3.1 Forces and Motion: Test Pack

Calculator allowed · about 65 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Which statement correctly describes what happens to a moving object when the resultant force acting on it is zero?

- ☐ A) It stops immediately
- ☐ B) It accelerates in the direction of the force
- ☐ C) It continues moving at the same constant velocity
- ☐ D) It always slows down due to friction

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2 Newton's third law states that when one object exerts a force on a second object, the second object exerts an equal and opposite force back on the first.

(a) A swimmer pushes backward on the water with their hands and feet. Use Newton's third law to explain how this makes the swimmer move forward. **(2)**

(b) A rocket engine pushes hot exhaust gases downward and out of the rocket. Identify the reaction force that results from this, and state its direction. **(2)**

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3 A skydiver jumps from a plane and falls toward the ground before opening their parachute. Explain, in terms of the forces of weight and air resistance, how the skydiver's speed changes during the fall, from the moment they jump to reaching a constant (terminal) velocity, and then explain what happens to their speed when the parachute opens.

(6)

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4 For each situation below, state whether the main force involved is a contact force or a non-contact force. 1) A skater pushing off the wall of an ice rink to start moving. 2) A compass needle turning to point north due to Earth's magnetic field. 3) A parachute canopy being slowed down by air resistance. 4) A balloon rubbed on a jumper picking up small pieces of paper without touching them. 5) Two teams pulling on a rope in a tug of war. 6) A satellite kept in orbit around the Earth by gravity.

(6)

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5 Friction can be a useful force or an unwanted force, depending on the situation.

(a) Give one example of where friction is deliberately increased to make something safer or more effective, and explain how. **(2)**

(b) Give one example of how friction is deliberately reduced. **(1)**

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6 A car of mass 800 kg accelerates at 2.5 m/s^2. Calculate the resultant force acting on the car.

(3)

7 A parachutist of mass 75 kg reaches a steady speed when falling. If the weight of the parachutist is 750 N, what upward force from air resistance acts on the parachutist at steady speed? Explain your answer briefly.

(3)

8 A cyclist is moving at steady speed along a straight road. State three forces acting on the cyclist and say whether each is a contact or a non-contact force.

(3)

9 Priya pushes a toy car from rest. The car accelerates and reaches a speed of 2.0 m/s in 4.0 s. Calculate the acceleration of the car and state its unit.

(4)

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10 Kwame drops a ball and measures its motion. He records that during a long fall the ball reaches a terminal speed when air resistance equals the weight. Describe, in terms of forces and resultant force, why the ball stops accelerating when it reaches terminal speed.

(4)

11 Equation you may need: speed = distance / time. The table shows the distance travelled by a jogger.

Time (s)	Distance (m)
0	0
10	40
20	80
30	80
40	120

(a) Calculate the jogger's speed between 0 s and 20 s. **(2)**

(b) Describe what is happening to the jogger between 20 s and 30 s. **(1)**

(c) Calculate the jogger's speed between 30 s and 40 s. **(2)**

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12 A swimmer floats motionless on the surface of a swimming pool.

(a) Name the two forces acting on the floating swimmer. **(2)**

(b) The swimmer is floating perfectly still. State the relationship between the sizes of these two forces. **(1)**

(c) The swimmer puts on a heavy weight belt and begins to sink. Explain, in terms of forces, why this happens. **(2)**

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13 Explain the factors that affect a car's overall stopping distance, and evaluate why speed limits are often lower near schools than on motorways. Refer to thinking distance, braking distance and the forces involved in your answer.

(6)

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Mark scheme · 3.1 Forces and Motion: Test Pack

Question 1

C cao **B1**

Answer: **C) It continues moving at the same constant velocity**

Question 2

(a) the swimmer pushes the water backward (the action force) **M1**

(a) the water pushes the swimmer forward with an equal and opposite force (the reaction force), propelling them forward, oe **A1**

(a) Answer: **The swimmer pushes water backward; by Newton's third law, the water pushes back on the swimmer with an equal and opposite force, moving them forward.**

(b) the exhaust gases push back on the rocket with an equal and opposite force **M1**

(b) this force acts upward, pushing the rocket upward, oe **A1**

(b) Answer: **The exhaust gases push back on the rocket with an equal and opposite force, acting upward, which pushes the rocket upward.**

Question 3

Level 1 Basic, mostly isolated statements about weight and/or air resistance, with little or no reference to how the forces change or to terminal velocity. May simply state that the skydiver 'speeds up then slows down' without explanation. **1-2**

Level 2 A description of how weight and air resistance change during the fall, with some correct reference to the resultant force decreasing as speed increases, and some mention of terminal velocity or of the effect of the parachute, but the explanation may be incomplete or not fully linked. **3-4**

Level 3 A clear, logically linked explanation covering: weight being constant and greater than air resistance at the start so the skydiver accelerates; air resistance increasing as speed increases, reducing the resultant force; the forces becoming balanced (resultant force = 0) at terminal velocity, so speed becomes constant; and the sudden large increase in air resistance when the parachute opens, causing the skydiver to decelerate to a new, lower terminal velocity. **5-6**

Indicative content:

- At the start of the fall, weight is constant and much bigger than air resistance, so there is a large resultant force downward and the skydiver accelerates.
- As the skydiver's speed increases, air resistance increases (more collisions with air particles per second).
- This means the resultant force gets smaller as speed increases, so the skydiver's acceleration decreases (though they are still speeding up).
- Eventually air resistance increases until it equals weight; the resultant force becomes zero (forces balanced), so the skydiver stops accelerating and falls at a constant speed, called terminal velocity.
- When the parachute opens, air resistance suddenly increases greatly (because of the much larger surface area), becoming much bigger than weight.
- This gives a large resultant force acting upward, so the skydiver decelerates (slows down rapidly).
- As the skydiver slows down, air resistance decreases again until it once more balances weight, at a new, lower terminal velocity.

