K20 Pressure, Moments and Simple Machines

AQA AQA KS3 Science - Physics · Calculator allowed · about 85 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Quickfire: circle the correct letter for each question.

(a) The unit of pressure is the pascal, which is equivalent to: **(1)**

- [ ] A) N
- [ ] B) N/m2
- [ ] C) kg/m3
- [ ] D) N times m

(b) A fixed force is spread over a larger area. What happens to the pressure? **(1)**

- [ ] A) it increases
- [ ] B) it decreases
- [ ] C) it stays the same
- [ ] D) it becomes zero

(c) The moment of a force about a pivot is defined as: **(1)**

- [ ] A) force x perpendicular distance from the pivot
- [ ] B) force divided by distance
- [ ] C) force x time taken
- [ ] D) mass x distance from the pivot

(d) Which of these is an example of a lever? **(1)**

- [ ] A) a pair of scissors
- [ ] B) a torch battery
- [ ] C) a glass of water
- [ ] D) a thermometer

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

(2)

3 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 cm2.

(3)

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4 Farm tractors that drive over soft, muddy fields are often fitted with very wide tyres instead of narrow ones.

(2)

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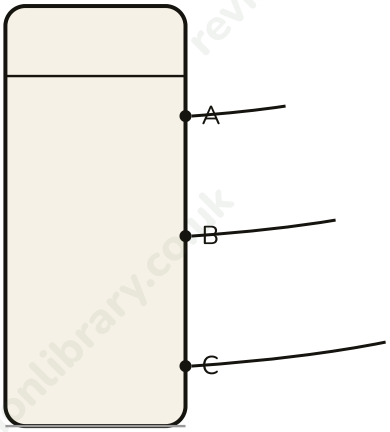
5 State two factors that affect the pressure at a point inside a liquid.

(2)

6 A plastic bottle full of water has three small holes made in a vertical line down one side: hole A near the top, hole B in the middle, and hole C near the bottom. Water squirts out of all three holes at the same time.



(3)

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7 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.

(3)

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8 State the equation for the moment of a force, and state its unit.

(2)

9 A mechanic uses a spanner to loosen a tight bolt. She applies a force of 45 N at right angles to the spanner, at a perpendicular distance of 0.20 m from the bolt (the pivot).

(2)

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10 Two children sit on opposite sides of a balanced see-saw, which pivots at its centre. Amelia has a weight of 300 N and sits 1.6 m from the pivot. Noah has a weight of 480 N and sits on the other side.

(a) State the condition needed for the see-saw to be balanced (in equilibrium). **(1)**

(b) Calculate Amelia's moment about the pivot. **(1)**

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(c) Calculate how far from the pivot Noah must sit for the see-saw to balance. **(2)**

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11 A mechanic finds a tight nut easier to loosen using a long spanner than a short one, even though he pushes with about the same force each time.

(3)

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12 A crowbar is placed under a heavy paving slab, resting on a small block of wood that acts as a pivot close to the slab. Explain why pushing down on the far end of the crowbar makes it much easier to lift the slab than lifting it directly by hand.

(3)

13 Name three everyday tools, other than a spanner or a crowbar, that work as levers.

(3)

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14 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.

(3)

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15 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.

(3)

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16 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)**

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

17 A sealed can of deodorant contains gas at high pressure. If the can is heated (for example, left near a radiator), the pressure inside increases and the can can even explode.

(3)

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18 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)

Mark scheme · K20 Pressure, Moments and Simple Machines

Question 1

- (a) **B1** B (N/m2) cao
- (a) Answer: **B) N/m2**
- (b) **B1** B (it decreases) cao
- (b) Answer: **B) it decreases**
- (c) **B1** A cao
- (c) Answer: **A) force x perpendicular distance from the pivot**
- (d) **B1** A (scissors) cao
- (d) Answer: **A) a pair of scissors**

Question 2

- **B1** pressure = force / area, oe (allow rearranged forms)
- **B1** unit: pascals (Pa) or N/m2, cao
- Answer: **pressure = force / area, measured in pascals (Pa) or N/m2.**

Question 3

- **M1** pressure = 480 / 3.0
- **A1** = 160 (N/cm2) cao
- **B1** correct unit N/cm2 given with the answer
- Answer: **160 N/cm2**

