3.4 Forces: 30-minute Pack

AQA 8461 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A magnet attracts a paperclip without touching it. State whether this force is a contact force or a non-contact force.

(Total for Question 1 is 1 mark)

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2 Calculate the resultant force on the toy car and state its direction.

(Total for Question 2 is 2 marks)

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3 Stopping distance = thinking distance + braking distance. A car is travelling at 24 m/s. The driver's reaction time is 0.60 s. Use the Physics Equations Sheet if needed: distance (m) = speed (m/s) x time (s).

(a) Define 'thinking distance' and 'braking distance'. **(2)**

(b) Calculate the thinking distance for this car. **(2)**

(c) State two factors that could increase the driver's reaction time. **(2)**

(d) State two factors, other than reaction time, that could increase the braking distance of the car. **(2)**

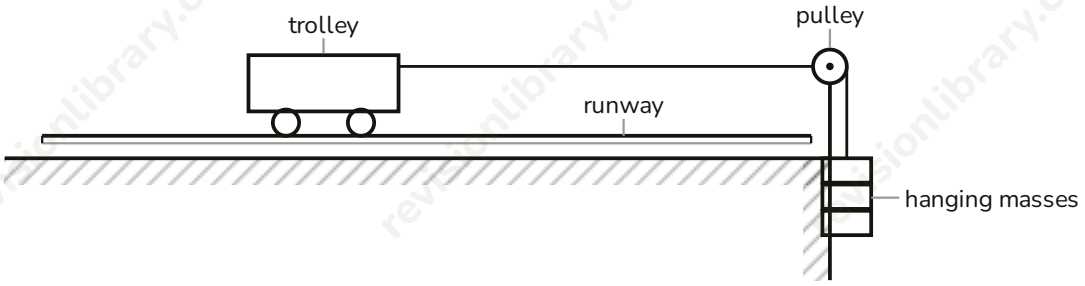
(Total for Question 3 is 8 marks)

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4 A student carried out the required practical investigation into the effect of force on the acceleration of a trolley. A string over a pulley connected the trolley to hanging masses, which provided the accelerating force. The total mass of the trolley system (trolley plus hanging masses) was kept constant. A light gate and data logger recorded the acceleration for each force used.

Force (N): 0.5, 1.0, 1.5, 2.0, 2.5

Acceleration (m/s^2): 0.21, 0.40, 0.62, 0.79, 1.02



Force (N)	0.5	1.0	1.5	2.0	2.5
Acceleration (m/s^2)	0.21	0.40	0.62	0.79	1.02

(a) Describe the relationship between resultant force and acceleration shown by these results. **(2)**

(b) Explain why it is important to keep the total mass of the trolley system constant throughout this investigation. **(2)**

(c) Using the result for a force of 2.0 N, calculate the total mass of the trolley system. Use the Physics Equations Sheet: F = m a. **(3)**

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(d) Suggest one improvement the student could make to increase the accuracy of the acceleration values obtained. **(2)**

(Total for Question 4 is 9 marks)

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5 A car travelling at high speed on a wet road has to perform an emergency stop. Explain, using ideas about forces and energy, why increasing the speed of a car has a much greater effect on its braking distance than the same increase in speed would have on its thinking distance. You may refer to the equations distance = speed x time, kinetic energy = 0.5 x mass x speed^2, and work done = force x distance in your answer.

(Total for Question 5 is 6 marks)

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Mark scheme · 3.4 Forces: 30-minute Pack

Question 1

non-contact cao **B1**

Answer: Non-contact.

Question 2

subtracts smaller force from larger to find resultant (8 - 3 = 5) **M1**

5 N to the left cao **A1**

Answer: 5 N to the left

Question 3

(a) thinking distance = the distance travelled during the driver's reaction time, before the brakes are applied, oe **B1**

(a) braking distance = the distance travelled while the vehicle is decelerating under the braking force, oe **B1**

(a) Answer: Thinking distance = distance travelled during the driver's reaction time. Braking distance = distance travelled while braking.

(b) 24 x 0.60 **M1**

(b) 14.4 m, cao **A1**

(b) Answer: 14.4 m

(c) any one valid factor, e.g. tiredness/fatigue, alcohol or drugs, being distracted (e.g. using a mobile phone), illness/age **B1**

(c) any second different valid factor from the list above **B1**

(c) Answer: Any two of: tiredness, alcohol/drugs, distraction (e.g. phone use), illness.

(d) any one valid factor, e.g. wet/icy/loose road surface, worn or faulty brakes, worn tyres/low tread, greater vehicle mass/heavier load, higher speed **B1**

(d) any second different valid factor from the list above **B1**

(d) Answer: Any two of: poor road/weather conditions, worn brakes or tyres, greater mass, higher speed.

Question 4

(a) acceleration increases as force increases (positive correlation) **B1**

(a) acceleration is (directly) proportional to resultant force, for a constant total mass, oe **B1**

(a) Answer: Acceleration is directly proportional to the resultant force (for a fixed total mass).

(b) total mass also affects acceleration, since F = m a, oe **B1**

(b) if mass changed between trials, it would not be possible to tell whether a change in acceleration was due to the change in force alone (not a valid/fair test), oe **B1**

(b) Answer: Mass also affects acceleration (F = ma), so keeping it constant ensures any change in acceleration is due only to the change in force, making it a fair test.

(c) correct rearrangement: m = F / a **M1**

(c) correct substitution: m = 2.0 / 0.79 **M1**

(c) 2.5 kg, awrt 2.5 **A1**

(c) Answer: 2.5 kg (2 s.f.)

(d) valid improvement identified, e.g. use light gates/a data logger instead of manual timing to remove human reaction-time error, oe **B1**

(d) explanation of how this improves accuracy/reduces error, e.g. repeat each force value and calculate a mean acceleration to reduce the effect of random error **B1**

(d) Answer: Use light gates and a data logger (removes human reaction-time error), and/or repeat each measurement and take a mean to reduce random error.

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Question 5

Level 1 Simple, largely unlinked statements are made, e.g. that a faster car takes longer to stop. Little or no reference to forces or energy. **1-2**

Level 2 Some correct links are made between speed and thinking distance and/or between speed and braking distance, with partial use of relevant ideas (e.g. distance = speed x time, or kinetic energy), but the explanation of why braking distance is affected more than thinking distance is incomplete. **3-4**

Level 3 A clear, logically structured explanation is given that correctly links thinking distance to distance = speed x time (so it increases in direct/linear proportion to speed), and links braking distance to kinetic energy (0.5 x mass x speed^2) and the work done by the brakes (force x distance), explaining that braking distance increases with the square of speed. The answer explains why this means braking distance is affected far more than thinking distance when speed increases, and may also link the wet road to reduced friction/braking force increasing the braking distance further. **5-6**

Indicative content:

- Thinking distance = speed x reaction time, so thinking distance increases in direct (linear) proportion to speed
- Braking distance depends on the kinetic energy of the car, KE = 0.5 x mass x speed^2, so kinetic energy increases with the square of speed
- The brakes do work to remove this kinetic energy: work done = braking force x braking distance, so for a roughly constant braking force, braking distance is proportional to kinetic energy, i.e. proportional to speed^2
- Doubling the speed doubles the thinking distance but roughly quadruples the braking distance (since it depends on speed squared)
- This means an increase in speed has a much greater effect on braking distance than on thinking distance
- A wet road reduces the friction between the tyres and the road, reducing the maximum braking force available, which further increases the braking distance and the risk of an accident at high speed

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