

Paper 2 explanations and practical methods

AQA GCSE Combined Science Trilogy 8464 and Separate Physics 8463 | Both tiers | Paper 2

20 parts / 40 marks per route | Both tiers | Timing estimated/untrialled

Specification points covered

8463 4.5.3 / 8464 6.5.3: spring deformation, proportionality and valid force–extension measurements

8463 4.5.6.2.2 / 8464 6.5.4.2.2: resultant force, mass, acceleration and investigation controls

8463 4.6.1.2 / 8464 6.6.1.2: wavelength, frequency and ripple speed measurements

8463 4.6.2.2 / 8464 6.6.2.2: selected infrared surface investigation skills only

A science centre is commissioning a model trolley ride, spring safety buffer and wave demonstration for a public event. Check the team's measurements and explanations before it writes the demonstration guides.

Original PhysicsUK practice, not official AQA. Each route is Sections 1–6 plus ONE final alternative: 20 parts / 40 marks. Both qualifications and tiers. Selected spring, acceleration, ripple-tank and infrared practical skills only, not full required-practical completion or a ride safety certification.

1 Checking the spring buffer

A model buffer contains a compression spring. Its unloaded length is 80.0 mm. With a 3.0 N compressive force its length is 68.0 mm. Table 1 gives further static measurements, taken after the spring settles.

1(a) Calculate the compression of the buffer spring at 3.0 N. **[1 mark]**

Answer / mark points: Compression = $80.0 - 68.0 = 12.0$ mm. [1] Compression is the decrease in length, not the final length.

1(b) State what is meant by elastic deformation of a spring. **[1 mark]**

Answer / mark points: It returns to its original shape/length when the deforming force is removed. [1] "It stretches" does not distinguish elastic from permanent deformation.

1(c) Use the 3.0 N reading to calculate the spring constant in N m^{-1} . **[2 marks]**

Answer / mark points: $e = 12.0 \text{ mm} = 0.0120 \text{ m}$. [1] $k = F / e = 3.0 / 0.0120 = 250 \text{ N m}^{-1}$. [1] Do not divide force by the total loaded length.



1 Checking the spring buffer continued

Table 1

Force / N	Compression / mm
1.0	4.0
2.0	8.0
3.0	12.0
4.0	20.0

1(d) Can the same k be used at 4.0 N? Explain using a numerical comparison from Table 1. **[2 marks]**

Answer / mark points: Doubling force from 2.0 to 4.0 N would double 8.0 mm to 16.0 mm if the relationship remained proportional, but the reading is 20.0 mm. [1] Therefore compression is no longer directly proportional to force/the same k cannot be used at 4.0 N. [1] Accept $k = 4.0 / 0.020 = 200 \text{ N m}^{-1}$ versus 250 N m^{-1} for the earlier region.

2 Improving the spring measurements

The team also investigates a different tension spring using Figure 1. The pointer is fixed to the lower end of the spring and moves with it; the ruler stays fixed. Ruler ticks are schematic, not numerical readings. Each calibrated load label gives the TOTAL force including its holder.

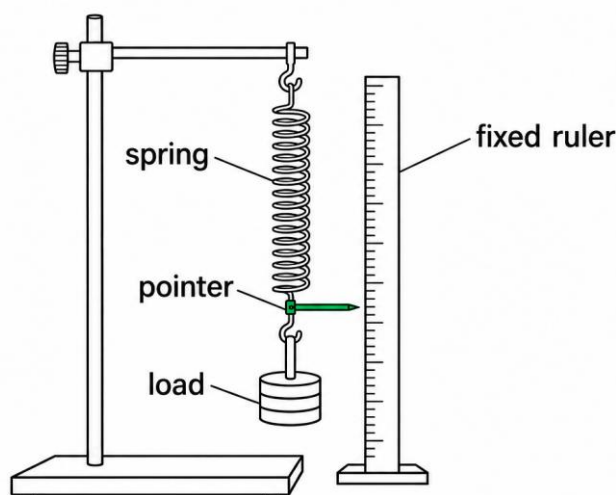


Figure 1

2(a) Describe how the pointer and ruler can be used to obtain the extension for each force. Explain why recording only the loaded reading is insufficient. **[2 marks]**

Answer / mark points: Record an unloaded pointer reading and the stationary loaded pointer reading using the same fixed ruler. [1] Subtract unloaded from loaded reading to obtain extension; a loaded position/length alone includes the original length or scale offset. [1] Establish the zero-load baseline with the load holder removed, or explicitly account for a holder baseline.

