

Force, mass and acceleration: required practical

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

Worked answers and marking guidance | 26 parts | 44 marks

Specification points covered

8463 4.5.6.2.2 / 8464 6.5.4.2.2: $F = ma$; required practical 7 / 19
8463 4.5.6.1.5 / 8464 6.5.4.1.5: acceleration as change in velocity per second
Supporting skills: 8463 4.5.6.1.2 / 8464 6.5.4.1.2: speed = distance / time
Supporting skills: 8463 4.5.1.3 / 8464 6.5.1.3: weight = mass $\times$ g

A parcel-conveyor manufacturer uses a trolley test track to investigate how driving force and moving mass affect acceleration. You will check the measurements, interpret data and plan two fair tests.

Original PhysicsUK practice, not an official AQA resource. Credit equivalent methods and consistent error carried forward (ECF). Use $g = 10 \text{ N/kg}$. Both tiers; no Higher-only inertial-mass terminology or coupled-tension calculation. Practice data are idealised.

1 Checking the conveyor model

“Resultant force” means the overall force after opposing forces are taken into account.

1(a) Explain what a forward acceleration of 0.50 m s^{-2} means for a load moving forwards. **[1 mark]**

Answer / mark points: Its velocity increases by 0.50 m/s each second. [1] Require change in velocity per unit time, not “it travels 0.50 m every second”.

1(b) Write the equation linking resultant force, mass and acceleration. **[1 mark]**

Answer / mark points: Resultant force = mass $\times$ acceleration, or $F = ma$. [1] F must mean resultant force.

1(c) A test load of mass 0.80 kg experiences a resultant force of 0.40 N . Calculate its acceleration. **[1 mark]**

Answer / mark points: $a = F / m = 0.40 / 0.80 = 0.50 \text{ m s}^{-2}$. [1]

1(d) A 0.80 kg test load is driven by 0.90 N while a 0.10 N force opposes its motion. Calculate its acceleration. **[2 marks]**

Answer / mark points: Resultant force = $0.90 - 0.10 = 0.80 \text{ N}$. [1]
 $a = 0.80 / 0.80 = 1.0 \text{ m s}^{-2}$. [1] Not $0.90 / 0.80$.

1(e) A loaded test unit has mass 1.60 kg and accelerates at 0.50 m s^{-2} . Calculate the resultant force needed. **[1 mark]**

Answer / mark points: $F = ma = 1.60 \times 0.50 = 0.80 \text{ N}$. [1]



2 What is moving?

Figure 1 is a schematic of the test track. The card interrupts each light beam. The trolley moves towards the pulley while the hanger falls. For this worksheet, M is the total moving mass: trolley, card, all loads and hanger. With negligible friction, use $a = \text{driving force} / M$, where driving force is the total hanging weight. Neglect the mass of the string and resistance of the pulley. This is a model of the whole trolley–hanger system, not the trolley alone.

