ABRHS PHYSICS (H) NAME: KEY

# Work & Kinetic Energy

*Concepts*

A. What is the definition (equation) of *kinetic energy*?

$K = \frac{1}{2}mv^2$ "the energy of motion – will make more sense next week.

B. Is kinetic energy a vector or a scalar? Can it be negative?

Scalar! NO! Always positive.

D. What is the *Work-Kinetic Energy Theorem*?

$\sum W = \Delta K$ The net work done on something equals the change in its kinetic energy.

*Problems*

1. A 100 Newton wind is blowing a 75 kg ice-boarder across a frozen frictionless pond for a distance of 50 meters.
   a. How much work did the wind do on the ice-boarder?

$W = Fd = (100)(50) = \boxed{5000\ J}$

   b. Assuming that the initial velocity of the ice-boarder was 0 m/s, how fast were they going at the end of the 50 meters?

$\sum W = \Delta K$, so $K = 5000J$ so $5000 = \frac{1}{2}(75)v^2$

$v^2 = 1333$

$\boxed{v = 11.5\ m/s}$

2. Betty pushes her physics book (m=2 kg) with a speed of 4 m/s. She lets go, and the book slides to stop in 0.75 meters.
   a. What was the initial kinetic energy of the book?

$K = \frac{1}{2}mv^2$ $K = \frac{1}{2}(2)(4)^2 = \boxed{16J}$

   b. What was the final kinetic energy of the book?

$\frac{1}{2}mv^2 = \frac{1}{2}(2)(0)^2 = \boxed{0J}$

   c. How much "work" did friction do?

$\sum W = \Delta K = K_f - K_i$

$= 0 - 16$

$\boxed{= -16\ J}$

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d. What was the force of friction on the book?

$W = Fd$ $\quad -16 = F(.75)$

$\boxed{F = 21.3\ N}$

3. A 60 kg skier has a kinetic energy of 6750 J at the bottom of a hill, and skids to a stop in a distance of 35 meters.
   a. What was the velocity of the skier just before the skid?

$K = \frac{1}{2}mv^2$ $\quad 6750 = \frac{1}{2}(60)v^2$

$v^2 = 225$ $\quad \boxed{v = 15\ m/s}$

   b. What was the average force of friction on the skier while skidding?

$\Delta K = -6750\ J$ (loses all K) $\quad W = \Delta K = Fd$

$-6750 = F(35)$ $\quad \boxed{F = -193\ N}$

4. You are pulling your 25 kg cousin in a toy wagon with a force of 150 N and at a constant velocity. You pull for a distance of 250 meters.
   a. How much work did you do on your cousin?

$W = Fd = (150)(250)$

$\boxed{W = 37{,}500\ J}$

   b. How much "work" did friction do on your cousin?

Since your cousin didn't gain any kinetic energy $\rightarrow$ "$W_{friction}$" $= \boxed{-37{,}500\ J}$

   c. Why did your cousin gain no kinetic energy?

You did + work, but friction undid all of it. It was canceled by friction.

5. A car has a mass of 1500 kg and a velocity of 20 m/s.
   a. What is the kinetic energy of the car?

$K = \frac{1}{2}mv^2 = \frac{1}{2}(1500)(20)^2 = \boxed{300{,}000\ J}$

   b. If the car gains an additional 400,000 J of kinetic energy, how fast will it be moving?

So $K = 300{,}000 + 400{,}000 = 700{,}000\ J$

$\therefore \quad 700{,}000 = \frac{1}{2}(1500)v^2$

$v^2 = 933$

$\boxed{v = 30.6\ m/s}$

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6. A 1750 kg car is driving down the road with a speed of 15 m/s. The car speeds up through a constant net force of 3500 N over a distance of 75 meters.
   a. What is the initial kinetic energy of the car?

$K = \frac{1}{2}mv^2 = \frac{1}{2}(1750)(15)^2$

$K = 197{,}000\ J$

   b. How much work did the net force do on the car?

$W = Fd = (3500)(75) = 263{,}000\ J$

   c. What is the final kinetic energy of the car?