Continue your physics journey

Videos, practice and support for your next step

www.physicsuk.co.uk



2 Improving the spring measurements continued

2(b) Give two reading precautions for Figure 1. Explain the problem each reduces. **[2 marks]**

Answer / mark points: Read at eye level with the pointer/scale to reduce parallax. [1 for linked action and reason] Wait for the spring/load to stop moving to avoid choosing a changing pointer position. [1 for linked action and reason] Accept a close ruler/pointer spacing to reduce parallax, but do not credit two descriptions of the same precaution twice.

2(c) A spring stops following a straight proportional trend as the force increases. Explain how to check whether this has also caused permanent deformation. **[2 marks]**

Answer / mark points: Remove the load and compare the settled zero-load length/pointer reading with its original baseline. [1] A remaining change shows permanent deformation; return to the original reading means no permanent change was detected. [1] A non-proportional loading trend alone does not establish permanent deformation.

3 Testing the trolley ride

The team tests a small model trolley on a level track. An accelerometer measures its acceleration independently. The supplied force values are RESULTANT horizontal forces, not uncorrected pulling forces.

3(a) Calculate the resultant horizontal force for a 0.50 kg trolley accelerating at 0.60 m s^{-2} . **[1 mark]**

Answer / mark points: $F = ma = 0.50 \times 0.60 = 0.30 \text{ N}$. [1] This is resultant force, not necessarily the force at the pulling point.

3(b) Test R uses 0.30 N and gives 0.60 m s^{-2} . Test S uses 0.60 N and gives 1.20 m s^{-2} . Both use the same trolley mass. Explain whether these readings agree with $F = ma$. **[2 marks]**

Answer / mark points: Both force and measured acceleration double from R to S. [1] With constant mass, $a = F / m$ predicts this proportional change, so the readings agree over these tested settings. [1] They support the relationship; two points do not prove it at every force.

3(c) To test only the effect of force, a technician increases the force but also adds a heavy display model to the trolley. Explain the fault and how to correct it. **[2 marks]**

Answer / mark points: Both resultant force and moving mass change, so the change in acceleration cannot be attributed to force alone. [1] Keep the total moving mass constant while changing the resultant force. [1] For a separate mass investigation, instead keep resultant force constant.

3(d) A trainee calculates every acceleration from F / m and plots those values to “verify $F = ma$ ”. Explain why the accelerometer readings provide a stronger test. **[2 marks]**

Answer / mark points: Calculated F / m values assume the very relationship being tested, so agreement is built in/circular. [1] Independently measured acceleration can be compared with the prediction and can reveal disagreement. [1] “Digital is more accurate” without independence is not the reason.

Continue your physics journey

Videos, practice and support for your next step

www.physicsuk.co.uk



4 Checking the wave demonstration

In a calibrated frozen image of a ripple tank, six consecutive crests extend from the 3.0 cm position to the 18.0 cm position. In the recording, 12 complete oscillations take 3.0 s of real time. Water depth and vibrator setting are steady.

4(a) Use the image and recording data to calculate wave speed in m s^{-1} . Show your working. **[3 marks]**

Answer / mark points: Six consecutive crests span five wavelengths: $\lambda = (18.0 - 3.0) / 5 = 3.0 \text{ cm} = 0.030 \text{ m}$. [1] $f = 12 / 3.0 = 4.0 \text{ Hz}$. [1] $v = f\lambda = 4.0 \times 0.030 = 0.12 \text{ m s}^{-1}$. [1] Use five gaps, not six; a bare final result earns only the final-result mark.

