

Part A: Mass, Speed, and KE

Answer without a calculator by thinking about $KE = \frac{1}{2}mv^2$.

1. A rolling cart has 200 J of kinetic energy. Find its new kinetic energy if:

- its mass is doubled (same speed)
- its speed is doubled (same mass)
- its speed is tripled (same mass)
- its speed is cut in half (same mass)

a. 400 J. KE is proportional to m , so 2×200 J.

b. 800 J. KE is proportional to v^2 , so $2^2 = 4$ and 4×200 J.

c. 1,800 J. $3^2 = 9$, so 9×200 J.

d. 50 J. $(\frac{1}{2})^2 = \frac{1}{4}$, so $\frac{1}{4} \times 200$ J.

2. Two identical soccer balls roll at 6 m/s, one to the left and one to the right. Which one has more kinetic energy? Can an object ever have negative kinetic energy? Explain both answers.

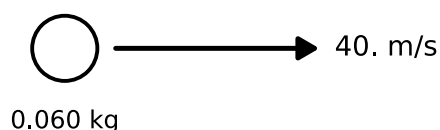
Neither: they have the same KE . KE is a scalar and does not depend on direction.

No: mass is positive and v^2 is never negative, so KE is always zero or positive.

Part B: Calculating KE

Show knowns, equation, substitution with units, and answer.

3. A tennis serve sends the ball across the court as shown. What is the ball's kinetic energy?



Knowns: $m = 0.060$ kg, $v = 40.$ m/s

Equation: $KE = \frac{1}{2}mv^2$

Substitute: $KE = \frac{1}{2}(0.060 \text{ kg})(40. \text{ m/s})^2 = \frac{1}{2}(0.060 \text{ kg})(1,600 \text{ m}^2/\text{s}^2)$

Answer: $KE = 48$ J

4. A bowling ball rolls down the lane at 4.0 m/s with 56 J of kinetic energy. What is its mass?

Knowns: $v = 4.0$ m/s, $KE = 56$ J, $m = ?$

Rearrange: $KE = \frac{1}{2}mv^2$, so $m = 2KE/v^2$

Substitute: $m = 2(56 \text{ J}) / (4.0 \text{ m/s})^2 = 112 \text{ J} / 16 \text{ m}^2/\text{s}^2$

Answer: $m = 7.0$ kg

5. Lucia and her scooter have a combined mass of 50. kg and 900 J of kinetic energy. How fast is she going?

Knowns: $m = 50. \text{ kg}$, $KE = 900 \text{ J}$, $v = ?$

Rearrange: $v = \sqrt{2KE/m}$

Substitute: $v = \sqrt{(2 \times 900 \text{ J} / 50. \text{ kg})} = \sqrt{(36 \text{ m}^2/\text{s}^2)}$

Answer: $v = 6.0 \text{ m/s}$

Part C: The Work-Energy Theorem

Use $W_{\text{net}} = KE_f - KE_i$.

6. A car merges onto a highway, speeding up as shown.



- Find the car's kinetic energy before and after.
- How much net work was done on the car?
- Later, the driver brakes from 15 m/s to a stop. How much net work do the brakes do? Why is the sign negative?

a. $KE_i = \frac{1}{2}(1,200 \text{ kg})(5.0 \text{ m/s})^2 = \mathbf{15,000 \text{ J}}$ $KE_f = \frac{1}{2}(1,200 \text{ kg})(15 \text{ m/s})^2 = \mathbf{135,000 \text{ J}}$ ($1.35 \times 10^5 \text{ J}$)

b. $W_{\text{net}} = KE_f - KE_i = 135,000 \text{ J} - 15,000 \text{ J} = \mathbf{120,000 \text{ J}}$ ($1.2 \times 10^5 \text{ J}$)

c. $W_{\text{net}} = 0 \text{ J} - 135,000 \text{ J} = \mathbf{-135,000 \text{ J}}$ ($-1.35 \times 10^5 \text{ J}$). It is negative because the braking force points opposite the motion, so it takes kinetic energy away.

Speed tripled (5.0 to 15 m/s), so KE grew 9 times.

7. Owen pulls a 40. kg sled that is already sliding at 2.0 m/s. His pull does 240 J of net work on the sled in the direction of motion. What is the sled's new speed?

Initial KE: $KE_i = \frac{1}{2}(40. \text{ kg})(2.0 \text{ m/s})^2 = 80. \text{ J}$

Work-energy theorem: $KE_f = KE_i + W_{\text{net}} = 80. \text{ J} + 240 \text{ J} = 320 \text{ J}$

Solve for speed: $v_f = \sqrt{(2KE_f/m)} = \sqrt{(2 \times 320 \text{ J} / 40. \text{ kg})} = \sqrt{(16 \text{ m}^2/\text{s}^2)}$

Answer: $v_f = 4.0 \text{ m/s}$