

Free-body diagrams and net force problems

AP Physics 1 (algebra-based) · Test answers (mark scheme)

The answers give the expected method and the mark scheme. Follow-through marks apply when an earlier error is carried correctly into later steps.

Level: AP Physics 1 (algebra-based) · **Curriculum:** AP P1 Unit 2

Question 1 Newton's first law (2 marks)

- a. If the net force on an object is zero, its velocity stays constant (at rest or moving in a straight line at steady speed).
- b. The net force is **zero**, because the velocity is constant, so the acceleration is zero.

Marking: (a) 1 mark for the zero net force and constant velocity statement; (b) 1 mark for zero with reason.

Question 2 Net force calculation (3 marks)

- a. $a = 18 \div 6.0 = \mathbf{3.0 \text{ m/s}^2}$.
- b. $F = ma = 900 \times 3.0 = \mathbf{2700 \text{ N}}$.

Marking: (a) 1; (b) 1 for the equation, 1 for the value with unit.

Question 3 Reading a free-body diagram (3 marks)

- a. A = normal force of the floor, B = weight, C = the push, D = friction.
- b. C and D are **equal in magnitude** because the velocity is constant, so the net force is zero. They are not a third-law pair; they act on the same object.

Marking: (a) 2 marks for all four correct (1 for two or three correct); (b) 1 mark.

Question 4 Third-law pairs (2 marks)

- a. The force of the water on her hands, forward.
- b. The force of the water on her hands accelerates her, because it acts on her; the force of her hands on the water acts on the water.

Marking: 1 mark each.

Question 5 Elevator problem (4 marks)

- a. $W = 60 \times 9.81 = \mathbf{589\text{ N}}$.
- b. $mg - N = ma$, so $N = 60 \times (9.81 - 1.5) = \mathbf{499\text{ N}}$.
- c. At constant velocity $N = W = \mathbf{589\text{ N}}$.

Marking: (a) 1; (b) 1 for the equation, 1 for the value; (c) 1.

Question 6 Pulling two blocks (3 marks)

- a. $a = 10 \div (1.5 + 0.50) = \mathbf{5.0\text{ m/s}^2}$.
- b. The string accelerates only the 0.50 kg block: $T = 0.50 \times 5.0 = \mathbf{2.5\text{ N}}$.

Marking: (a) 1; (b) 1 for choosing the 0.50 kg block, 1 for the value.

Question 7 Mass and weight (1 mark)

The **weight changes** (it depends on g , which is smaller on the Moon), but the mass stays the same because it measures the amount of matter.

Marking: 1 mark for the correct quantity with reason.

Question 8 Rocket in empty space (2 marks)

The rocket pushes the exhaust gas backward, so the gas pushes the rocket forward with an equal and opposite force. This forward force on the rocket produces its acceleration, and no outside object is needed to push against.

Marking: 1 for the pair of forces, 1 for the force on the rocket causing acceleration.