Physics First I Cycle 5 Lesson 2

OBJECTIVE: Define and Calculate Kinetic Energy

VOCAB: kinetic energy, conservation of energy

CLASSWORK:

p. 80 “Understanding Vocabulary” #5, #8
p. 81 “Reviewing Concepts” #18-20
p. 82 “Solving Problems” #14(a-d), #15
(Hint for #15: for a falling object,
Potential Energy + Kinetic Energy = Constant)

What is Kinetic Energy?

Objects that are moving also have the ability to cause change. Energy of motion is called kinetic energy. A moving billiard ball has kinetic energy because it can hit another object and change its motion.

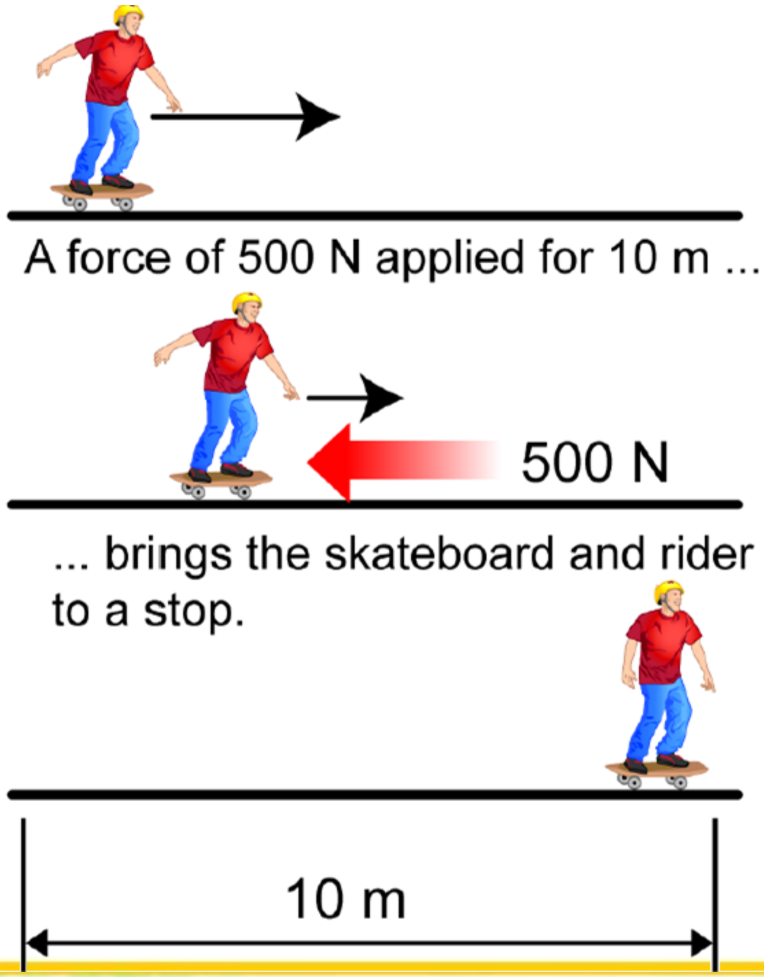
Kinetic energy can easily be converted into potential energy. The kinetic energy of a basketball tossed upward converts into potential energy as the height increases.

At the top of the trajectory, the initial kinetic energy has all become potential energy.

As the ball falls back down, the potential energy becomes kinetic energy again.

Kinetic Energy and Work

Kinetic Energy is the **work** an object can do based on its motion.



Work done = 500 N x 10 m
= 5,000 joules

Therefore ...

The kinetic energy is 5,000 joules because that is the amount of work the skateboard can do as it stops.

Calculating Kinetic Energy

The kinetic energy of a moving object is equal to one half its mass multiplied by the square of its speed.

Remember that 1 Joule = 1 Newton*m = 1 kg*m^2/sec^2 so the units work out. But don't forget the factor of ½!

KINETIC ENERGY

$$E_k = \frac{1}{2} m v^2$$

Kinetic energy (joules) → E_k

Mass (kg) → m

Speed (m/sec) → v

Proof that $E_k = ½ MV^2$ *(not on test but helps you think!)*

A mass M at rest with a force F applied for time T.

The **work** done on this mass must equal **kinetic energy.**

It accelerates at $A = F/M$ for time interval T

Final velocity $V_f = A*T$

Average velocity $V_{AVG} = ½ A*T$

Distance travelled $D = V_{AVG}*T = ½ A*T*T = ½ A*T^2$

$Work = F * D = F * ½ A*T^2$

But remember that $F = MA$ so

$Work = M*A*½*A*T^2 = ½ M*A^2*T^2 = ½ M*(A*T)^2$

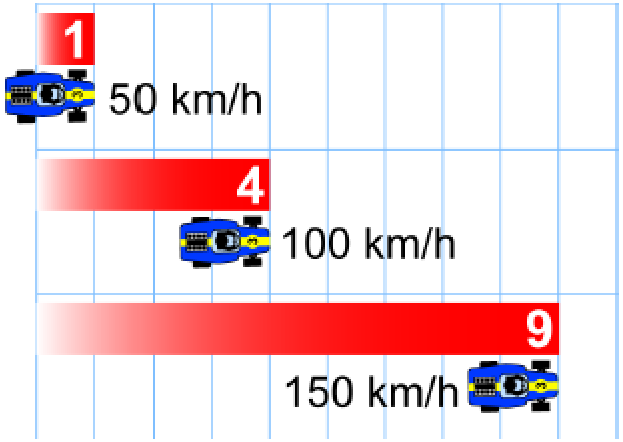
Remember $V_f = A*T$ so $½ M*(A*T)^2 = ½ MV_f^2$

This is the same formula!