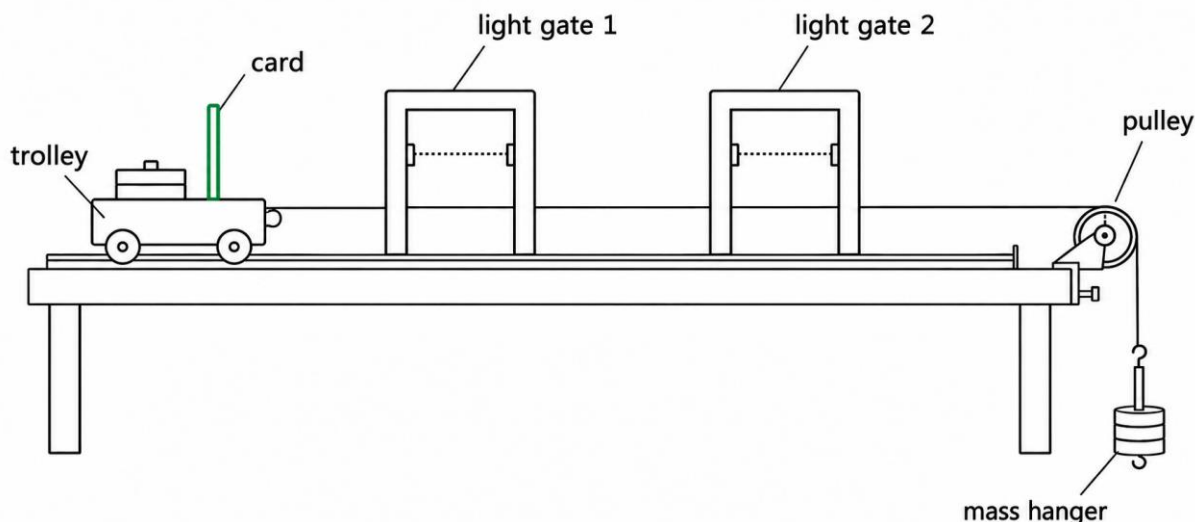


Figure 1

2(a) The light-gate software is used to find acceleration. State the two velocity readings and the time interval it must obtain. **[2 marks]**

Answer / mark points: The velocity at the first gate and the velocity at the second gate. [1 for both]
The time between those two velocity measurements. [1] Not just the time for the card to block one beam.

2(b) The trolley including its card has mass 0.50 kg. The empty hanger has mass 0.020 kg. Removable weights totalling 0.28 kg are shared between them. Calculate the total moving mass M . **[1 mark]**

Answer / mark points: $M = 0.50 + 0.020 + 0.28 = 0.80$ kg. [1] Include weights on both trolley and hanger, and the empty hanger itself.

2(c) Initially the total hanging mass is 40 g, including the hanger. A 20 g weight is transferred from the trolley to the hanger. Calculate the new driving force using $W = mg$, and state the total moving mass M . **[2 marks]**

Answer / mark points: New hanging mass = 60 g = 0.060 kg, so driving force = $0.060 \times 10 = 0.60$ N. [1 for correct SI calculation]
 M remains 0.80 kg. [1] No mass has entered or left the moving system.

2(d) Instead, a trainee adds a new weight from the bench to the hanger. Explain why this is not a fair test of changing force at constant moving mass. **[2 marks]**

Answer / mark points: Adding a new weight increases both the driving force and the total moving mass. [1]
Both affect acceleration, so the change cannot be attributed to force alone. [1] Transfer an existing weight instead.



3 Measuring acceleration, not assuming it

Use speed = card length / beam-blocking time. The software reports a velocity at each gate and the time between those velocity measurements. Treat these velocities as instantaneous readings. Motion is in one direction. Use acceleration = change in velocity / time taken.

Table 1

Measurement	Value
Card length	50 mm
First gate: beam blocked	0.100 s
Second gate: beam blocked	0.050 s
Between velocity measurements	0.50 s

3(a) The card is 50 mm long. It blocks the first gate for 0.100 s. Calculate the velocity reported at the first gate, in m/s. **[2 marks]**

Answer / mark points: 50 mm = 0.050 m. [1]
 $v = 0.050 / 0.100 = 0.50$ m/s. [1] The card length, not the full trolley length, passes through the beam.

3(b) The same card blocks the second gate for 0.050 s. Calculate the velocity reported at the second gate. **[1 mark]**

Answer / mark points: $v = 0.050 / 0.050 = 1.0$ m/s. [1] Use the already converted card length.

3(c) The software gives 0.50 s between the two velocity measurements. Calculate the acceleration. **[1 mark]**

Answer / mark points: $a = (1.0 - 0.50) / 0.50 = 1.0$ m s⁻². [1] Accept ECF from 3(a)–3(b). This time is not either beam-blocking time.

3(d) Three repeats give accelerations of 0.98, 1.00 and 1.02 m s⁻². Calculate the mean acceleration. **[1 mark]**

Answer / mark points: Mean = $(0.98 + 1.00 + 1.02) / 3 = 1.00$ m s⁻². [1]

3(e) Explain why using a mean of repeated measurements is better than using one reading. **[1 mark]**

Answer / mark points: It reduces the effect of random variation on the result. [1] It does not remove a systematic effect such as friction. Accept a repeat-and-check explanation linked to random differences.

