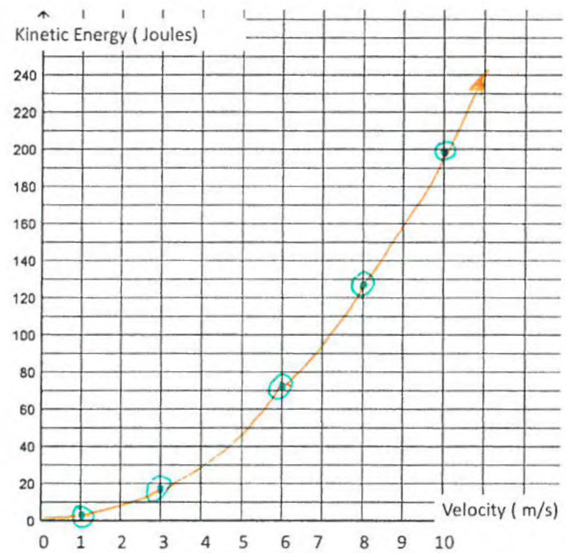
Unit 9: Energy Transformations

Relate kinetic energy to an object's mass and its velocity $E_K = \frac{1}{2}mv^2$

1. **Complete the chart by calculating the Kinetic Energy of a 4 kilogram cart at the velocities listed.**

Velocity (m/s)	Kinetic Energy (Joules)
1	2
3	18
6	72
8	128
10	200



Graph the data at the right.

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

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

$= 2v^2$

Is this a linear or exponential curve? EXPONENTIAL

2. **Refer to the table to answer a and b below.**
   a. **When velocity increases from 3 m/s to 6 m/s, by what FACTOR does velocity change?**
   (3m/s) x 2 **= (6 m/s)**

   b. **When KINETIC ENERGY increases from 18 Joules to 72 Joules, , by what FACTOR does kinetic energy change?**

   (18 J) x 4 **= (72 ~~m/s~~ J)**

$E_K = \frac{1}{2}mv^2$ Use this to explain your answers to a & b above. When velocity ~~is~~ increased by a factor of 2, kinetic energy increased by a factor of 4. Since the velocity is squared in the E_K formula, E_K will increase by a factor of 2^2.

3. Find the kinetic energy of a 2 kg cart moving at 1 m/s.

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

4. Find the kinetic energy of a 2 kg cart moving at 3 m/s.

$E_K = \frac{1}{2}(2)(3)^2 = 9 J$

5. Compare the velocities in #4 & #5: By what FACTOR does the velocity change? V changes by a factor of 3. $(1\frac{m}{s})3 = (3\frac{m}{s})$

6. Compare the kinetic energy from number 4 & 5 above. By what FACTOR does the kinetic energy change?
   E_K changes by a factor of 9. $(1J)9 = (9J)$

7. Use $E_K = \frac{1}{2}mv^2$ to explain how to use changes in velocity (#5) to predict changes in kinetic energy (#6).
   If v changes by a factor of 3, E_K will increase by a factor of $3^2 = 9$. Since v is squared in the E_K formula

8. Find the kinetic energy of a 25 kg cart moving at 2 m/s.

$E_K = \frac{1}{2}(25)(2)^2 = 50J$

9. Find the kinetic energy of a 25 kg cart moving at 4m/s.

$E_K = \frac{1}{2}(25)(4)^2 = 200J$

10. Compare the velocities in #9 & #10: By what FACTOR does the velocity change? V changes by a factor of 2. $(2)2 = (4)$

11. Compare the kinetic energy from number #9 & #10: above. By what FACTOR does the kinetic energy change?
    E_K changes by a factor of 4 $(50J)4 = 200J$

12. Use $E_K = \frac{1}{2}mv^2$ to explain how to use changes in velocity (#10) to predict changes in kinetic energy (#11).
    If v changes by a factor of 2, E_K will change by a factor of $2^2 = 4$.

FINISH THE SENTENCE STEM BELOW TO MAKE A GENERAL RULE ABOUT HOW KINETIC ENERGY WILL CHANGE WHEN VELOCITY CHANGES.

When velocity changes by a factor "x",
Kinetic Energy will change by a factor x^2.

Relate an object's gravitational potential energy to its weight and height relative to the surface of the Earth $E_{GRAV} = mgh$

13. Find the Gravitational Potential Energy of a 3 kg object that is located at a height of 4 meters.

$E_g = (3)(10)(4) = 120J$

14. Find the Gravitational Potential Energy of a 3 kg object that is located at a height of 8 meters.

$E_g = (3)(10)(8) = 240J$

15. Compare the Gravitational Potential energy and the heights from number 14 and 15 above. How does the Gravitational Potential energy change when height doubles?

When h doubled, Eg doubled, too.

