

Paper 2 multi step calculations

AQA GCSE Combined Trilogy 8464 and Separate Physics 8463 | Paper 2 | Tier pathways

Worked answers | 31 parts and 45 marks per pathway | 36 printed parts

Specification points covered

8463 4.5.2 / 8464 6.5.2: work done by a specified force
8463 4.5.3 / 8464 6.5.3: spring force, extension and elastic energy
8463 4.5.6.1.2 and 4.5.6.1.5 / 8464 6.5.4.1.2 and 6.5.4.1.5: speed and acceleration
8463 4.5.6.2.2 / 8464 6.5.4.2.2: resultant force and acceleration
8463 4.6.1.2 / 8464 6.6.1.2: wave speed, frequency, wavelength and period
Higher section 7 only: 8463 4.7.2.2 / 8464 6.7.2.2: motor force and direction

An electric cargo-bike test centre checks journey timings, braking, a spring carrier and an audible warning system. Each section is a separate test. Use its stated values; do not carry speeds or forces between tests unless instructed.

Original PhysicsUK practice, not an official AQA resource. Sections 1–5 plus ONE final pathway per pupil. Higher section 7 replaces section 6, not extra work. Credit suitable rounding and consistent error carried forward. $v^2 - u^2 = 2as$ is GCSE both-tier content; no velocity–time area calculation is required on either route.

1 Preparing the dispatch report

1(a) State the SI unit of work done. [1 mark]

Answer / mark points: Joule (J); accept the equivalent newton metre (N m). [1] A newton alone is force, not work.

1(b) In $F = ma$, does F mean a single named force or the resultant force? [1 mark]

Answer / mark points: The resultant force. [1] A named force is equal to it only if the other forces cancel or are absent.

1(c) A dispatch route takes 6.0 minutes, including stops, to cover 1.8 km. Calculate the average speed in m s^{-1} . [2 marks]

Answer / mark points: $1.8 \text{ km} = 1800 \text{ m}$ and $6.0 \text{ min} = 360 \text{ s}$. [1 for both conversions]
Average speed = $1800 / 360 = 5.0 \text{ m s}^{-1}$. [1] Include the whole elapsed time, not just riding time.

1(d) On a separate straight section, the bike travels at a constant speed of 6.0 m s^{-1} for 180 m. Calculate the time taken. [1 mark]

Answer / mark points: $t = \text{distance} / \text{speed} = 180 / 6.0 = 30 \text{ s}$. [1] Do not use a changing-speed formula for this constant-speed section.



2 Interpreting the level-track data

The total mass of bike, rider and load is 160 kg. East is positive. Table 1 gives velocity data for one straight run: acceleration is uniform from 0–4 s, velocity is constant from 4–12 s, and deceleration is uniform from 12–16 s. In 2(d), the resistive force from 0–4 s is 60 N westwards.

Table 1

Time / s	Velocity / m s ⁻¹
0	0
2	+3.0
4	+6.0
12	+6.0
16	0

2(a) Read the velocity at 2.0 s from Table 1. Include the direction. **[1 mark]**

Answer / mark points: 3.0 m s⁻¹ eastwards. [1] It is positive under the given sign convention.

2(b) Calculate the acceleration from 0 s to 4.0 s. **[1 mark]**

Answer / mark points: $a = (6.0 - 0) / 4.0 = 1.5 \text{ m s}^{-2}$ eastwards. [1]

2(c) Calculate the resultant force on the 160 kg bike system during those first 4.0 s. **[1 mark]**

Answer / mark points: $F = ma = 160 \times 1.5 = 240 \text{ N}$ eastwards. [1] This is the resultant, not the driving force alone.

2(d) During those first 4.0 s, the resistive force is 60 N westwards. Calculate the driving force. **[1 mark]**

Answer / mark points: Driving force – 60 = 240, so driving force = 300 N eastwards. [1] Opposing resistance must be added to the required resultant.

2(e) Calculate the distance travelled from 4.0 s to 12.0 s, when the velocity is constant. **[1 mark]**

Answer / mark points: Time interval = $12.0 - 4.0 = 8.0 \text{ s}$; distance = $6.0 \times 8.0 = 48 \text{ m}$. [1] Use the duration of this section, not the clock reading 12 s.

