3.14 Forces, Newton's Laws and Momentum: 1-hour Pack

AQA 8464 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A car of mass 1000 kg is travelling when the driver brakes. Use the equation force = mass x acceleration (F = m x a).

(a) The brakes provide a braking force of 4000 N. Calculate the deceleration of the car. **(2)**

.....

(b) The car's tyres are worn, reducing the maximum braking force that can be safely applied to 2500 N. Calculate the new deceleration. **(2)**

.....

(c) State and explain the effect of the worn tyres on the car's braking distance for the same initial speed. **(2)**

(Total for Question 1 is 6 marks)

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2 A parcel of mass 5.0 kg is released from rest and falls through the air. Air resistance acts on the parcel as it falls. Take the gravitational field strength as 9.8 N/kg.

(a) Calculate the weight of the parcel, using W = m x g. **(2)**

.....

(b) Just after release, air resistance is very small, so the resultant force on the parcel can be approximated as equal to its weight. Use F = m x a to calculate the parcel's initial acceleration. **(2)**

.....

(c) As the parcel speeds up, air resistance increases until it becomes equal in size to the parcel's weight. State the resultant force on the parcel at this point, describe its motion from then on, and name this constant speed. **(3)**

(d) Explain, in terms of the forces acting, why the parcel's acceleration gradually decreases as its speed increases, before it reaches terminal velocity. **(2)**

(Total for Question 2 is 9 marks)

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3 The gravitational field strength on Earth is 9.8 N/kg. Use the equation weight = mass x gravitational field strength (W = m x g).

(a) A bag of cement has a mass of 25 kg. Calculate its weight on Earth. **(2)**

.....

(b) On the Moon, the gravitational field strength is 1.6 N/kg. Calculate the weight of the same bag of cement on the Moon. **(2)**

.....

(c) State what happens to the mass of the bag of cement when it is taken to the Moon, and explain your answer. **(2)**

.....

.....

(Total for Question 3 is 6 marks)

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4 Leah, a swimmer, pushes backwards against the water with her hands and feet in order to swim forwards.

(a) State Newton's Third Law. **(1)**

(b) Identify the pair of forces described by Newton's Third Law in this situation, stating how their sizes and directions compare. **(2)**

.....

.....

(c) A common misconception is that Newton's Third Law pairs of forces cancel out. Explain why they do not cancel out in this situation. **(1)**

.....

.....

.....

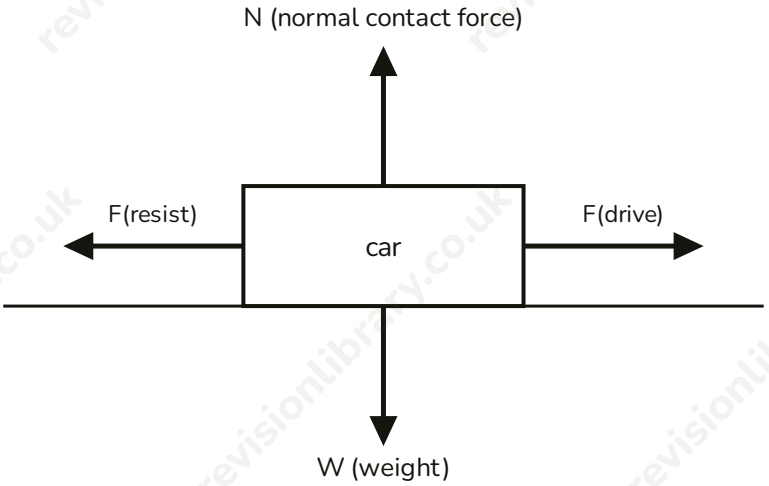
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(Total for Question 4 is 4 marks)

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5 Figure 2 shows a car of mass 1200 kg travelling along a level road. Four forces act on the car: the driving force from the engine (F(drive)), the combined resistive force from air resistance and friction (F(resist)), the car's weight (W), and the normal contact force from the road (N).



(a) State the name of the pair of forces that act vertically on the car, and state how their sizes compare while the car travels along the flat, level road. **(2)**

(b) At one instant, F(drive) = 3000 N and F(resist) = 3000 N. Calculate the resultant horizontal force on the car at this instant, and state what this means for the car's motion. **(2)**

(c) The driver presses the accelerator so that F(drive) increases to 3900 N, while F(resist) stays at 3000 N. Calculate the new resultant force, and use F = m x a to calculate the car's acceleration at this instant. **(3)**

(Total for Question 5 is 7 marks)

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6 Priya is driving at 24 m/s and has a reaction time of 0.60 s. Use thinking distance = speed x reaction time.

(a) Calculate Priya's thinking distance. **(2)**

.....

(b) Priya then reads a text message while driving, which increases her reaction time to 1.5 s. Calculate her new thinking distance at the same speed, and state how much further she travels while thinking, compared with part (a). **(3)**

.....

(Total for Question 6 is 5 marks)

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7 Higher tier only. Kwame, a rugby player of mass 95 kg, runs with a velocity of 6.0 m/s. Use the equation momentum = mass x velocity (p = m x v).

(a) Calculate Kwame's momentum. **(2)**

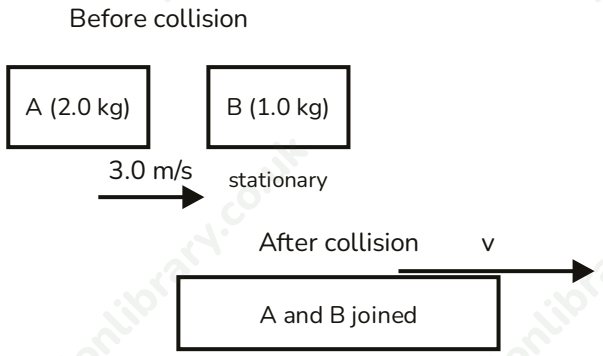
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(b) State the direction of Kwame's momentum. **(1)**

(Total for Question 7 is 3 marks)

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8 Higher tier only. Figure 3 shows trolley A (mass 2.0 kg) moving at 3.0 m/s towards stationary trolley B (mass 1.0 kg). They collide and stick together, moving off with a common velocity, v.