16. Find the Gravitational Potential Energy of a 7 kg object that is located at a height of 2 meters.

$E_g = (7)(10)(2) = 140J$

17. Find the Gravitational Potential Energy of a 14 kg object that is located at a height of 2 meters.

$E_g = (14)(10)(2) = 280J$

18. Compare the Gravitational Potential energy and the heights from number 16 and 17 above. How does the Gravitational Potential energy change when mass doubles?

When mass doubled, Eg doubled, too.

CREATE A GENERAL RULE ABOUT HOW GRAVITATIONAL POTENTIAL ENERGY WILL CHANGE WHEN HEIGHT OR MASS CHANGES.

$E_{GRAV} = mgh$

* When height changes by a factor, Eg will change by the same factor.

* When mass changes, by a factor, Eg will change by the same factor.

Determine the Elastic Energy of the situations described below:

$E_{EL} = \frac{1}{2} k x^2$

1. A spring with a spring coefficient of 5.6 N/m (k= 5.6 N/m) is compressed 3 cm. Find the energy stored in the spring. *(Note: all distance units must be in meters so convert cm to meters)*

G:
$k = 5.6 \frac{N}{m}$
$x = 3cm = 0.03m$

U:
E_{EL}

E: $E_{EL} = \frac{1}{2} k x^2$

S/S: $E_K = \frac{1}{2}(5.6)(0.03)^2$

~~= 0.084 J~~

= 0.00252 J

2. 450 Joules of work are done on a spring that compressed 3.7 cm. Find the spring coefficient of the spring. *(Note: all distance units must be in meters so convert cm to meters)*

G:
$E_{EL} = 450 J$
$x = 3.7cm = 0.037m$

U:
$k = ?$

E: $E_{EL} = \frac{1}{2} k x^2$

S/S: $450 = \frac{1}{2}(k)(.037)^2$

$k = 657414 J$

3. If 684 Joules of energy is stored by a spring that has a spring coefficient of 341 N/m, how far is the spring compressed?

G:
$E_{EL} = 684 J$
$k = 341 N/m$

U:
$x = ?$

E: $E_{EL} = \frac{1}{2} k x^2$

S/S: $684 = \frac{1}{2}(341) x^2$

$x^2 = 4.0117$

$x = 2m$

Putting it together:

$E_{EL} = ½\, k\, x^2$ $E_K = \frac{1}{2}mv^2$ $E_{GRAV} = mgh$

1. **A 4kg mass is launched from the ground by a spring. The mass reaches a peak high of 3.7 meters.**
    a. **How much energy was stored in the spring?**
    b. **What is the spring coefficient if the spring is compressed .56 m?**

(A) G:
m = 4 Kg
h = 3.7m

Assumption: $E_{loss} = 0$

U: E_G = ___
E_{EL} = ___

$E_g = mgh = 4 \cdot 10 \cdot 3.7 = 148J$

$E_{EL} = 148J$

(B) G:
$E_{EL} = 148J$
x = .56m
U: k = ?
E: $E_{EL} = \frac{1}{2} k x^2$
$148 = \frac{1}{2} k (.56)^2$
$k = 943.9 \frac{N}{m}$

2. **An 87 kg diver leaves a diving board with an upward velocity of 14.5 m/s. How much elastic energy did the diving board have?**

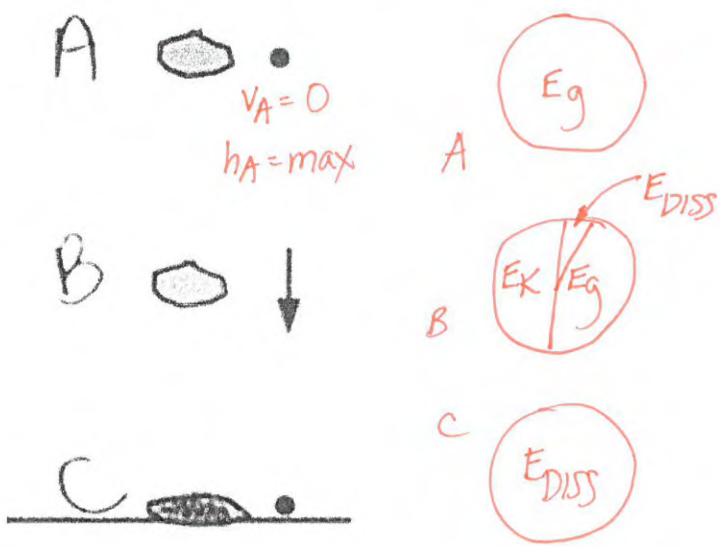
G:
m = 87 kg
V = 14.5 m/s
U: E_K = ___
E_{EL} = ___
E: $E_K = \frac{1}{2} m v^2$
S/S: $E_K = \frac{1}{2}(87)(14.5)^2$
$E_K = 9145.875J$

$E_{EL} = 9145.875J$

Energy Pie Charts

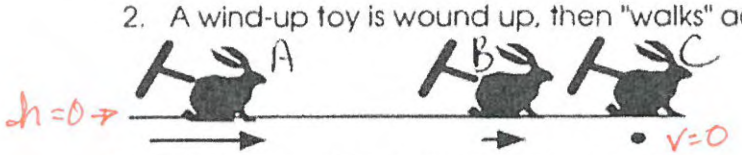
For the lettered locations, please sketch an energy pie chart showing the energy transformations.