4(b) Slow playback makes the same 12 oscillations take 18 s to watch. A trainee uses 18 s to calculate the actual wave frequency. Explain the error and give the correct frequency. **[2 marks]**

Answer / mark points: Playback time is not the real elapsed time for the oscillations; use the 3.0 s recording interval. [1] Actual $f = 12 / 3.0 = 4.0 \text{ Hz}$, not $12 / 18 = 0.67 \text{ Hz}$. [1] Slow playback assists counting; it does not change the original oscillation frequency.

4(c) Suggest two ways to improve a wavelength measurement from an image. Link each improvement to a measurement problem. **[2 marks]**

Answer / mark points: Measure across several wavelength gaps and divide by the number of gaps, reducing the fractional effect of endpoint reading error. [1] Put a visible calibration ruler in the water-surface plane/use its recorded calibration so image magnification or a ruler at another height does not bias the distance. [1] Accept perpendicular viewing to reduce perspective distortion as an alternative linked improvement. Do not claim that averaging removes a fixed scale error.



5 Choosing a surface for the infrared exhibit

The exhibit compares how two surface finishes affect heating under an infrared lamp. Except where a question states a fault, the cells have equal size, shape and water mass, the same initial temperature, exposed area, orientation and lamp-to-face distance, and the lamp output is steady.

Table 2

Finish	Initial temperature / °C	After 3 minutes / °C
Matt black	20	28
Polished metal	20	24

5(a) In a faulty trial, the matt-black cell is 20 cm from the lamp and the polished cell is 40 cm away. Explain one change needed for a valid comparison of the finishes. **[2 marks]**

Answer / mark points: Place both test faces the same distance from the lamp under the same source conditions. [1] This makes their incident radiation intensity comparable, so a heating difference is not simply caused by different distances. [1] No inverse-square calculation is required.

5(b) Table 2 comes from a corrected trial. Which finish is supported for a cell intended to warm most in 3 minutes? Use the temperature rises, and state one limit to the conclusion. **[2 marks]**

Answer / mark points: Matt black: its temperature rise is 8 °C compared with 4 °C for polished metal under the matched conditions. [1 for choice and supporting rises] This supports the larger net heating in this test, not a claim of exactly twice the absorbed radiation or a universal ranking in every environment. [1 for a valid limitation] Accept limited repeats/range/conditions, if linked to what the test establishes.

5(c) A repeat trial uses 80 g of water in the black cell and 160 g in the polished cell. Explain why comparing only their temperature rises is now insufficient. **[2 marks]**

Answer / mark points: Different water masses also affect the temperature rise for a given energy input. [1] The smaller mass may warm more even without a finish effect, so use equal masses before attributing the difference to surface finish. [1] No specific-heat-capacity calculation is required.



6 Repairing the practical write up

The team reviews two sentences before drafting the final guide.

6(a) A draft method says only “spring, clamp, ruler, loads”. What essential information is missing? **[1 mark]**

Answer / mark points: A sequence of actions specifying what to vary and what to measure/record, such as changing known force and measuring extension from a baseline. [1] Naming apparatus is not a method.

6(b) A draft evaluation says: “The repeats agree, so the measurements cannot contain a systematic error.” Correct the claim. **[1 mark]**

Answer / mark points: Agreement shows repeatability but does not exclude a shared bias such as a wrongly calibrated ruler/scale. [1] Repeats may all reproduce the same error.

7 Writing one independent extended answer

Your teacher assigns EITHER 7(a) OR 7(b). Both tasks are 6 marks and suitable for both tiers. Complete only the assigned alternative. Write a connected method that could produce a valid result, not just an equipment list.