3(f) The hanger lands on a tray before the card reaches the second gate. Explain why this run cannot test the intended constant driving force, and suggest a suitable change to the set-up. **[2 marks]**

Answer / mark points: The hanger is supported by the tray, so it no longer provides the intended pulling force throughout the measurement. [1]
 Move the tray lower / move the second gate closer while retaining a measurable velocity change / shorten the string so the hanger starts higher. [1] Check the full card clears gate 2 before the hanger lands.



4 Investigation A: changing the driving force

The total moving mass is kept at 0.80 kg by transferring weights from the trolley to the hanger. Table 2 gives idealised mean accelerations with negligible friction. Each mean is based on repeated light-gate measurements, not calculated from $F = ma$.

Table 2

Driving force / N	Mean acceleration / m s^{-2}
0.20	0.25
0.40	0.50
0.60	0.75
0.80	1.00
1.00	1.25

4(a) Plot all five results from Table 2 on Figure 2. Draw a straight line of best fit. [3 marks]

Answer / mark points: All five points correctly plotted. [2; 1 for three or four correct] Accept centres within one tenth of a supplied grid interval.
Straight best-fit line through the plotted trend and origin. [1] See the green reference plot.

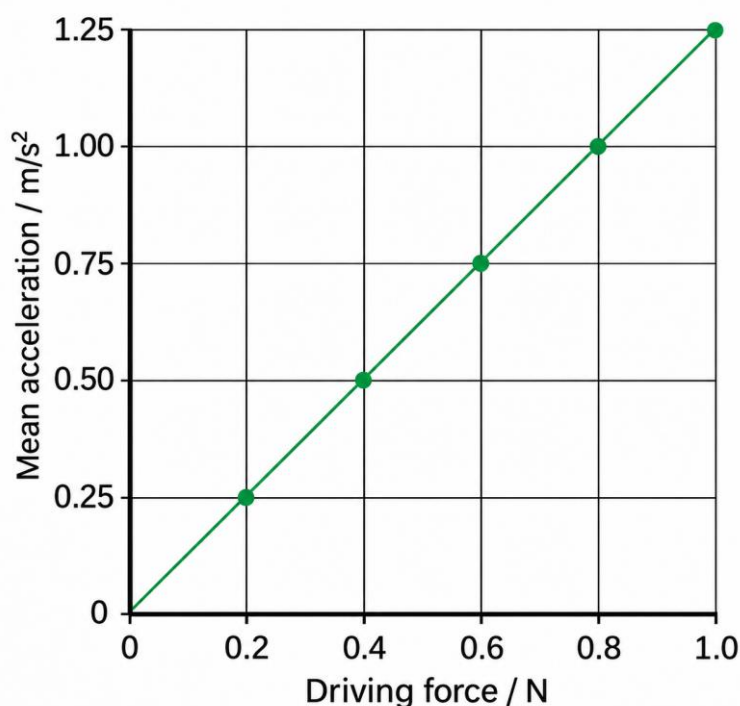


Figure 2

4(b) Describe the relationship between driving force and mean acceleration. Give graph evidence that supports your description. [2 marks]

Answer / mark points: Mean acceleration is directly proportional to driving force at constant M. [1]
The graph is a straight line through the origin. [1] "Both increase" alone is not proportionality.

4(c) Use your graph to estimate the acceleration when the driving force is 0.50 N. [1 mark]

Answer / mark points: About 0.63 m s^{-2} (exact model value 0.625 m s^{-2}). [1] Allow $0.60\text{--}0.65 \text{ m s}^{-2}$ for a sensible graph reading, or consistent reading from their best-fit line.

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5 Investigation B: changing the moving mass

The hanging mass is now kept fixed, giving a driving force of 0.80 N. Loads are added to the trolley from the bench. Table 3 gives idealised light-gate results with negligible friction. M still includes the hanger and its weights.

Table 3

Total moving mass M / kg	Mean acceleration / m s ⁻²
0.80	1.00
1.00	0.80
1.25	0.64
1.60	0.50
2.00	0.40

5(a) Use two pairs of values from Table 3 to show what happens to acceleration when total moving mass doubles at constant force. **[2 marks]**

Answer / mark points: M: 0.80 → 1.60 kg gives a: 1.00 → 0.50 m s⁻². [1]
M: 1.00 → 2.00 kg gives a: 0.80 → 0.40 m s⁻². [1] Acceleration halves: inverse proportionality. "It decreases" without the two numerical comparisons is insufficient.