2(f) Calculate the signed acceleration from 12.0 s to 16.0 s. Explain why its sign does not mean the bike is travelling westwards. **[2 marks]**

Answer / mark points: $a = (0 - 6.0) / (16.0 - 12.0) = -1.5 \text{ m s}^{-2}$. [1]

Velocity is still positive/eastwards until it reaches zero; the negative acceleration means velocity is decreasing. [1] It does not say the bike reverses.



3 Braking and work calculations

A SEPARATE level-track braking test starts at 6.0 m s^{-1} eastwards. The 160 kg bike system slows uniformly at 2.0 m s^{-2} until it stops. Take east as positive. The brakes provide the only horizontal retarding force during this test.

3(a) Calculate the magnitude of the resultant braking force. [1 mark]

Answer / mark points: Force magnitude = $m \times \text{deceleration magnitude} = 160 \times 2.0 = 320 \text{ N}$. [1]
The force is westwards, opposite the initial motion.

3(b) Calculate how long the bike takes to stop after braking begins. [1 mark]

Answer / mark points: $t = (v - u) / a = (0 - 6.0) / (-2.0) = 3.0 \text{ s}$. [1] Equivalently, speed reduction / deceleration magnitude = $6.0 / 2.0$.

3(c) Use $v^2 - u^2 = 2as$ to calculate the distance travelled during braking. [2 marks]

Answer / mark points: $0^2 - 6.0^2 = 2 \times (-2.0) \times s$. [1]
 $s = (-36) / (-4.0) = 9.0 \text{ m}$. [1] Use consistent signs; a negative distance along the actual eastward travel is not correct here.

3(d) Calculate the magnitude of the work done by the brakes over that braking distance. [1 mark]

Answer / mark points: Work magnitude = force magnitude $\times$ distance = $320 \times 9.0 = 2880 \text{ J}$. [1]
Work by the brakes opposes motion; this positive magnitude does not mean energy is added to the bike.

3(e) In a DIFFERENT accelerating test, the driving force is 300 N and resistance is 60 N over 20 m . Calculate the work done by the driving force and the magnitude of work done against resistance. [2 marks]

Answer / mark points: Driving-force work = $300 \times 20 = 6000 \text{ J}$. [1]
Work against resistance = $60 \times 20 = 1200 \text{ J}$. [1] Use each named force, not their resultant for both.

3(f) For the test in 3(e), a trainee calculates $(300 - 60) \times 20 = 4800 \text{ J}$ and calls this the work done by the driving force. Explain what 4800 J represents and why it differs from the driving-force work. [2 marks]

Answer / mark points: 4800 J is the net work done on the bike by the horizontal forces/resultant. [1]
It is 1200 J less than the 6000 J driving-force work because 1200 J is transferred against resistance. [1] Net force and driving force are different in this test.



4 Testing the spring carrier

A carrier test uses ONE spring with spring constant 4000 N m^{-1} . Its unloaded length is 8.0 cm; its loaded length is 10.5 cm. Every spring in this section is used below its limit of proportionality. Forces and energies refer to the individual spring, not an unspecified spring arrangement.

4(a) Calculate the extension in metres and the force exerted by the loaded spring. **[2 marks]**

Answer / mark points: Extension = $(10.5 - 8.0) \text{ cm} = 2.5 \text{ cm} = 0.025 \text{ m}$. [1]
 $F = ke = 4000 \times 0.025 = 100 \text{ N}$. [1] The loaded length 10.5 cm is not the extension.

4(b) Calculate the elastic potential energy stored at this extension. **[1 mark]**

Answer / mark points: Elastic energy = $0.5ke^2 = 0.5 \times 4000 \times 0.025^2 = 1.25 \text{ J}$. [1] Square the extension in metres, not centimetres.

4(c) The permitted force in this test is at most 150 N. Calculate the spring force at an extension of 4.0 cm and decide whether it meets this limit. Show your working. **[2 marks]**

Answer / mark points: $F = 4000 \times 0.040 = 160 \text{ N}$. [1]
 It does not meet the limit: 160 N exceeds 150 N. [1] A bare decision without calculation earns at most 1 mark; this is one test limit, not complete safety certification.

