GreatHearts Irving

Physics Remote Learning Packet

Please submit scans of written work in Google Classroom at the end of the week.

Week 7: May 11-15, 2020

Course: 11 Physics
Teacher: Miss Weisse natalie.weisse@greatheartsirving.org
Resource: *Miss Weisse's Own Physics Textbook* — new pages found at the end of this packet

Weekly Plan:

Monday, May 11
- ☐ Read *Unit 8 Part 6* of *Miss Weisse's Own Physics Textbook*
- ☐ Complete Worksheet 3 #1-5
- ☐ Email Miss Weisse with Questions and to Ask for Solutions

Tuesday, May 12
- ☐ Read *Unit 8 Part 6* of *Miss Weisse's Own Physics Textbook*
- ☐ Complete Worksheet 3 #6-8
- ☐ Email Miss Weisse with Questions and to Ask for Solutions

Wednesday, May 13
- ☐ Review *Unit 8 Part 6* of *Miss Weisse's Own Physics Textbook*
- ☐ Complete Worksheet 3 #9-10
- ☐ Complete Worksheet 4 #1-2
- ☐ Email Miss Weisse with Questions and to Ask for Solutions

Thursday, May 14
- ☐ Review *Unit 8 Part 6* of *Miss Weisse's Own Physics Textbook*
- ☐ Complete Worksheet 4 #3-4
- ☐ Email Miss Weisse with Questions and to Ask for Solutions

Friday, May 15
- ☐ Attend Office Hours at 9:30 AM! W
- ☐ Turn in your assignments on Google Classroom by the end of the day Sunday May 17.

Statement of Academic Honesty

I affirm that the work completed from the packet is mine and that I completed it independently.

____
Student Signature

I affirm that, to the best of my knowledge, my child completed this work independently

____
Parent Signature

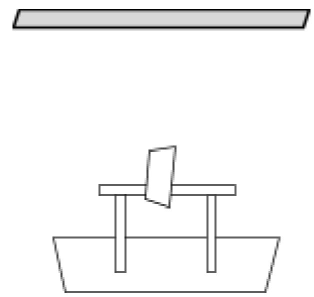
Monday, May 11

- ➔ Read *Unit 8 Part 6* of *Miss Weisse's Own Physics Textbook*
- ➔ Complete Worksheet 3 #1-5 showing all your work.
- ➔ Email Miss Weisse with Questions and to Ask for Solutions

Energy Storage and Transfer Model Worksheet 3 #1-5:
Quantitative Energy Calculations & Energy Conservation

Be careful with units and unit conversions!

1. How much kinetic energy does a 2000 kg SUV traveling 70 mph have? (1 mile = 1600 meters)



2. Consider your 3 kg physics binder resting on the table in your bedroom. Determine the gravitational energy of the earth-book system if the zero reference level is chosen to be:
   a. the table
   b. the floor, 0.68 meters below the book
   c. the ceiling, 2.5 meters above the book

3. A bungee cord stretches 25 meters and has a spring constant of 140 N/m. How much energy is stored in the bungee?

4. How fast does a 50 gram arrow need to travel to have 40 joules of kinetic energy?

5. How much energy is stored when a railroad car spring is compressed 10.0 cm? (The spring requires about 10,000 N to be compressed 3.0 cm.)

Tuesday, May 12

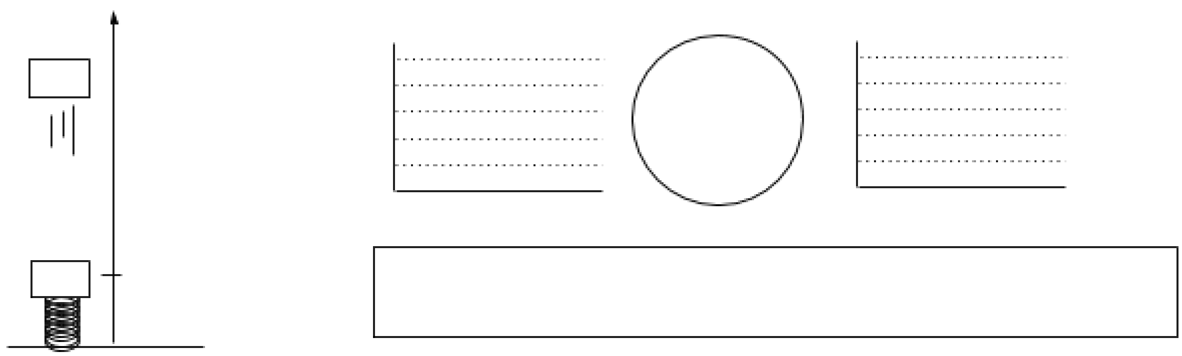
- ➔ Read *Unit 8 Part 6* of *Miss Weisse's Own Physics Textbook*
- ➔ Complete Worksheet 3 #6-8
- ➔ Email Miss Weisse with Questions and to Ask for Solutions

Energy Storage and Transfer Model Worksheet 3 #6-8: Quantitative Energy Calculations & Energy Conservation