5(b) Use the negligible-friction model to predict the acceleration if M were 2.50 kg with the same 0.80 N driving force. **[1 mark]**

Answer / mark points: $a = 0.80 / 2.50 = 0.32 \text{ m s}^{-2}$. [1] This is a model prediction, not approval to exceed the apparatus load limit.

5(c) Describe how to increase the total moving mass while keeping the driving force constant in Investigation B. **[2 marks]**

Answer / mark points: Keep the same hanger and the same weights on it. [1]
Add loads from the bench to the trolley, so total moving mass increases without changing hanging weight / driving force. [1] Transferring weights from hanger to trolley would change force, not total mass.

5(d) In a separate test, the driving force is 0.80 N and M is 0.80 kg. A constant friction force of 0.16 N opposes the motion. Calculate the acceleration using the whole-system model. **[2 marks]**

Answer / mark points: Resultant driving force = $0.80 - 0.16 = 0.64 \text{ N}$. [1]
 $a = 0.64 / 0.80 = 0.80 \text{ m s}^{-2}$. [1]

5(e) For the test in 5(d), a trainee estimates M by dividing the 0.80 N driving force by the measured acceleration. Calculate this estimate and explain why it is too large. **[2 marks]**

Answer / mark points: Estimated M = $0.80 / 0.80 = 1.0 \text{ kg}$, larger than the actual 0.80 kg. [1]
The trainee uses the full driving force instead of subtracting friction to obtain the resultant force; the measured acceleration is smaller because of friction. [1] Use ECF from 5(d) if the comparison is consistent.



6 Plan a repeatable investigation

The manufacturer needs evidence for BOTH relationships: how acceleration changes with force at constant moving mass, and with moving mass at constant force. Use Figure 1. The first two questions help you plan, but your six-mark answer must be a complete method.

6(a) In Investigation A, which mass must be kept constant? [1 mark]

Answer / mark points: Total moving mass of trolley, card, all weights and hanger. [1] "Trolley mass" alone is incorrect.

6(b) In Investigation B, how is the driving force kept constant? [1 mark]

Answer / mark points: Keep the total hanging mass (hanger plus its weights) unchanged. [1] Do not merely state "keep force constant".

6(c) Describe a complete method to investigate BOTH relationships using the trolley, hanger and light gates. Explain how to measure acceleration, change each independent variable fairly, obtain reliable data and use the results. Include a relevant precaution. Do not use $F = ma$ to generate the acceleration data. [6 marks]

Answer / mark points: Use a levels judgement, not one mark per keyword. Level 3 (5–6): a coherent, repeatable account of both investigations, valid controls and measured acceleration, with repeats and analysis. Level 2 (3–4): one viable investigation, or both partly described with significant omissions. Level 1 (1–2): relevant fragments without a workable sequence. 0: no relevant content. Choose within a level by completeness and precision.

Indicative method: secure the pulley and set a level, low-friction track. Measure card length and masses, including the empty hanger. Set two gates to measure velocities and their time interval; find $a = \text{change in velocity} / \text{interval}$. Release without pushing from the same position.

A: transfer weights from trolley to hanger, keeping total moving mass fixed. Record hanging mass and calculate driving force with $W = mg$. Use at least five force settings. B: keep hanging mass fixed; add weighed loads from the bench to the trolley and record total moving mass for at least five settings. Keep the same track, gates and release procedure.

Repeat each setting at least three times, check any anomalous run and calculate a mean. Plot mean acceleration against driving force for A, and against total moving mass for B. Look for a straight line through the origin for A, and halving acceleration when mass doubles for B. Ensure the card clears gate 2 before the hanger lands; secure loads and stop/catch the trolley before the pulley.

Equivalent valid equipment/methods earn credit. For top level, both controls must be correct and acceleration must be measured, not assumed from F/M . Do not equate trolley-string tension to hanging weight during acceleration.

Review and improve

Use "acceleration increases", not "acceleration speeds up". Distinguish driving force from resultant force, and total moving mass from trolley mass alone. Timing is estimated, not trialled. No required-practical completion claim.

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