Kinetic Energy depends on Velocity^2

Kinetic energy increases as the square of the speed. This means that if you go twice as fast, your energy increases by four times ($2^2 = 4$). If your speed is three times as fast, your energy is nine times bigger ($3^2 = 9$).

Discuss: Why is driving at high speeds dangerous?



Kinetic & Potential Energy of a Falling Object

A 2 kg rock is at the edge of a cliff 20 meters above a lake. It becomes loose and falls toward the water below. Calculate its potential energy when it is at the top, halfway down, and as it hits the water.

Potential Energy @ 20 meters high:

Ep = mgh = 2 kg * 9.8 m/sec^2 * 20 m = 392 J

Potential Energy @ 10 meters high:

Ep = mgh = 2 kg * 9.8 m/sec^2 * 10 m = 196 J

Potential Energy @ 0 meters high:

Ep = mgh = 2 kg * 9.8 m/sec^2 * 20 m = 0 J

A 2 kg rock is at the edge of a cliff 20 meters above a lake. It becomes loose and falls toward the water below. Calculate its kinetic energy when it is at the top, halfway down, and as it hits the water.

K.E. @ 20 meters high: V = 0 so Ek = 0 J

Kinetic Energy @ 10 meters high: we need V!

Fell for 10 m so 10 m = V_{AVG}* T

$V_{AVG} = (V_f + V_i)/2 = (9.8*T)/2 = 4.9*T$

$10\ m = 4.9 * T * T = 4.9 * T^2$

$T^2 = 10/4.9 = 2.041$ $T = \sqrt{2.041} = 1.4286$

$V_f = 9.8\ m/sec^2 * 1.4286\ sec = 14\ m/sec$

$Ek = ½ * 2\ kg * (14\ m/sec)^2 = 196\ J$

A 2 kg rock is at the edge of a cliff 20 meters above a lake. It becomes loose and falls toward the water below. Calculate its kinetic energy when it is at the top, halfway down, and as it hits the water.

K.E. @ 0 meters high:

Fell for 20 m so 20 m = V_{AVG}* T

$V_{AVG} = (V_f + V_i)/2 = (9.8*T)/2 = 4.9*T$

$20 \text{ m} = 4.9 * T * T = 4.9 * T^2$

$T^2 = 20/4.9 = 4.082$ $T = \sqrt{4.082} = 2.0204$ sec

$V_f = 9.8 \text{ m/sec}^2 * 2.0204 \text{ sec} = 19.8 \text{ m/sec}$

$Ek = ½ * 2 \text{ kg} * (19.8 \text{ m/sec})^2 = 392 \text{ J}$

This was a total pain. Is there a shortcut? As you will see, yes! Ek + Ep turns out to be … constant!

Kinetic & Potential Energy of a Falling Object

A 2 kg rock is at the edge of a cliff 20 meters above a lake. It becomes loose and falls toward the water below. Calculate its potential energy when it is at the top, halfway down, and as it hits the water.

Height	Potential Energy	Kinetic Energy
20 m	392 J	0 J
10 m	196 J	196 J
0 m	0 J	392 J

DISCUSS: What is the relationship between potential energy and kinetic energy as this object falls?

CONCLUSION: Total of P.E. and K.E. is always 392 J – it is constant! Potential energy becomes kinetic energy.

The Law of Conservation of Energy

The idea that energy converts from one form into another without a change in the total amount is called **the law of conservation of energy**.

The law states that **energy can never be created or destroyed, just converted from one form into another.**

The law of conservation of energy is one of the most important laws in physics. It applies to not only kinetic and potential energy, but to all forms of energy.

Émilie du Châtelet (1706-1749)

Using Kinetic & Potential Energy to Find Speed

The Top Thrill rollercoaster at Cedar Point begins by lifting a car to a hill 130 m tall. Assuming that the car descends the hill without losing energy to friction, what is the final speed?

What is the potential energy of the car on top of the hill?

$E_p = Mgh = M*9.8\ m/sec^2 * 130\ m = M*1274$

What is the final kinetic energy of the car at the bottom?

The same: M*1274

What is the speed of the car?

$M*1274 = ½*MV^2$

$2548 = V^2$

$V = \sqrt{2548} = 50.5\ m/sec$

DISCUSS: We didn't know the mass of the car or the shape of the track. Did we need to? Why or why not?

Using Kinetic & Potential Energy

A cannon fires a projectile upwards at 50 m/sec. How high does it reach?

What is the kinetic energy of the ball when launched?

$Ek = ½*MV^2 = M*½*50^2 = M*1250$

What is the final potential energy of the ball at the highest point of its trajectory?

The same: M*1250

What is the highest height of the ball?

$M*1250 = MgH = M*9.8\ m/sec^2*H$

$1250 = 9.8\ m/sec^2 * H$

$H = 1250/9.8 = 128\ m$

DISCUSS: Using the free-fall formulas, can you get the same answer? Which is easier?