K11D Forces and Motion: Exam Drill

AQA AQA KS3 Science - Physics · Calculator allowed · about 75 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 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)

3 A ceiling lamp hangs motionless from a cable attached to the ceiling.

(a) Name the force pulling the lamp downward. **(1)**

(b) Name the force in the cable that holds the lamp up. **(1)**

(c) The lamp is not moving. Use the idea of resultant force to explain why. **(2)**

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4 Use the Physics Equations Sheet: weight = mass x gravitational field strength (W = m g). On the Moon, gravitational field strength g = 1.6 N/kg. An astronaut's life-support backpack has a mass of 25 kg.

(a) Calculate the weight of the backpack on the Moon. **(2)**

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(b) The same backpack would weigh 250 N on Earth. Explain why its weight is different on the Moon even though its mass is unchanged. **(2)**

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5 A delivery driver's morning route has three legs. Leg 1: 12 km in 20 minutes. Leg 2: 8 km in 10 minutes. Leg 3: 15 km in 25 minutes.

(a) Calculate the total distance travelled over the whole route. **(1)**

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(b) Calculate the total time taken for the whole route, in hours. **(2)**

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(c) Calculate the driver's average speed for the whole route, in km/h. **(2)**

....

6 In a tug of war, the Red team pulls with a combined force of 850 N. The Blue team pulls in the opposite direction with a combined force of 780 N.

(a) Calculate the resultant force on the rope, including its direction. **(3)**

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(b) State what would happen to the resultant force if the Blue team's pull increased to exactly 850 N. **(1)**

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7 Required practical: a student investigates how the angle of a ramp affects the average speed of a trolley released from rest at the top. She uses a stopwatch to time the trolley over a fixed distance of 2.0 m, marked with tape at the start and finish lines, for four different ramp angles. Her results are shown in the table. Angle (degrees): 10, 20, 30, 40. Time (s): 4.0, 2.5, 1.8, 1.4.

(a) Identify the independent variable and the dependent variable in this investigation. **(2)**

(b) State two variables that should be kept the same to make this a fair test. **(2)**

(c) Calculate the trolley's average speed at a ramp angle of 30 degrees. **(2)**

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(d) Describe the pattern shown by the results, and suggest why this pattern occurs. **(2)**

8 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 where friction is deliberately reduced, and state one method used to reduce it. **(1)**

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9 Use the Physics Equations Sheet: pressure = force / area. A figure skater weighing 500 N stands on one skate blade, which has a contact area with the ice of 0.001 m^2.

(a) Calculate the pressure the skater exerts on the ice while balanced on the blade. **(2)**

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(b) Without skates, the same skater's boot has a contact area of 0.02 m^2 with the ice. Calculate the pressure exerted by the boot alone, using the same force of 500 N, and explain why a skate blade can cut into ice more easily than a boot. **(2)**

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10 Use the Physics Equations Sheet: moment = force x distance (from the pivot). A mechanic uses a spanner to turn a bolt. She applies a force of 40 N at a distance of 0.20 m from the centre of the bolt.

(a) Calculate the moment produced on the bolt. **(2)**

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(b) The bolt is very tight and does not turn. Suggest and explain one change the mechanic could make to produce a larger moment without increasing the force she applies. **(2)**

(c) The mechanic swaps to a spanner where the same force of 40 N is applied 0.35 m from the bolt. Calculate the new moment. **(1)**

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11 In a party trick, a tablecloth is pulled very quickly and horizontally from under plates and cups, leaving them almost undisturbed on the table.

(a) Name the property of the plates and cups that makes them tend to stay still when the cloth is pulled quickly. **(1)**

(b) Explain, using ideas about forces, why the plates and cups stay almost still if the cloth is pulled quickly enough. **(2)**

12 A runner's distance-time graph shows the following: a straight line sloping upward from 0 to 20 s, then a flat (horizontal) section from 20 s to 30 s, then a straight line sloping downward back to zero distance from 30 s to 50 s.

(a) Describe what is happening to the runner between 0 and 20 s. **(1)**

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

(c) Describe what is happening to the runner between 30 and 50 s. **(1)**

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13 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)**

14 A submarine has ballast tanks that can be filled with seawater, or emptied by pumping in compressed air, changing the submarine's weight without changing the upthrust of the water pushing up on it.

(a) Name the two forces that act on a submarine when it is staying still at a constant depth underwater. **(2)**

(b) State the relationship between the sizes of these two forces when the submarine is staying at a constant depth. **(1)**

(c) Explain, in terms of these forces, how filling the ballast tanks with more seawater causes the submarine to sink. **(2)**

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15 Use the Physics Equations Sheet: resultant force = mass x acceleration (F = m a). An ice hockey puck has a mass of 0.17 kg. A player's stick exerts a resultant force of 34 N on the puck during a shot. Calculate the puck's acceleration during the shot.