7(a) Alternative A — spring guide. Using Figure 1, describe a method to investigate force against extension and check for permanent deformation. You have a secured stand, spring, pointer, fixed ruler and calibrated loads labelled with their total forces. The teacher sets a safe maximum force. Include how you would use the data and improve the measurement. Answer this OR 7(b), not both. **[6 marks]**

Answer / mark points: Original PhysicsUK best-fit rubric, not an official AQA mark scheme. Level 3 (5–6): a workable, logically ordered method obtains paired force and extension readings from a clear baseline, uses a suitable range within the stated limit, explains data analysis and a valid unloading check, and includes a linked measurement improvement. Award 6 for a clear complete method; 5 for a minor omission. Level 2 (3–4): several key steps are present but baseline, analysis, unloading or links are incomplete enough to weaken validity. Level 1 (1–2): isolated relevant steps or equipment, insufficient for a valid outcome. 0: no relevant physics. Judge overall quality, not six keyword ticks. Example: secure the stand and fix the ruler parallel and close to the spring. With all labelled loads removed, record the lower pointer's zero-load position at eye level. Add calibrated loads in small increments up to the teacher's limit, allowing the spring to settle. Record each total force and pointer position; subtract the original reading to obtain extension. Repeat appropriate readings, investigate unexpected values and calculate means where valid. Plot force vertically against extension horizontally; a straight line through the origin supports proportionality, and its gradient gives k when extension is in metres. Remove the loads and recheck the zero-load reading: a residual extension indicates permanent deformation. Stop if permanent change is detected; use a fresh spring for further calibration. Close ruler/pointer spacing and eye-level reading reduce parallax. Protect the bench below falling loads and follow teacher safety instructions. Accept valid equivalent ordering, axes or analysis; if extension is vertical the gradient is $1/k$, not k . Not every indicative detail is needed for the top level.

Continue your physics journey

Videos, practice and support for your next step

www.physicsuk.co.uk



7 Writing one independent extended answer continued

Alternative B only. If you completed 7(a), do not answer this page.

7(b) Alternative B — ripple-tank guide. Describe a method to measure ripple speed using a ripple tank with a vibrator, a visible calibration ruler in the water-surface plane, a camera with known real recording times, and playback or image software. Include both quantities needed for $v = f\lambda$ and how to improve their measurement. Answer this OR 7(a), not both. **[6 marks]**

Answer / mark points: Original PhysicsUK best-fit rubric, not an official AQA mark scheme. Level 3 (5–6): a logically ordered valid method measures both wavelength and frequency, handles image calibration and real recording time correctly, calculates speed and explains a useful improvement. Award 6 for a clear complete method; 5 for a minor omission. Level 2 (3–4): both measurements or their links are partly explained, but a major omission or calibration/time ambiguity weakens the outcome. Level 1 (1–2): isolated steps, or only one quantity described without a workable link to speed. 0: no relevant physics. Judge the whole response, not six isolated words. Example: keep water depth and vibrator setting steady and let regular ripples form. Film from directly above with the calibration ruler visible in the water-surface plane. Freeze a clear frame and measure perpendicular to the wavefronts from one crest to another several complete gaps away; use the calibration to convert the image distance to actual distance, then divide by the number of gaps to obtain wavelength. At a fixed location count complete oscillations over a known real recording interval and calculate $f = N/t$, using slow playback only to count. Repeat and use consistent means; measuring multiple gaps and timing many oscillations reduce the fractional effect of endpoint/timing errors. Calculate $v = f\lambda$ with wavelength in metres and frequency in hertz. Keep the water away from electrical connections and follow school low-voltage procedures. Accept a valid directly measured or calibrated-projection method; do not accept an uncorrected magnified screen distance as the wavelength. This selected water method does not complete the solid-wave part of RP8/20.

Review and improve

Review the assigned final task only. A method must make the stated quantities measurable. Explanations need linked causes and outcomes; evaluations need evidence and a justified judgement. Do not count six keywords or require every indicative detail for the highest level.

Continue your physics journey

Videos, practice and support for your next step

www.physicsuk.co.uk