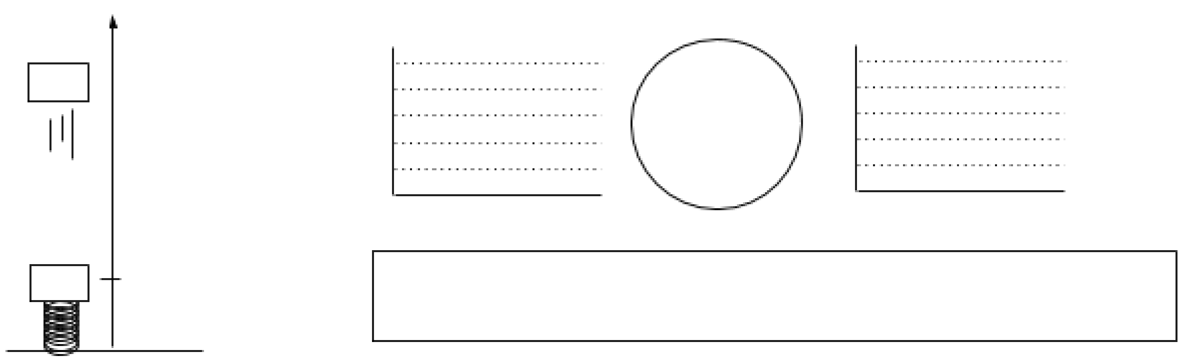
Directions: For each problem,

→ identify what is part of your system inside the circle
→ create bar graphs for the initial (A) and final (B) conditions of the object (don't forget to label your axes!)
→ write an equation for the conservation of energy

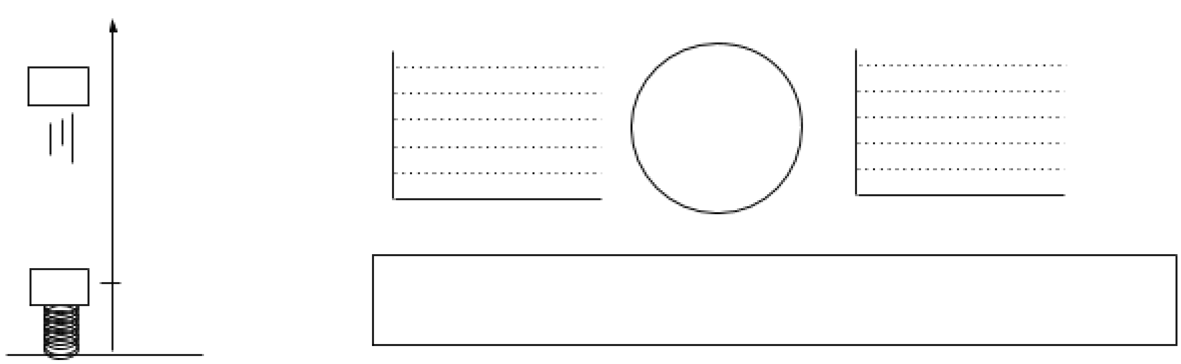
6. A load of bricks rests on a tightly coiled spring and is then launched into the air. Assume a system that includes the spring, the bricks and the earth. Do this problem without friction.



7. Repeat problem 7 with friction.



8. Repeat problem 7 for a system that does not include the spring.



Wednesday, May 13

- ➔ Review *Unit 8 Part 6* of *Miss Weisse's Own Physics Textbook*
- ➔ Complete Worksheet 3 #9-10
- ➔ Complete Worksheet 4 #1-2.
- ➔ Email Miss Weisse with Questions and to Ask for Solutions

Energy Storage and Transfer Model Worksheet 3 #6-8:
Quantitative Energy Calculations & Energy Conservation

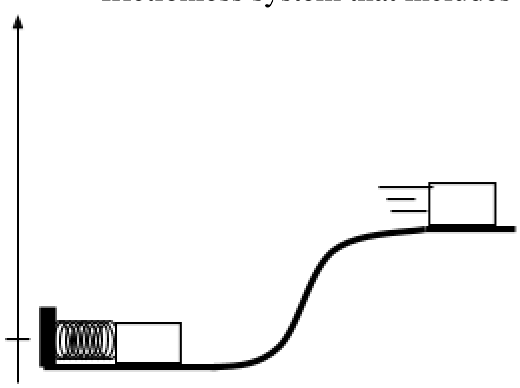
Directions: For each problem,

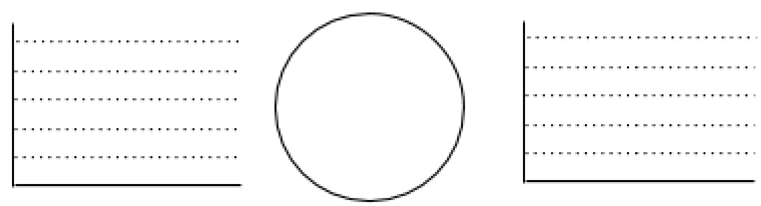
→ identify what is part of your system inside the circle

→ create bar graphs for the initial (A) and final (B) conditions of the object (don't forget to label your axes!)