Question 4

1) contact **B1**

2) non-contact **B1**

3) contact **B1**

4) non-contact **B1**

5) contact **B1**

6) non-contact **B1**

Answer: **1) contact, 2) non-contact, 3) contact, 4) non-contact, 5) contact, 6) non-contact**

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Question 5

(a) valid example, e.g. tyre treads, football boot studs, rubber soles on shoes **M1**

(a) explanation of how the roughened/textured surface increases grip and reduces slipping, oe **A1**

(a) Answer: **e.g. Tyre treads increase friction with the road, giving better grip and reducing skidding.**

(b) one valid way friction is deliberately reduced, e.g. oiling/lubricating a bicycle chain or a door hinge to reduce friction between moving parts, ball bearings in a wheel, streamlining a vehicle (a named example or the method on its own, such as using a lubricant, is enough), oe **B1**

(b) Answer: **e.g. Oiling a bicycle chain reduces friction between the moving links.**

Question 6

use F = m a substitution F = 800 x 2.5 **M1**

2000 N cao **A1**

unit stated as N or shown in answer **B1**

Answer: **2000 N**

Question 7

state at steady speed upward force equals weight **M1**

750 N cao **A1**

brief explanation that resultant is zero so speed is constant **B1**

Answer: **750 N; because at steady speed the upward air resistance balances the weight giving a resultant force of 0 N.**

Question 8

friction or air resistance - contact **B1**

normal contact force from the road on the tyres - contact **B1**

gravity (weight) - non-contact **B1**

Answer: **Examples: friction or air resistance - contact; normal contact force from road - contact; gravity (weight) - non-contact.**

Question 9

use a = change in speed / time = (2.0 - 0) / 4.0 **M1**

0.50 cao **A1**

unit stated as m/s^2 **B1**

calculation shown 2.0 / 4.0 = 0.5 cao **A1**

Answer: **0.50 m/s^2**

Question 10

air resistance increases with speed until it equals weight **M1**

when air resistance = weight the upward and downward forces are equal **M1**

resultant force is zero so acceleration stops and speed is constant (terminal speed) **A1**

statement that before equality the resultant was downwards causing acceleration, oe **A1**

Answer: **Air resistance increases as the ball speeds up until it equals the weight; at that point upward and downward forces balance so resultant force is zero and acceleration stops, giving a constant terminal speed.**

Question 11

(a) correct substitution speed = 80 / 20 **M1**

(a) 4 m/s cao **A1**

(a) Answer: **4 m/s**

(b) the jogger is stationary/resting, since the distance does not change (oe) **B1**

(b) Answer: **The jogger is stationary (resting), since the distance does not change.**

(c) correct substitution speed = (120-80) / (40-30) **M1**

(c) 4 m/s cao **A1**

(c) Answer: **4 m/s**

Question 12

(a) weight **B1**

(a) upthrust (the upward force from the water) **B1**

(a) Answer: **Weight and upthrust.**

(b) they are equal in size, balanced (oe) **B1**

(b) Answer: **They are equal in size (balanced forces).**

(c) the weight belt increases the swimmer's total weight (downward force) **M1**

(c) weight is now greater than upthrust, giving a resultant (unbalanced) force downward, so the swimmer sinks (oe) **A1**

(c) Answer: **The weight belt increases the swimmer's weight so it becomes greater than the upthrust, giving an unbalanced downward force that makes the swimmer sink.**

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Question 13

Level 1 Basic, mostly unlinked statements about stopping distance, thinking distance or braking distance, with little reference to forces. May be presented as a simple list.	**1-2**
Level 2 A description of factors affecting thinking distance and/or braking distance, with some correct reference to forces (e.g. friction, reaction time), but the evaluation of speed limits near schools is limited or missing.	**3-4**
Level 3 A clear, logically linked explanation of factors affecting both thinking distance and braking distance, correctly referring to forces (e.g. friction between tyres and road, reaction time), together with a well-reasoned evaluation of why lower speed limits near schools reduce the risk of collisions.	**5-6**

Indicative content:

- Thinking distance is the distance travelled during the driver's reaction time, before the brakes are applied.
- Thinking distance increases if the driver is tired, distracted, or under the influence of drink or drugs (slower reaction time).
- Braking distance is the distance travelled while the brakes are being applied until the vehicle stops.
- Braking distance increases in wet or icy conditions, with worn tyres or worn brakes, or with a greater vehicle mass or load, because the friction force between tyres and road is reduced or a larger braking force is needed.
- At higher speed, both thinking distance and braking distance increase, so total stopping distance is much greater at higher speeds.
- Near schools there is more risk of pedestrians, especially children, stepping into the road unexpectedly, so a shorter stopping distance is needed to avoid a collision.
- Lower speed limits near schools reduce both thinking distance and braking distance, giving drivers more time and distance to stop safely.

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