4(d) A DIFFERENT spring extends by 3.0 cm when the force is 90 N. Calculate its spring constant, then predict its force at an extension of 4.0 cm. **[2 marks]**

Answer / mark points: $k = F / e = 90 / 0.030 = 3000 \text{ N m}^{-1}$. [1]
 New force = $3000 \times 0.040 = 120 \text{ N}$. [1] Accept the equivalent force ratio $90 \times 4/3$ after finding k .

4(e) For the original 4000 N m^{-1} spring, the extension is doubled while it remains in the proportional range. State what happens to the force and to the stored elastic energy. **[2 marks]**

Answer / mark points: The force doubles because $F = ke$. [1]
 The elastic energy becomes four times as large because energy is proportional to e^2 . [1] It is not four times the force.



5 Matching the warning signal

The stationary bike's warning system is tested with two tones, A and B. Sound travels at 340 m s^{-1} in the test conditions. A receiver accepts wavelengths from 0.15 m to 0.25 m inclusive. This is a stated receiver setting, not a complete test of loudness or safety.

5(a) Tone A has frequency 850 Hz. Calculate its wavelength. **[1 mark]**

Answer / mark points: $\lambda = \text{wave speed} / \text{frequency} = 340 / 850 = 0.40 \text{ m}$. [1]

5(b) Tone B has wavelength 17 cm. Calculate its frequency. **[2 marks]**

Answer / mark points: $\lambda = 17 \text{ cm} = 0.17 \text{ m}$. [1]

$f = 340 / 0.17 = 2000 \text{ Hz}$. [1] The bike's speed is not the speed of sound.

5(c) Calculate the period of tone B. **[1 mark]**

Answer / mark points: $T = 1 / 2000 = 0.00050 \text{ s}$ (0.50 ms). [1] Use its frequency, not its wavelength.

5(d) A sensor is 85 m from the stationary sound source. Calculate the sound travel time. **[1 mark]**

Answer / mark points: $t = \text{distance} / \text{sound speed} = 85 / 340 = 0.25 \text{ s}$. [1] Ignore any electronic detection delay; only propagation time is requested.

5(e) Which tone, A or B, is within the receiver's accepted wavelength range? Justify your choice by checking both tones. **[2 marks]**

Answer / mark points: B is accepted: 0.17 m is between 0.15 m and 0.25 m. [1]

A is not accepted: 0.40 m exceeds 0.25 m. [1] Receiver compatibility alone does not establish safe loudness or audibility.



6 Foundation replacement section

Foundation: complete this page after sections 1–5, then stop. Higher pupils skip this page. These are separate follow-up checks, using common Paper 2 equations.

6(a) The loaded bike system now has mass 200 kg. A 300 N driving force acts eastwards and a 60 N resistance acts westwards. Calculate its acceleration. **[2 marks]**

Answer / mark points: Resultant force = $300 - 60 = 240$ N eastwards. [1]
 $a = F / m = 240 / 200 = 1.20$ m s⁻² eastwards. [1]

6(b) Starting from rest at this constant acceleration, calculate the time needed to reach 4.8 m s⁻¹. **[1 mark]**

Answer / mark points: $t = (v - u) / a = (4.8 - 0) / 1.20 = 4.0$ s. [1] Accept consistent follow-through from 6(a).

6(c) On a separate route the bike covers 360 m at a steady 6.0 m s⁻¹ and has one 10 s stop. Calculate the total elapsed time and decide whether it meets a deadline of at most 70 s. **[2 marks]**

Answer / mark points: Riding time = $360 / 6.0 = 60$ s. [1]
 Total elapsed time = $60 + 10 = 70$ s, which meets the inclusive 70 s deadline. [1] Stops contribute to journey time even though no distance is travelled.

6(d) A carrier spring has $k = 3000$ N m⁻¹ and an extension of 6.0 cm. Calculate the force and decide whether it meets a stated limit of at most 160 N. **[2 marks]**

Answer / mark points: $F = 3000 \times 0.060 = 180$ N. [1]
 It does not meet the limit: 180 N is greater than 160 N. [1] Check metres before substituting.

