Kinetic Energy

Quick Concepts

A. In words, what is kinetic energy?

The energy of MOTION.

B. What is the equation (and therefore the definition) of kinetic energy?

$KE = \frac{1}{2}mv^2$ m = mass of object, v = speed of object

C. What are the units used for kinetic energy?

J (Joules)

D. Is kinetic energy a vector or a scalar? Why?

Scalar. There is no direction involved

E. Can *kinetic energy* ever be negative? Why?

No! Bc mass is only positive and v^2 will always be positive.

Calculations

1. How much kinetic energy does a 65 kg person running at 2 m/s have?

$KE = \frac{1}{2}mv^2$ $KE = \frac{1}{2}(65)(2)^2$ $KE = 130\ J$

2. How fast is a 1500 kg car moving if it has a kinetic energy of 200,000 J?

$KE = \frac{1}{2}mv^2$ $200{,}000 = \frac{1}{2}(1500)v^2$ $v^2 = 266.7$ $v = 16.3\ m/s$

3. What is the mass of something moving at 12 m/s that has a kinetic energy of 1000 J?

$KE = \frac{1}{2}mv^2$ $1000 = \frac{1}{2}m(12)^2$ $m = 13.9\ kg$

4. What is the kinetic energy of a 0.0001 kg bee flying at 5 m/s?

$KE = \frac{1}{2}mv^2$ $KE = \frac{1}{2}(.0001)(5)^2$ $KE = 0.00125\ J$

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5. A 1200 kg car is driving down the road with a speed of 5 m/s.
   a. What is the kinetic energy of the car?

$KE = \frac{1}{2}mv^2$ $KE = \frac{1}{2}(1200)(5)^2$ **$KE = 15{,}000$ J**

   b. If the car gains 50,000 J of kinetic energy, how much kinetic energy would it have?

$15{,}000 + 50{,}000 =$ **$65{,}000$ J**

   c. And so how fast would it then be going?

$KE = \frac{1}{2}mv^2$ $65{,}000 = \frac{1}{2}(1200)v^2$

$v^2 = 108.3$ **$v = 10.4$ m/s**

6. A 3 kg box is sliding along the floor. It has an intial speed of 8 m/s.
   a. How much kinetic energy does it have?

$KE = \frac{1}{2}(3)(8)^2$ **$KE = 96$ J**

   b. If it loses 60 J of kinetic energy, how fast will it be going?

$96 - 60 =$ **36 J**

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

$36 = \frac{1}{2}(3)v^2$

$v^2 = 24$

$v = 4.9$ m/s

7. If you <u>gain</u> kinetic energy, what has to happen to you?

Since you can't change your mass, you would have to speed up

8. If you <u>lose</u> kinetic energy, what has to happen to you?

You have to slow down

9. Both momentum and kinetic energy depend on *mass* and *velocity*.
   a. Is it possible to have a constant kinetic energy, but a changing momentum? Explain.

Yes! Remember momentum is a <u>vector</u>.
Going in a circle with a constant speed would be a constant KE but a changing $\vec{p}$

   b. How about a constant momentum and a changing kinetic energy? Explain.

Nope! If $\vec{p}$ is constant, that means $\vec{v}$ is constant, so KE would also be constant.

Kinetic Energy

10. a. Which has more kinetic energy: a mass of 1 kg moving at 2 m/s or a mass of 2 kg moving at 1 m/s?

① $KE = \frac{1}{2}mv^2$

$KE = \frac{1}{2}(1)(2)^2 = 2\,J$

② $KE = \frac{1}{2}mv^2$

$= \frac{1}{2}(2)(1)^2$

$= 1\,J$

So 1kg @ 2 m/s has more KE.

b. Which has more momentum: a 1 kg object moving at 2 m/s or a 2 kg object moving at 1 m/s?

① $p = mv$

$p = (1)(2) = 2\ kg\,m/s$

② $p = mv$

$p = (2)(1) = 2\ kg\,m/s$

They are the same!

11. Imagine there are two objects traveling in ~~opposite~~ directions. A mass of 5 kg moving at 4 m/s to the left and a mass of 5 kg moving at 4 m/s to the right.

a. What is the total kinetic energy of the two objects?

$K_1 = \frac{1}{2}mv^2$

$= \frac{1}{2}(5)(-4)^2 = 40\,J$

$K_2 = \frac{1}{2}mv^2$

$= \frac{1}{2}(5)(4)^2$

$= 40\,J$

So $40 + 40$

$= 80\,J$

b. What is the total momentum of the two objects?

$p_1 = mv$

$= (5)(-4) = -20\ kg\,m/s$

$p_2 = mv$

$= (5)(4)$

$= 20\ kg\,m/s$

So $(-20) + 20$

$= 0\ kg\cdot m/s$

12. Imagine you are driving down the road with a certain speed.

a. If you double your speed, how much does your kinetic energy change? how about momentum?

Since $KE = \frac{1}{2}mv^2$, if we double the speed we get

$KE = \frac{1}{2}m(2v)^2 = 4\left(\frac{1}{2}mv^2\right)$ So 4x the KE!

momentum see below

b. If you triple your speed, how much does your kinetic energy change? how about momentum?

Likewise $\frac{1}{2}m(3v)^2 = \frac{1}{2}m9v^2 = 9\left(\frac{1}{2}mv^2\right)$

$= 9x$ the KE!

momentum see below

c. If you cut your speed in half, what happens to your kinetic energy? how about momentum?

So $\frac{1}{2}m\left(\frac{1}{2}v\right)^2 = \frac{1}{2}m\frac{1}{4}v^2 = \frac{1}{4}\left(\frac{1}{2}mv^2\right)$

$= \frac{1}{4}$ x the KE!

momentum see below

a) $p = mv$ So $m(2v) = 2mv =$ 2x the momentum

b) and So $m(3v) = 3mv =$ 3x the momentum

c) and $m\left(\frac{1}{2}v\right) = \frac{1}{2}mv =$ half the momentum