(3)

16 Required practical: a student investigates how the extension of a length of catapult elastic depends on the force applied. She measures its natural length, then hangs increasing loads from it and measures the new length each time. Her results are shown in the table. Force (N): 0, 2, 4, 6, 8, 10. Extension (mm): 0, 15, 30, 45, 60, 90.

(a) Describe the pattern shown by the results between 0 N and 6 N. **(1)**

(b) State the force at which the elastic stops extending proportionally with the force applied (the limit of proportionality). **(1)**

(c) Use the Physics Equations Sheet: elastic constant k = force / extension (k = F / e). Use the result at 4 N to calculate the elastic constant of the catapult elastic. Give your answer in N/mm. **(2)**

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(d) The student wants to predict the extension the elastic would give with a 20 N force. Explain why she should not use her elastic constant from part (c) to make this prediction. **(1)**

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17 For each statement, identify whether it is True or False. If a statement is false, give the correct version.

(a) If the forces acting on a stationary object are balanced, the object will remain at rest. **(1)**

(b) A non-contact force can only act between two magnetic objects. **(1)**

(c) For an object of fixed mass, a bigger resultant force gives a greater acceleration. **(1)**

(d) Moment is measured in newtons (N). **(1)**

18 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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Question 1

- **B1** C cao
- Answer: **C) It continues moving at the same constant velocity**

Question 2

- **B1** 1) contact
- **B1** 2) non-contact
- **B1** 3) contact
- **B1** 4) non-contact
- **B1** 5) contact
- **B1** 6) non-contact
- Answer: **1) contact, 2) non-contact, 3) contact, 4) non-contact, 5) contact, 6) non-contact**

Question 3

- (a) **B1** weight
- (a) Answer: **Weight.**
- (b) **B1** tension
- (b) Answer: **Tension.**
- (c) **M1** the two forces (weight and tension) are equal in size and opposite in direction (balanced)
- (c) **A1** so the resultant force on the lamp is 0 N, meaning it stays at rest, oe
- (c) Answer: **The weight and the tension in the cable are balanced, giving a resultant force of 0 N, so the lamp stays at rest.**

Question 4

- (a) **M1** W = 25 x 1.6
- (a) **A1** = 40 N cao
- (a) Answer: **40 N**
- (b) **M1** mass (the amount of matter in the backpack) stays the same wherever it is
- (b) **A1** weight depends on gravitational field strength, which is much smaller on the Moon than on Earth, so the weight is smaller, oe
- (b) Answer: **Mass is unchanged because the amount of matter is the same; weight is smaller on the Moon because the Moon's gravitational field strength is much smaller than Earth's.**

Question 5

- (a) **B1** 35 km cao
- (a) Answer: **35 km**
- (b) **M1** 20 + 10 + 25 = 55 minutes
- (b) **A1** 55 / 60 = 0.92 hours (awrt 0.92) cao
- (b) Answer: **0.92 hours (awrt)**
- (c) **M1** speed = total distance / total time = 35 / 0.92, ft from (a) and (b)
- (c) **A1** awrt 38.2 km/h cao
- (c) Answer: **awrt 38.2 km/h**

Question 6

- (a) **M1** correct subtraction 850 - 780
- (a) **A1** 70 N
- (a) **A1** direction: in the direction of the Red team's pull cao
- (a) Answer: **70 N in the direction of the Red team's pull.**
- (b) **B1** resultant force = 0 N, forces balanced (oe)
- (b) Answer: **Resultant force = 0 N (the forces would be balanced).**

Question 7

- (a) **B1** independent variable = angle of the ramp (oe)
- (a) **B1** dependent variable = time taken to travel the fixed distance (oe)
- (a) Answer: **Independent variable: angle of the ramp. Dependent variable: time taken to travel 2.0 m.**
- (b) **B1** any one of: the trolley used (same mass), the distance measured (2.0 m), the surface/material of the ramp, the starting position/point of release
- (b) **B1** a second, different valid control variable from the list above
- (b) Answer: **Any two of: same trolley/mass, same distance measured, same ramp surface, same starting point of release.**
- (c) **M1** speed = 2.0 / 1.8
- (c) **A1** awrt 1.1 m/s cao
- (c) Answer: **awrt 1.1 m/s**
- (d) **M1** as the angle increases, the time taken decreases, so the trolley's average speed increases, oe
- (d) **A1** a steeper ramp increases the component of the trolley's weight acting down the slope, giving a larger resultant force and a greater acceleration, oe
- (d) Answer: **As the ramp angle increases, the time falls and average speed increases, because a steeper slope gives a larger resultant force down the ramp and so a greater acceleration.**

Question 8

- (a) **M1** valid example, e.g. tyre treads, football boot studs, rubber soles on shoes
- (a) **A1** explanation of how the roughened/textured surface increases grip and reduces slipping, oe
- (a) Answer: **e.g. Tyre treads increase friction with the road, giving better grip and reducing skidding.**
- (b) **B1** valid example with method, e.g. oiling/lubricating a bicycle chain or a door hinge to reduce friction between moving parts, oe
- (b) Answer: **e.g. Oiling a bicycle chain reduces friction between the moving links.**

