Force, mass and acceleration

Answers, marking points and revision notes | AQA Combined Science 8464 and AQA GCSE Physics 8463

GCSE science required practicals

This practical online

Answers

1 Look at Kofi and Megan's investigation.

a. Name the independent variable.

b. Name the dependent variable.

c. Give one control variable.

(3 marks)

a. The force pulling the trolley (weight of the hanging masses).
b. The acceleration of the trolley.
c. The total mass being accelerated.

Marking points

- Independent: force or weight on the hanger
- Dependent: acceleration
- Control: total mass, same runway or surface, same start position or gate distance

2 The masses not on the hanger were taped to the trolley. Each time, one mass was moved from the trolley to the hanger. Explain why.

(2 marks)

The hanger and the trolley are joined by the string, so they accelerate together. Moving masses rather than adding new ones keeps the total mass being accelerated the same, so only the force changes and the test is fair.

Marking points

- Keeps the total mass being accelerated constant
- So any change in acceleration is only caused by the change in force (fair test)

3 A card is fixed to the top of the trolley. Describe how a light gate and data logger can use the card to find the speed of the trolley.

(2 marks)

The light gate records how long the card blocks the light beam. The logger divides the length of the card by this time to give the speed.

Marking points

- The gate measures the time the card takes to pass through (blocks the beam)
- Speed = length of card ÷ that time

4 Give one hazard in this investigation and say how the risk could be reduced.

(2 marks)

The masses could hit the floor or land on a foot when the hanger falls. Put a box of crumpled paper under the hanger and keep feet away from it.

Marking points

- Hazard: falling masses or trolley running off the bench
- Matching control: soft landing box and feet clear, or a buffer at the end of the runway

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5 Describe the relationship between force and acceleration shown in the table. (2 marks)

As the force increases the acceleration increases. Each extra 0.2 N or so increases the acceleration by about 0.2 m/s^2, so the graph would be a straight line.

Marking points

- As force increases, acceleration increases
- Increases in roughly equal steps (about 0.2 m/s^2 for each extra 0.2 N), so a straight line or linear relationship

6 Calculate the weight of an 80 g hanging mass. Gravitational field strength = 9.8 N/kg. Give your answer to 2 significant figures. (2 marks)

Weight = 0.080 × 9.8 = 0.784 N, so 0.78 N.

mass = 80 g = 0.080 kg

weight = mass × gravitational field strength

weight = 0.080 × 9.8

weight = 0.784 N

weight = 0.78 N (2 s.f.)

Marking points

- Uses 0.080 kg × 9.8
- 0.78 N

7 Use the data for the 80 g hanging mass to calculate the acceleration of the trolley. Give your answer to 2 significant figures. Show your working. (3 marks)

Change in velocity = 1.02 - 0.55 = 0.47 m/s. Acceleration = 0.47 ÷ 0.63 = 0.746, so 0.75 m/s^2.

change in velocity = 1.02 - 0.55

change in velocity = 0.47 m/s

acceleration = change in velocity ÷ time

acceleration = 0.47 ÷ 0.63

acceleration = 0.746...

acceleration = 0.75 m/s^2 (2 s.f.)

Marking points

- Change in velocity = 1.02 - 0.55 = 0.47 m/s
- 0.47 ÷ 0.63
- 0.75 m/s^2

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8 **Higher tier**

Megan ignored friction and used the 100 g row to work out the mass being accelerated.

a. Calculate the mass she would get. Give your answer to 3 significant figures.

b. The real total mass was 1.00 kg. Suggest why her answer is bigger.

Show your working. (3 marks)

a. Mass = 0.98 ÷ 0.95 = 1.03 kg

b. Friction acts against the motion, so the resultant force is less than 0.98 N. Using 0.98 N as if it were the resultant force makes the mass seem too big.

resultant force = mass × acceleration, so mass = force ÷ acceleration

mass = 0.98 ÷ 0.95

mass = 1.031... kg

mass = 1.03 kg (3 s.f.)

Marking points

- mass = force ÷ acceleration = 0.98 ÷ 0.95
- 1.03 kg
- Friction means the resultant force is less than the weight of the hanging mass

9 **Higher tier**

For the 100 g run the trolley went from 0.61 m/s at gate A to 1.15 m/s at gate B with an acceleration of 0.95 m/s^2. Calculate the distance between the two light gates. Give your answer to 2 significant figures.

(final velocity)^2 - (initial velocity)^2 = 2 × acceleration × distance

Show your working. (3 marks)

$1.15^2 - 0.61^2 = 1.3225 - 0.3721 = 0.9504$. Distance = 0.9504 ÷ (2 × 0.95) = 0.50 m.

$v^2 - u^2 = 1.15^2 - 0.61^2$

$v^2 - u^2 = 1.3225 - 0.3721 = 0.9504$

distance = $(v^2 - u^2)$ ÷ (2 × acceleration)

distance = 0.9504 ÷ (2 × 0.95)

distance = 0.9504 ÷ 1.9 = 0.500...

distance = 0.50 m (2 s.f.)

Marking points

- $1.15^2 - 0.61^2 = 0.9504$
- Divides by 2 × 0.95 = 1.9
- 0.50 m

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10 **Higher tier**

Kofi says, "When we doubled the force from 0.39 N to 0.78 N, the acceleration more than doubled, so acceleration is not proportional to force." Explain why Kofi's conclusion is wrong, and suggest a change to the set-up that would fix the problem.

(3 marks)

The acceleration did go from 0.35 to 0.75 m/s^2, which is more than double. This is because friction takes away about the same small force each time, so the resultant force is less than the weight on the hanger and does not exactly double. The acceleration is proportional to the resultant force. Raising one end of the runway slightly, until the trolley just keeps moving at a steady speed when given a push, cancels out the friction.

