3.1 Forces and Motion: 1-hour Pack

Calculator allowed · about 60 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 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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2 Equation you may need: 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)**

(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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3 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)**

.....

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

.....

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4 Practical investigation: 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)	Time (s)
10	4.0
20	2.5
30	1.8
40	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)**

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

5 Describe how increasing the mass of an object affects its acceleration when the same force is applied, and say what happens to the acceleration if the mass is doubled. Use Newton's second law idea in your answer.

(3)

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6 Extended response: A class is asked to investigate how the length of a slope affects the speed of a toy car at the bottom. They use the same car, the same slope angle, and three different slope lengths. Describe a fair method the class could use, identify the key variables, predict the expected trend and explain the scientific reason using forces and energy ideas. Finally, suggest two improvements to make the investigation more reliable.

(6)

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7 A student measures the time taken for a toy car to travel 0.40 m when pushed with two different forces. With force A the time is 0.80 s; with force B the time is 0.57 s. Calculate the average speed in each case and say which force produced the greater speed. Show your working.

(4)

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8 Give the equation linking weight, mass and gravitational field strength. Then calculate the weight of a 9 kg suitcase using g = 10 N/kg.

(2)

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9 Explain what is meant by the resultant force acting on an object.

(3)

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10 For each force below, state whether it is a contact force or a non-contact force. 1) Friction between a car's tyres and the road. 2) The gravitational force between the Earth and the Moon. 3) The normal contact force from a table pushing up on a book. 4) The magnetic force between two magnets. 5) Air resistance acting on a falling leaf. 6) The electrostatic force between a charged balloon and a wall (without touching).

(6)

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11 Equation you may need: weight = mass x gravitational field strength (W = m g). On Earth, gravitational field strength g = 10 N/kg.

(a) A rucksack has a mass of 4.5 kg. Calculate its weight on Earth. **(2)**

(b) Explain why the rucksack's mass would stay the same on the Moon, but its weight would change. **(2)**

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12 A cyclist's distance-time graph is a curve that becomes steeper as time goes on.

(a) State what this shape shows about the cyclist's speed. **(1)**

(b) The cyclist then travels at a constant (steady) speed. Describe how this part of the distance-time graph would look. **(1)**

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Mark scheme · 3.1 Forces and Motion: 1-hour Pack

Question 1

(a) weight **B1**

(a) Answer: **Weight.**

(b) tension **B1**

(b) Answer: **Tension.**

(c) the two forces (weight and tension) are equal in size and opposite in direction (balanced) **M1**

(c) so the resultant force on the lamp is 0 N, meaning it stays at rest, oe **A1**

(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 2

(a) W = 25 x 1.6 **M1**

(a) = 40 N cao **A1**

(a) Answer: **40 N**

(b) mass (the amount of matter in the backpack) stays the same wherever it is **M1**

(b) weight depends on gravitational field strength, which is much smaller on the Moon than on Earth, so the weight is smaller, oe **A1**

(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 3

(a) 35 km cao **B1**

(a) Answer: **35 km**

(b) 20 + 10 + 25 = 55 minutes **M1**

(b) 55 / 60 = 0.92 hours (awrt 0.92) cao **A1**

(b) Answer: **0.92 hours (awrt)**

(c) speed = total distance / total time = 35 / (55/60) or 35 / 0.9167, ft from (a) and (b) **M1**

(c) awrt 38.2 km/h (accept 38.0 km/h from 35 / 0.92) **A1**

(c) Answer: **awrt 38.2 km/h**

Question 4

(a) independent variable = angle of the ramp (oe) **B1**

(a) dependent variable = time taken to travel the fixed distance (oe) **B1**

(a) Answer: **Independent variable: angle of the ramp. Dependent variable: time taken to travel 2.0 m.**

(b) 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 **B1**

(b) a second, different valid control variable from the list above **B1**

(b) Answer: **Any two of: same trolley/mass, same distance measured, same ramp surface, same starting point of release.**

(c) speed = 2.0 / 1.8 **M1**

(c) awrt 1.1 m/s cao **A1**

(c) Answer: **awrt 1.1 m/s**

(d) as the angle increases, the time taken decreases, so the trolley's average speed increases, oe **M1**

(d) 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 **A1**

(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 5

state F = m a idea or that acceleration depends on force and mass **M1**

explain that with same force larger mass gives smaller acceleration **M1**

states that doubling the mass halves the acceleration (oe, e.g. acceleration is inversely proportional to mass) **A1**

Answer: **Using F = m a, if the applied force stays the same then a = F/m, so increasing mass reduces acceleration; for example doubling mass halves acceleration.**

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Question 6

Level 1 Basic method and limited physics. Simple suggestion of variables and a vague prediction. Limited or no improvements suggested. **1-2**

Level 2 Clear method with control of key variables, correct prediction and some scientific explanation using forces or energy. At least one reasonable improvement. **3-4**

Level 3 Detailed, repeatable method controlling variables, accurate prediction and clear explanation using both forces and conservation of energy. Two realistic improvements that would increase reliability or reduce random and systematic error. **5-6**

Indicative content:

- Method: set up slope at fixed angle, measure three slope lengths, release car from top with identical release mechanism, measure speed at bottom using light gate or measure time over set distance and calculate speed.
- Variables: independent = slope length; dependent = speed at bottom; control = slope angle, car mass, wheel condition, release method, surface.
- Prediction: longer slope gives larger speed at bottom (up to a point) because more gravitational potential energy is converted to kinetic energy, ignoring larger energy losses to friction/air resistance.
- Explanation: gravitational force along slope does work; energy lost to friction increases with distance so trend may show diminishing returns; using F = m a and energy ideas gives consistent explanation.
- Improvements: repeat each length several times and take mean; use a light gate to measure speed accurately; ensure slope surface and car wheels are clean to reduce variability.

Question 7

calculate speed A = 0.40 / 0.80 = 0.5 m/s **M1**

0.50 m/s cao **A1**

calculate speed B = 0.40 / 0.57 = 0.70175... -> 0.70 m/s **M1**

0.70 m/s cao and statement that force B produced the greater speed **A1**

Answer: **Speed A = 0.50 m/s; Speed B = 0.70 m/s. Force B produced the greater speed.**

Question 8

weight = mass x gravitational field strength or W = m g **M1**

90 N cao **A1**

Answer: **W = m g; 90 N**

Question 9

statement that resultant force is the single force that has the same effect as all the forces acting combined **M1**

idea that if resultant is zero forces are balanced and motion does not change **A1**

idea that non-zero resultant changes speed or direction (cause acceleration) oe **B1**

Answer: **The resultant force is the single force that represents the combined effect of all forces; if it is zero forces are balanced and motion does not change, if not zero the object accelerates or changes direction.**

Question 10

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**

Question 11

(a) correct substitution W = 4.5 x 10 **M1**

(a) 45 N cao **A1**

(a) Answer: **45 N**

(b) mass is the amount of matter in the rucksack, and this does not change wherever it is **B1**

(b) weight depends on the gravitational field strength, which is smaller on the Moon, so the weight decreases (oe) **B1**

(b) Answer: **Mass stays the same because the amount of matter is unchanged; weight decreases because the Moon's gravitational field strength is smaller than Earth's.**

Question 12

(a) the cyclist's speed is increasing, the cyclist is accelerating/speeding up (oe) **B1**

(a) Answer: **The cyclist's speed is increasing.**

(b) a straight line with a constant/unchanging gradient (oe) **B1**

(b) Answer: **A straight line.**

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