Question 9

- (a) **M1** P = 500 / 0.001
- (a) **A1** 500000 Pa cao
- (a) Answer: **500000 Pa**
- (b) **M1** P = 500 / 0.02 = 25000 Pa
- (b) **A1** the blade has a much smaller area, so for the same force it produces a much greater pressure, allowing it to cut into the ice (ft from a) oe
- (b) Answer: **25000 Pa; the blade's much smaller area gives a far higher pressure (500000 Pa) than the boot (25000 Pa) for the same force, letting the blade cut into the ice.**

Question 10

- (a) **M1** 40 x 0.20
- (a) **A1** 8 Nm cao
- (a) Answer: **8 Nm**
- (b) **M1** use a longer spanner (increase the distance from the pivot at which the force is applied)
- (b) **A1** because moment = force x distance, increasing the distance while the force stays the same increases the moment, oe
- (b) Answer: **Use a longer spanner; since moment = force x distance, a greater distance from the pivot gives a larger moment for the same force.**
- (c) **B1** 14 Nm cao (40 x 0.35)
- (c) Answer: **14 Nm**

Question 11

- (a) **B1** inertia (their mass resisting a change in motion) oe
- (a) Answer: **Inertia.**
- (b) **M1** friction between the cloth and the plates/cups only acts for a very short time as the cloth is pulled quickly
- (b) **A1** this is not enough time for a large enough force to noticeably change the motion of the plates/cups, so their own inertia keeps them almost still, oe
- (b) Answer: **The cloth only exerts friction on the plates and cups for a very short time, so it does not have long enough to change their motion much, and their inertia keeps them almost still.**

Question 12

- (a) **B1** moving away from the start at a constant/steady speed, oe
- (a) Answer: **Moving away from the start at a constant speed.**
- (b) **B1** stationary/resting (not moving), oe
- (b) Answer: **Stationary (resting), since the distance does not change.**
- (c) **B1** moving back toward the start at a constant/steady speed, oe
- (c) Answer: **Moving back toward the start at a constant speed.**

Question 13

- (a) **M1** the swimmer pushes the water backward (the action force)
- (a) **A1** the water pushes the swimmer forward with an equal and opposite force (the reaction force), propelling them forward, oe
- (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) **M1** the exhaust gases push back on the rocket with an equal and opposite force
- (b) **A1** this force acts upward, pushing the rocket upward, oe
- (b) Answer: **The exhaust gases push back on the rocket with an equal and opposite force, acting upward, which pushes the rocket upward.**

Question 14

- (a) **B1** weight
- (a) **B1** upthrust (the upward force from the water)
- (a) Answer: **Weight and upthrust.**
- (b) **B1** they are equal in size (balanced), oe
- (b) Answer: **They are equal in size (balanced forces).**
- (c) **M1** filling the tanks with more seawater increases the submarine's total weight
- (c) **A1** weight becomes greater than upthrust, giving a resultant (unbalanced) force downward, so the submarine sinks, oe
- (c) Answer: **Filling the tanks with more seawater increases the submarine's weight so it becomes greater than upthrust, giving an unbalanced downward force that makes it sink.**

Question 15

- **M1** correct rearrangement a = F / m
- **A1** correct substitution a = 34 / 0.17
- **A1** 200 m/s^2 cao
- Answer: **200 m/s^2**

Question 16

- (a) **B1** extension is directly proportional to force between 0 N and 6 N (a straight line through the origin; extension increases by 15 mm for every extra 2 N), oe
- (a) Answer: **Extension is directly proportional to the force applied between 0 N and 6 N.**
- (b) **B1** 8 N (accept between 8 N and 10 N) cao
- (b) Answer: **8 N.**
- (c) **M1** correct substitution k = 4 / 30
- (c) **A1** awrt 0.13 N/mm cao
- (c) Answer: **awrt 0.13 N/mm**
- (d) **B1** 20 N is beyond the limit of proportionality (found in part b), so extension is no longer directly proportional to force and the elastic constant no longer applies, oe
- (d) Answer: **20 N is beyond the limit of proportionality, so extension is no longer proportional to force and the elastic constant from part (c) no longer applies.**

Question 17

- (a) **B1** True cao
- (a) Answer: **True**
- (b) **B1** False; non-contact forces also include gravitational and electrostatic forces, which do not need magnetism, oe
- (b) Answer: **False - non-contact forces also include gravitational and electrostatic forces, not only magnetism.**
- (c) **B1** True cao
- (c) Answer: **True**
- (d) **B1** False; moment is measured in newton-metres (Nm); newtons (N) is the unit of force, oe
- (d) Answer: **False - moment is measured in newton-metres (Nm), not newtons.**

Question 18

- **Level 1** (1-2): 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.
- **Level 2** (3-4): 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.
- **Level 3** (5-6): 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.
- **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.