Question 4

- **B1** 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
- 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 5

- **B1** depth below the surface (pressure increases with depth)
- **B1** density of the liquid (pressure increases with density), oe
- Answer: **The depth below the surface and the density of the liquid.**

Question 6

- **B1** the jet from hole C travels furthest (and the jet from A travels the shortest distance)
- **B1** hole C is at the greatest depth below the water surface
- **B1** pressure increases with depth, so the water pressure (and speed of the jet) is greatest at C, oe
- Answer: **The jet from hole C (nearest the bottom) travels the furthest, because it is at the greatest depth, where the water pressure is highest.**

Question 7

- **B1** 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
- 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.**

Question 8

- **B1** moment = force x perpendicular distance from the pivot, oe
- **B1** unit: newton metres (Nm), cao
- Answer: **moment = force x perpendicular distance from the pivot, measured in newton metres (Nm).**

Question 9

- **M1** moment = 45 x 0.20
- **A1** = 9.0 Nm cao
- Answer: **9.0 Nm**

Question 10

- (a) **B1** the clockwise moment must equal the anticlockwise moment (the total moments about the pivot are balanced), oe
- (a) Answer: **The clockwise moment must equal the anticlockwise moment.**
- (b) **B1** 300 x 1.6 = 480 Nm cao
- (b) Answer: **480 Nm**
- (c) **M1** sets Noah's moment equal to Amelia's moment: 480 x distance = 480
- (c) **A1** distance = 1.0 m cao
- (c) Answer: **1.0 m**

Question 11

- **B1** moment = force x perpendicular distance from the pivot
- **B1** a longer spanner increases the distance from the pivot (the nut) to where the force is applied
- **B1** so for the same applied force, the moment produced is bigger, giving a greater turning effect on the nut, oe
- Answer: **A longer spanner increases the distance from the pivot to where the force is applied. Since moment = force x distance, the same force produces a bigger moment (turning effect) on a longer spanner, making the nut easier to turn.**

Question 12

- **B1** the crowbar is a lever, turning about the pivot (the wooden block)
- **B1** the distance from the pivot to where the person pushes (the far end) is much greater than the distance from the pivot to the slab
- **B1** so a smaller effort force, applied over the larger distance, can produce a moment big enough to overcome the much larger moment of the heavy slab close to the pivot, oe
- Answer: **The crowbar acts as a lever turning about the pivot. Because the effort is applied much further from the pivot than the slab is, a smaller push force there produces a moment large enough to balance and overcome the large moment of the heavy slab close to the pivot.**

Question 13

- **B1** any one of: scissors, wheelbarrow, bottle opener, nutcracker, tweezers, a pair of pliers, a broom, a fishing rod, a see-saw
- **B1** a second correct example from the list above
- **B1** a third correct example from the list above
- Answer: **Any three of: scissors, wheelbarrow, bottle opener, nutcracker, tweezers, pliers, a broom, a fishing rod, a see-saw.**

Question 14

- **B1** 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
- 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 15

- **B1** 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
- 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 16

- (a) **M1** load moment = 5 x 0.20 = 1.0 Nm, so effort x 0.50 = 1.0
- (a) **A1** x = 2.0 N cao
- (a) Answer: **2.0 N**
- (b) **B1** as the distance from the pivot increases, the effort force needed decreases
- (b) **B1** the effort force is inversely proportional to the distance (doubling the distance halves the force needed), oe
- (b) Answer: **As the distance from the pivot increases, the effort force needed decreases; the force is inversely proportional to the distance.**

Question 17

- **B1** heating the gas gives its particles more energy, so they move faster (on average)
- **B1** the faster particles collide with the inside walls of the can more often and with greater force
- **B1** more frequent, harder collisions with the walls increase the pressure inside the can, oe
- Answer: **Heating the gas increases the average speed of its particles, so they collide with the inside walls of the can more often and with greater force, which increases the pressure inside the sealed can.**

Question 18

- **Level 1** (1-2): Simple, isolated statements, e.g. the wheel helps you push it, with little or no reference to moments, pivots or distances.
- **Level 2** (3-4): 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.
- **Level 3** (5-6): 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.
- **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).