1. **A lump of clay is dropped from rest. Position C shows the object just after it has struck the ground and come to a stop. Energy is dissipated to heat and sound as the clay falls.**

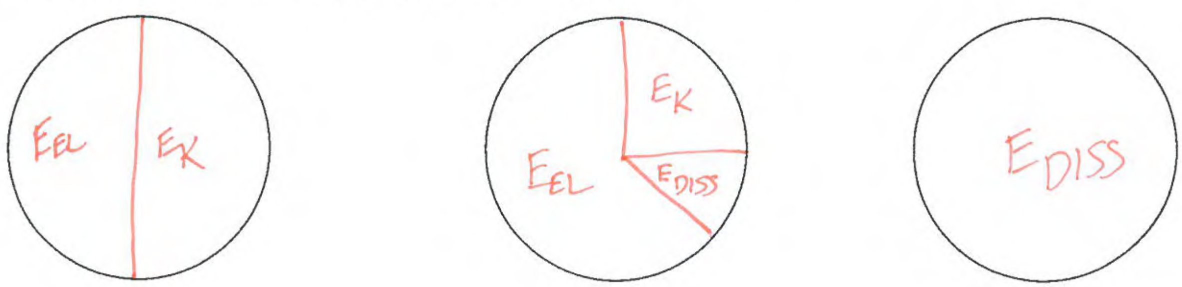


How would pie chart C be different if the directions asked you to show the energy just as it reached the ground but right before it stopped?

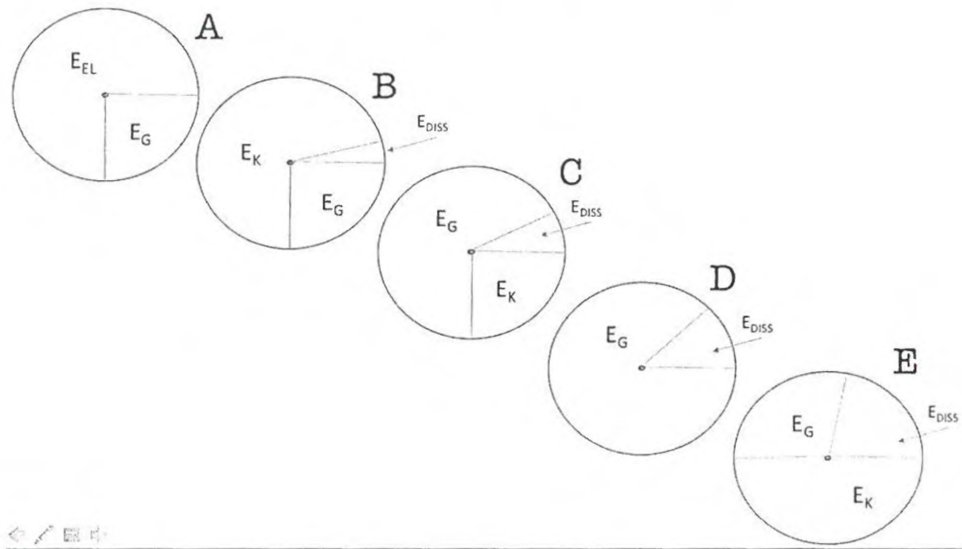
2. A wind-up toy is wound up, then "walks" across a table and comes to a stop.



The vectors underneath the wind-up toy bunny show it's velocity. Since it is a wind-up toy, the initial energy at A is stored in a spring as Elastic Potential energy. Energy is dissipated to heat and sound as the bunny moves. Draw the energy pie charts for positions A, B and C:



2. Use the pie charts below to answer the questions that follow. These pie charts show the energy transfers for a 10 kg ball



A Based on the energy chart, describe what is happening to the ball at A.

The ball is "deformed" and above the ground.

B Which pie chart shows when the ball is moving fastest?

At pie B, the ball is going fastest.

C Does the ball move up or down according to the energy transfers in the pie charts?

It moves up from B to C to D. It falls from D to E.

D What is happening at D?

It is at the highest point.

E Below, make a sketch of the ball's motion based on the pie charts.