6(e) In a separate brake test, a constant retarding force of 180 N acts over 4.0 m. Calculate the magnitude of the work done by this force. **[1 mark]**

Answer / mark points: Work magnitude = $180 \times 4.0 = 720$ J. [1] The magnitude is positive; the force opposes the motion.



7 Higher replacement section

Higher only: complete this page INSTEAD of section 6. Figure 1 is a TOP VIEW of a small straight-conductor cargo-latch actuator, not the force on the whole bike. Current is into the page; field is rightwards. Weight and support balance perpendicular to this view. Use $F = B I \ell$ with $B = 0.40 \text{ T}$, $I = 2.5 \text{ A}$ and $\ell = 6.0 \text{ cm}$. The conductor is perpendicular to the field.

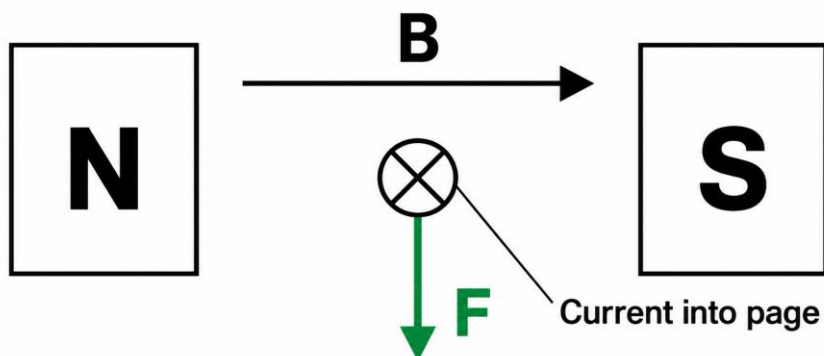


Figure 1

7(a) Calculate the magnetic force on the conductor. **[2 marks]**

Answer / mark points: $\ell = 6.0 \text{ cm} = 0.060 \text{ m}$. [1]
 $F = B I \ell = 0.40 \times 2.5 \times 0.060 = 0.060 \text{ N}$. [1] Only the length within the field is used.

7(b) On Figure 1, draw one arrow labelled F to show the direction of the magnetic force on the conductor. **[1 mark]**

Answer / mark points: Arrow vertically towards the BOTTOM of the page from the conductor, labelled F . [1] Field right and conventional current into page give this direction by Fleming's left-hand rule. "Down the page" is a horizontal bench direction in this TOP VIEW, not gravity.

7(c) The moving actuator has mass 0.020 kg . A 0.020 N in-plane resistance opposes the magnetic force. Calculate the resultant force and the acceleration. **[2 marks]**

Answer / mark points: Resultant force $= 0.060 - 0.020 = 0.040 \text{ N}$ towards the bottom of the page. [1]
 $a = 0.040 / 0.020 = 2.0 \text{ m s}^{-2}$ in that direction. [1] The magnetic force alone is not the resultant.

7(d) The actuator starts from rest and has this constant acceleration for 0.20 s in the uniform field. Calculate its final speed. **[1 mark]**

Answer / mark points: $v = u + at = 0 + 2.0 \times 0.20 = 0.40 \text{ m s}^{-1}$. [1] This rearranges the GCSE acceleration equation; no extra motion equation is needed.

7(e) The current is doubled; all other values, including resistance, stay the same. Calculate the new acceleration and explain why it is not simply twice the original acceleration. **[2 marks]**

Answer / mark points: New magnetic force $= 0.120 \text{ N}$; resultant $= 0.120 - 0.020 = 0.100 \text{ N}$; $a = 0.100 / 0.020 = 5.0 \text{ m s}^{-2}$. [1 for correct acceleration]
 The magnetic force doubles but the fixed opposing force does not, so the resultant force does not double (0.040 to 0.100 N); acceleration therefore increases by a factor 2.5, not 2. [1]

Review and improve

Use resultant force for $F = ma$, but the specified force for its work done. A negative acceleration need not mean a negative velocity. Extension is the change in length; convert before squaring. Timing is estimated and untrials. These checks are not a complete safety approval.

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