(a) State the law of conservation of momentum. **(1)**

(b) Calculate the total momentum of the system before the collision. **(2)**

.....

(c) Use conservation of momentum to calculate the common velocity, v, of the two trolleys after the collision. **(3)**

.....

(Total for Question 8 is 6 marks)

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Mark scheme · 3.14 Forces, Newton's Laws and Momentum: 1-hour Pack

Question 1

(a) substitutes: a = 4000 / 1000 **M1**

(a) 4.0 m/s^2 cao **A1**

(a) Answer: 4.0 m/s^2

(b) substitutes: a = 2500 / 1000 **M1**

(b) 2.5 m/s^2 cao **A1**

(b) Answer: 2.5 m/s^2

(c) the braking distance increases **B1**

(c) because with a smaller deceleration, the car takes longer (and travels further) to reduce its speed to zero, oe **B1**

(c) Answer: The braking distance increases, because the smaller deceleration means the car travels further before stopping.

Question 2

(a) substitutes: W = 5.0 x 9.8 **M1**

(a) 49 N cao **A1**

(a) Answer: 49 N

(b) ft substitutes: a = their (a) / 5.0 **M1**

(b) 9.8 m/s^2 cao ft **A1**

(b) Answer: 9.8 m/s^2

(c) resultant force = 0 N **B1**

(c) the parcel no longer accelerates; it moves at a constant velocity **B1**

(c) this constant velocity is called terminal velocity **B1**

(c) Answer: 0 N; the parcel moves at a constant velocity, called terminal velocity.

(d) as the parcel's speed increases, air resistance increases, oe **B1**

(d) this reduces the resultant force on the parcel, and since acceleration = resultant force / mass, a smaller resultant force gives a smaller acceleration, oe **B1**

(d) Answer: As speed increases, air resistance increases, reducing the resultant force; since acceleration = force / mass, the acceleration decreases.

Question 3

(a) substitutes: W = 25 x 9.8 **M1**

(a) 245 N cao **A1**

(a) Answer: 245 N

(b) substitutes: W = 25 x 1.6 **M1**

(b) 40 N cao **A1**

(b) Answer: 40 N

(c) the mass stays the same (unchanged) **B1**

(c) because mass is the amount of matter in an object, which does not depend on gravitational field strength, oe **B1**

(c) Answer: The mass stays the same, because mass does not depend on gravitational field strength.

Question 4

(a) when two objects interact, they exert equal and opposite forces on each other, oe **B1**

(a) Answer: When two objects interact, they exert equal and opposite forces on each other.

(b) Leah pushes the water backwards, and the water pushes Leah forwards, oe **B1**

(b) the two forces are equal in size and opposite in direction, acting on different objects **B1**

(b) Answer: Leah pushes the water backwards; the water pushes Leah forwards. The forces are equal in size and opposite in direction.

(c) because the two forces act on different objects (one on the water, one on Leah), so they cannot cancel; only forces acting on the same object can combine to give a resultant, oe **B1**

(c) Answer: The two forces act on different objects, so they cannot cancel out; only forces on the same object combine to a resultant.

Question 5

(a) weight and the normal contact force (reaction force) **B1**

(a) they are equal in size (and opposite in direction), because the car does not accelerate vertically, oe **B1**

(a) Answer: Weight and the normal contact force; they are equal in size because the car does not accelerate vertically.

(b) resultant force = 0 N (3000 - 3000) **B1**

(b) the car travels at a constant velocity (Newton's First Law), oe **B1**

(b) Answer: 0 N; the car travels at a constant velocity.

(c) resultant = 3900 - 3000 = 900 N **M1**

(c) substitutes: a = 900 / 1200 **M1**

(c) 0.75 m/s^2 cao **A1**

(c) Answer: 0.75 m/s^2

Question 6

(a) substitutes: distance = 24 x 0.60 **M1**

(a) 14.4 m cao **A1**

(a) Answer: 14.4 m

(b) substitutes: distance = 24 x 1.5 **M1**

(b) 36 m cao **A1**

(b) ft difference = 36 - their (a) = 21.6 m further **B1**

(b) Answer: 36 m; 21.6 m further than in part (a).

Question 7

(a) substitutes: p = 95 x 6.0 **M1**

(a) 570 kg m/s cao **A1**

(a) Answer: 570 kg m/s

(b) the same direction as his velocity (the direction he is running) **B1**

(b) Answer: The same direction he is running in.

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Question 8

(a) in a closed system, the total momentum before an event (such as a collision) equals the total momentum after the event, provided no external forces act, oe **B1**

(a) Answer: Total momentum before a collision equals total momentum after, provided no external forces act.

(b) momentum of A = 2.0 x 3.0 = 6.0 kg m/s; momentum of B = 1.0 x 0 = 0 **M1**

(b) 6.0 kg m/s cao (total) **A1**

(b) Answer: 6.0 kg m/s

(c) (m(A) + m(B)) x v = their (b), i.e. 3.0 x v = their (b) **M1**

(c) ft rearranges: v = their (b) / 3.0 **M1**

(c) 2.0 m/s cao ft **A1**

(c) Answer: 2.0 m/s

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