3.6 Pressure, Moments and Simple Machines: 30-minute Pack

Calculator allowed · about 30 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 It is easier to push a heavy wheelie bin up a sloped ramp into a van than to lift it straight up over the same height. Explain why using the ramp means a smaller force is needed.

(3)

2 A group of students investigates how the distance from the pivot at which a force is applied affects the force needed to lift a fixed 5 N load on the other end of a metre ruler lever. Identify the independent variable, dependent variable and one control variable in this investigation.

(3)

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3 Using the same 5 N load fixed at 0.20 m from the pivot, students measure the effort force needed at different distances from the pivot. Distance (m): 0.10, 0.20, 0.40, 0.50. Effort force (N): 10.0, 5.0, 2.5, x.

(a) Calculate the missing effort force x at 0.50 m, assuming the same load moment throughout. **(2)**

(b) Describe the relationship shown by this data between distance from the pivot and the effort force needed. **(2)**

4 A gardener uses a wheelbarrow to move a heavy load of soil. The wheel sits at the front of the barrow (acting as the pivot), the load of soil sits in the tub close to the wheel, and the gardener lifts and pushes using the two handles at the back, far from the wheel. Explain, using ideas about moments, why the wheelbarrow's design makes it much easier to lift and move the heavy load than carrying the soil in a box by hand.

(6)

5 State the equation linking pressure, force and area, including the unit of pressure.

(2)

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6 A dancer stands still, balanced on the tip of one shoe. Her weight is 480 N and the tip of the shoe touches the floor over an area of 3.0 cm^2. Calculate the pressure exerted on the floor.

(3)

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7 Farm tractors that drive over soft, muddy fields are often fitted with very wide tyres instead of narrow ones. Explain why wide tyres make the tractor less likely to sink into the mud.

(2)

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8 Mountaineers climbing very high mountains often need to carry oxygen tanks, because the air pressure is much lower at high altitude than at sea level. Explain why air pressure is lower at high altitude than at sea level.

(3)

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Mark scheme · 3.6 Pressure, Moments and Simple Machines: 30-minute Pack

Question 1

a ramp (inclined plane) is a simple machine that lets you raise the bin to the same height using a smaller force	B1
the force needed is smaller because it is applied over a longer distance (along the slope) than the straight vertical lift	B1
so pushing along the ramp needs less force at any one moment, even though the bin travels further, oe	B1

Answer: **A ramp is a simple machine that raises the bin to the same height but over a longer sloped distance, so a smaller push force is needed at any moment than lifting it straight up.**

Question 2

independent variable: distance from the pivot at which the force is applied	B1
dependent variable: force needed to just lift the load	B1
a control variable: e.g. the size of the load, the distance of the load from the pivot, or the ruler/lever used, oe	B1

Answer: **Independent variable: distance from the pivot where the force is applied. Dependent variable: force needed to lift the load. Control variable: the size of the load (5 N) and its distance from the pivot.**

Question 3

(a) load moment = 5 x 0.20 = 1.0 Nm, so effort x 0.50 = 1.0	M1
(a) x = 2.0 N cao	A1

(a) Answer: **2.0 N**

(b) as the distance from the pivot increases, the effort force needed decreases	B1
(b) the effort force is inversely proportional to the distance (doubling the distance halves the force needed), oe	B1

(b) Answer: **As the distance from the pivot increases, the effort force needed decreases; the force is inversely proportional to the distance.**

Question 4

Level 1 Simple, isolated statements, e.g. the wheel helps you push it, with little or no reference to moments, pivots or distances.	1-2
Level 2 Identifies the wheel as a pivot and refers to force and/or distance from the pivot, with a partial explanation of why less effort is needed; may not clearly compare the load and effort distances.	3-4
Level 3 A clear, fully linked explanation identifying the wheel as the pivot, comparing the short distance from pivot to load with the much longer distance from pivot to the handles, and correctly explaining, using moment = force x distance, why a smaller effort force at the handles balances the larger load close to the pivot.	5-6

Indicative content:

- The wheelbarrow acts as a lever, turning (pivoting) about the wheel at the front when lifted.
- The load of soil sits close to the pivot (the wheel), so its moment (load force x short distance) is limited even though the load itself is heavy.
- The gardener's hands on the handles are much further from the pivot than the load is.
- Because moment = force x perpendicular distance from the pivot, applying the effort force at this much greater distance means a smaller effort force is needed to produce a moment big enough to lift and balance the load's moment.
- This means the gardener needs to apply far less force at the handles than the actual weight of the soil, making the load feel much lighter to lift than carrying it directly.
- The wheel itself also reduces friction with the ground once the barrow is moving, but the main reason lifting feels easier is the mechanical advantage from the pivot and unequal distances (the moment/lever effect).

Question 5

pressure = force / area, oe (allow rearranged forms)	B1
unit: pascals (Pa) or N/m2, cao	B1

Answer: **pressure = force / area, measured in pascals (Pa) or N/m2.**

Question 6

pressure = 480 / 3.0	M1
= 160 (N/cm2) cao (accept 1 600 000 Pa, or 1.6 x 10^6 N/m2, as the equivalent in SI units)	A1
correct unit N/cm2 (or Pa, N/m2 if converted) given with the answer	B1

Answer: **160 N/cm2 (accept 1 600 000 Pa)**

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Question 7

wide tyres increase the contact area between the tyre and the ground for the same weight of tractor **B1**

this spreads the same force over a larger area, reducing the pressure on the ground, so the tractor is less likely to sink into the mud, oe **B1**

Answer: **Wide tyres increase the contact area with the ground, so the tractor's weight is spread over a larger area, reducing the pressure and making the tractor less likely to sink into soft mud.**

Question 8

atmospheric pressure is caused by the weight of the column of air above a point, pressing down **B1**

at high altitude, there is less air above (a shorter column of air) than at sea level **B1**

so there is less weight of air pressing down, meaning lower atmospheric pressure at altitude, oe **B1**

Answer: **Atmospheric pressure is caused by the weight of air above a point. At high altitude there is less air above, so less weight is pressing down, giving a lower atmospheric pressure than at sea level.**

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