Marking points

- Friction acts on the trolley, reducing the resultant force by about the same amount each time
- Acceleration is proportional to the resultant force, not the hanging weight
- Tilt the runway slightly so the trolley runs at constant speed with no hanging mass (friction compensated)

11 Megan's teacher asks why they used light gates rather than timing with a stopwatch. Give two reasons.

(2 marks)

A stopwatch depends on human reaction time, which adds random error, especially as the times here are under 1.5 s. Light gates measure much shorter times with a better resolution, so the speeds and times are more accurate.

Marking points

- Light gates remove human reaction time (less random error)
- Light gates can time very short intervals with better resolution, so more accurate or precise

12 Kofi and Megan repeated each run three times. Their three accelerations for the 60 g mass were 0.55, 0.54 and 0.56 m/s^2. Are these results precise? Explain your answer.

(2 marks)

Yes. The three values are very close together, with a spread of only 0.02 m/s^2, and precise results are ones that are close to each other.

Marking points

- Yes, they are precise
- The values are very close together (range of only 0.02 m/s^2)

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13 Plan an investigation to find out how the mass of a trolley affects its acceleration when the pulling force stays the same.

(6 marks)

Set up a runway with a pulley clamped at one end. Tie a string from the trolley over the pulley to a hanger with a fixed mass, for example 50 g, which stays the same for every run so the force is constant. Place two light gates a measured distance apart along the runway with a card on the trolley passing through both. Measure the mass of the trolley on a balance. Release the trolley from the same start line and record the speed at each gate and the time between them. Work out acceleration = change in velocity ÷ time. Add a 200 g mass to the trolley, measure the new mass and repeat. Keep adding masses in equal steps up to about 1 kg extra. Repeat each run three times and find a mean. Tilt the runway slightly to compensate for friction. Plot acceleration against mass, or against 1 ÷ mass. The acceleration should decrease as the mass increases, and a graph of acceleration against 1 ÷ mass should be a straight line. Put a box of crumpled paper under the hanger to catch it and a buffer at the end of the runway.

Marking points (any 6, with the method in a logical order)

- Pulley, string and hanger with the same hanging mass every time so the force is constant
- Measure the mass of the trolley (plus added masses) with a balance
- Add masses to the trolley in equal steps to change the mass
- Two light gates (or a ticker timer or video) to find speeds and time
- Acceleration = change in velocity ÷ time
- Same start position and same runway every run
- Repeat each mass and find a mean
- Compensate for friction by tilting the runway
- Plot acceleration against mass (or 1 ÷ mass) to find the pattern, with a safety step such as a catch box

How it is marked

- 5-6 marks: a clear, logical plan that would work, keeping the force constant, changing the mass in steps, measuring acceleration properly and saying how the results are analysed
- 3-4 marks: a workable plan that changes the mass and measures something to do with acceleration, but with gaps in control of the force, measurements or analysis
- 1-2 marks: a few relevant ideas, such as adding masses to a trolley and timing it, without a clear method

Revision notes: the method

Aim: To find out how the acceleration of a trolley depends on the force pulling it and on its mass.

Equipment

- Trolley
- Smooth runway or bench at least 1.5 m long
- Pulley clamped to the end of the bench
- String
- Mass hanger and ten 10 g slotted masses
- Two light gates connected to a data logger
- Card of known length fixed on top of the trolley
- Metre ruler
- Balance
- Box of crumpled paper or a cushion to catch the masses

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Method

1. Clamp the pulley to the end of the bench and place the trolley on the runway, with string running from the trolley over the pulley to the mass hanger.
2. Put two light gates over the runway a measured distance apart, with the card on the trolley passing through both.
3. Measure the total mass of the trolley, the hanger and all ten slotted masses on a balance. This total stays the same for every run.
4. Start with two 10 g masses (20 g) on the hanger and the other masses taped to the trolley.
5. Hold the trolley at the same start line each time, then let go.
6. The data logger uses the card length and the time the card blocks each gate to find the speed at each gate, and records the time taken to travel between the gates.
7. Work out the acceleration using acceleration = change in velocity ÷ time.
8. Move two more 10 g masses (20 g) from the trolley to the hanger and repeat. Keep going until all the masses are on the hanger.
9. Repeat each run three times and find a mean acceleration.
10. Work out the force for each run as the weight of the hanging masses (W = mg, g = 9.8 N/kg) and plot acceleration against force.

Variables

- **Independent:** The force pulling the trolley (the weight of the masses on the hanger)
- **Dependent:** The acceleration of the trolley, worked out from the speeds at two light gates and the time between them
- **Control:** The total mass being accelerated (trolley, hanger and all slotted masses), kept the same by moving masses from the trolley to the hanger; The same runway and surface, so friction stays the same; The same starting position and the same distance between the light gates

Hazards

Hazard	What could happen	How to reduce the risk
Falling masses when the hanger reaches the floor	Masses could land on someone's foot	Put a box of crumpled paper or a cushion under the hanger and keep feet clear
The trolley running off the end of the bench	The trolley could fall and hit someone or break	Put a block or buffer at the end of the runway to stop the trolley

Key points

- When changing the force, move masses from the trolley to the hanger so the total mass being accelerated stays the same
- The force is the weight of the hanging masses: change grams to kilograms, then multiply by 9.8 N/kg
- Acceleration = change in velocity ÷ time, so you need two speeds and the time between them
- Acceleration is directly proportional to the resultant force and inversely proportional to the mass (F = ma)
- Friction makes the graph cut the force axis above zero; tilting the runway slightly can cancel it out
- Light gates remove reaction time errors that a stopwatch would add

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