

Work, kinetic energy and the net-work theorem

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

Model answers with a marking guide. Give credit for correct methods even when an arithmetic slip follows, and check that every work value carries the right sign and unit.

Level: AP Physics 1 (algebra-based) · **Curriculum:** AP P1 Unit 3

Question 1 Definition and theorem (2 marks)

The net work done on an object equals its change in kinetic energy ($W_{\text{net}} = \Delta K$). $1 \text{ J} = 1 \text{ kg m}^2/\text{s}^2$.

Marking: 1 mark for the theorem, 1 mark for $\text{kg m}^2/\text{s}^2$.

Question 2 Arrow in a target (3 marks)

- a. $K = \frac{1}{2} \times 0.040 \times 55^2 = \mathbf{60.5 \text{ J}}$.
- b. $F = K \div d = 60.5 \div 0.12 = \mathbf{5.0 \times 10^2 \text{ N}}$.
- c. K is four times larger, so $d = 4 \times 0.12 = \mathbf{0.48 \text{ m}}$.

Marking: 1 mark per part.

Question 3 Variable force on a block (4 marks)

- a. Rectangle: $10 \times 3.0 = 30 \text{ J}$; triangle: $\frac{1}{2} \times 2.0 \times 10 = 10 \text{ J}$; total $\mathbf{40 \text{ J}}$.
- b. $\frac{1}{2} m v^2 = 40$, so $v = \sqrt{(2 \times 40 \div 4.0)} = \mathbf{4.5 \text{ m/s}}$.

Marking: (a) 1 for each area; (b) 1 for the theorem, 1 for the value.

Question 4 Hauling firewood (4 marks)

- a. $W = 90 \times 25 \times \cos 30^\circ = \mathbf{1.9 \times 10^3 \text{ J}}$ (1949 J).
- b. $W = -55 \times 25 = \mathbf{-1375 \text{ J}}$.
- c. $W_{\text{net}} = 574 \text{ J}$; $v = \sqrt{(2 \times 574 \div 40)} = \mathbf{5.4 \text{ m/s}}$.

Marking: (a) and (b) 1 mark each; (c) 1 for net work, 1 for the speed.

Question 5 Satellite in orbit (3 marks)

The gravitational force on the satellite always points toward the centre of the circle, while its

displacement over a short time is along the tangent. These directions are perpendicular, so $\cos\theta = 0$ and gravity does no work. With zero net work, the work-energy theorem gives $\Delta K = 0$, so the speed stays constant.

Marking: 1 mark for perpendicular directions, 1 for zero work, 1 for linking to $\Delta K = 0$.

Question 6 Lifting two ways (2 marks)

The work done by gravity is the same in both: $-m g h$, because it depends only on the height change. On the ramp the displacement is longer but only the component along the vertical counts.

Marking: 1 mark for equal work, 1 mark for the justification based on height.

Question 7 Speed scaling (1 mark)

$K \propto v^2$, so the factor is $3^2 = 9$.

Marking: 1 mark.

Question 8 Gradient meaning (1 mark)

The **net force** on the cart, since $\Delta K = F_{\text{net}} d$.

Marking: 1 mark.