at 2.6 m/s^2.

F = m·a = 35 × 2.6 = **91 N** (down the slope).

(b)(i) Sketch the speed–time graph until she reaches constant speed.

Draw a **straight line rising from the origin** (constant acceleration up to t_1), then a line that **curves and flattens** as the acceleration decreases, becoming a **horizontal line** once she travels at constant speed.

(b)(ii) How distance travelled is found from a speed–time graph.

The **distance travelled equals the area under the speed–time graph**.

Note from Megalecture. These are original Megalecture worked solutions prepared from first principles for revision use. Several parts require reading values from printed graphs and metre rules; the working shown is the important part, and small differences in read-off values are normal. Please verify against your own marking before classroom use.