$197{,}000 + 263{,}000 = 459{,}000\ J$ ← answers to a & b were both rounded up, and their sum rounds down. Don't stress. Saying 460,000 is fine.

   d. What is the final velocity of the car?

$459{,}000 = \frac{1}{2}(1750)v^2$

$v^2 = 525$

$V = 22.9\ m/s$

7. Al is pulling Charlene (m=70 kg) with a force of 25 N for a distance of 20 meters. At the end of the 20 meters, Charlene has a speed of 3 m/s. Assuming that Charlene's initial velocity was 0,
   a. How much work did Al do on Charlene?

$W = Fd = (25)(20) = 500\ J$

   b. What is Charlene's final kinetic energy?

$K = \frac{1}{2}mv^2 = \frac{1}{2}(70)(3)^2 = 315\ J$

   c. Why are your answers to a and b different?

Must have been friction!

   d. How much "work" did friction do?

$\Sigma W = \Delta K$

$500 + W_f = 315$

"$W_f$" $= -185\ J$

   e. What was the average force of friction?

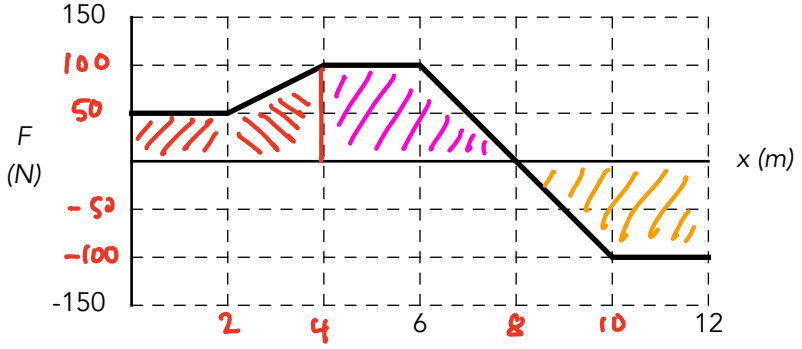
$W = Fd$

$-185 = F(20)$

$F = -9.3\ N$

# Work & Kinetic Energy

8. The net force on a 3 kg object which is initially at rest is shown below.




Notice the symmetry from x = 4 to x=12. So the areas will cancel!

a. How fast is the object moving when it reaches the x = 4 meter position?

W = Area (red above)

$= (50)(2) + \frac{1}{2}(50+100)2 = 100 + 150 = \boxed{250\text{J}}$

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

$250 = \frac{1}{2}(3)v^2$

b. What is the total work done on the object for the 12 meters shown?

Total Work = Total Area

Pink Area $= (100)(2) + \frac{1}{2}(100)2$

$= 200 + 100 = \underline{300\text{ J}}$

Orange Area $= \frac{1}{2}(2)(-100) + (2)(-100)$

$= -100 - 200$

$= \underline{-300\text{ J}}$

So total = 250 + 300 − 300 = 250J

c. What is the fastest the object is moving over the 12 meters shown?

Fastest occurs after MOST work done → ∴ @ x=8!!

So $W = 250 + 300 = \underline{550\text{ J}}$

$\therefore 550 = \frac{1}{2}(3)v^2 \quad v^2 = 367 \quad \boxed{v = 19.1\text{ m/s}}$

*Note: "work" by friction actually should read "mechanical energy dissipated by friction" - this terminology won't make sense until chapter 8.*

*Answers:*

| | | | | |
|---|---|---|---|---|
| *1. a) 5000 J* | *b) 11.5 m/s* | | | |
| *2. a) 16 J* | *b) 0 J* | *c) -16 J* | *d) -21.3 N* | |
| *3. a) 15 m/s* | *b) -193 N* | | | |
| *4. a) 37,500 J* | *b) -37,500 J* | | | |
| *5. a) 300,000 J* | *b) 30.6 m/s* | | | |
| *6. a) 197,000 J* | *b) 263,000 J* | *c) 460,000 J* | *d) 22.9 m/s* | |
| *7. a) 500 J* | *b) 315 J* | *c) friction* | *d) -185 J* | *e) -9.3 N* |
| *8. a) 12.9 m/s* | *b) 250 J* | *c) 19.2 m/s* | | |

rounding error ∴