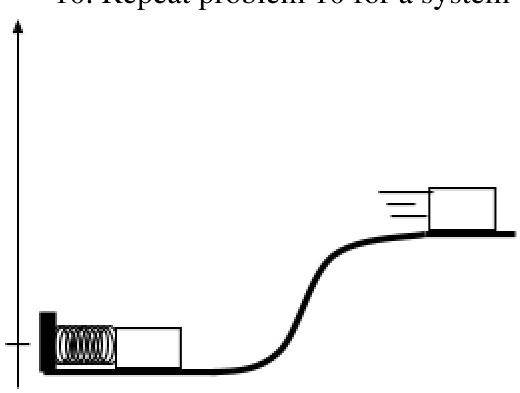
→ write an equation for the conservation of energy

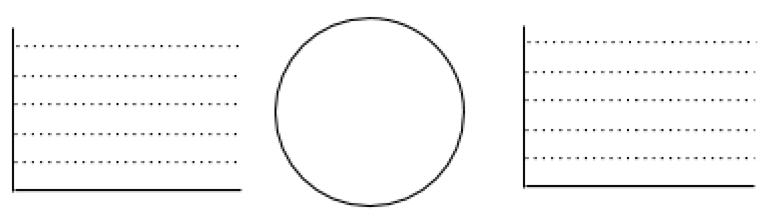
9. A crate is propelled up a hill by a tightly coiled spring. Analyze this situation for a frictionless system that includes the spring, the hill, the crate, and the earth.





10. Repeat problem 10 for a system that does not include the spring and does have friction.

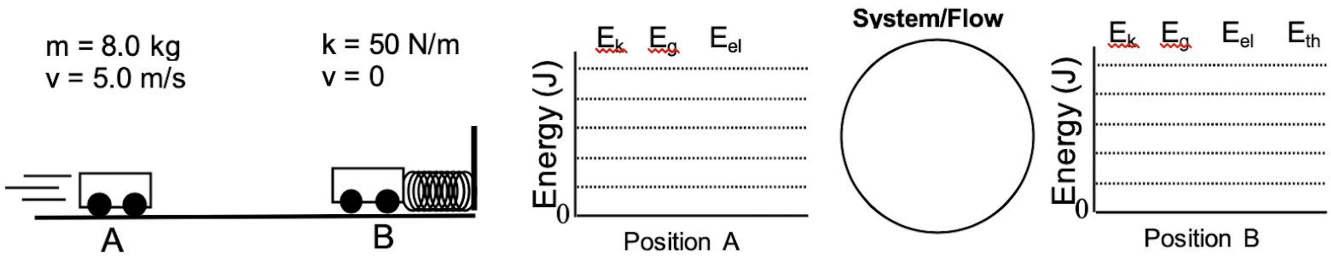




Energy Storage and Transfer Model Worksheet 4 #1-2:

Quantitative Energy Conservation

1. A cart moving at 5.0 m/s collides with a spring. At the instant the cart is motionless, what is the largest amount that the spring could be compressed? Assume no friction.

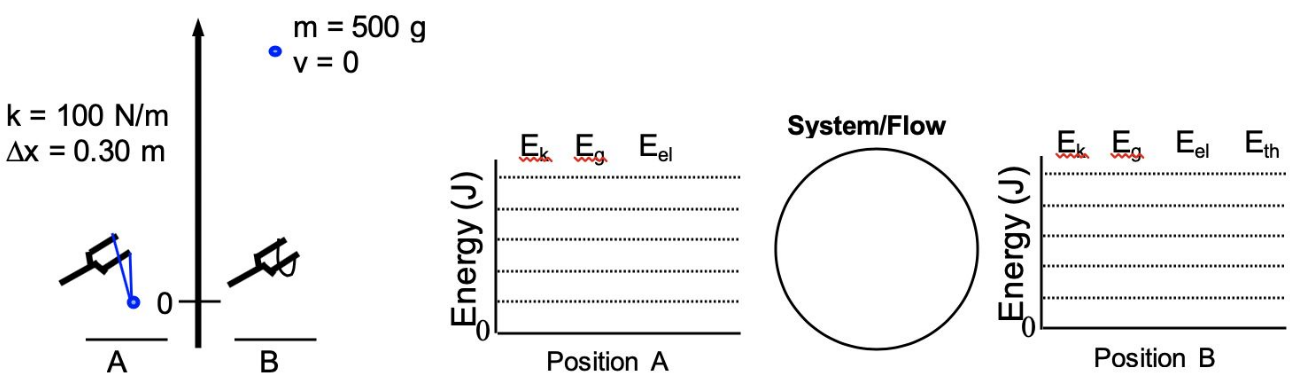


a. Define the system with the energy flow diagram, then complete the energy bar graphs qualitatively.

b. Quantitative Energy Conservation Equation:

c. Determine the maximum compression of the spring.

2. A rock is shot straight up into the air with a slingshot that had been stretched 0.30 m. Assume no air resistance.



a. Qualitatively complete the energy flow diagram and the energy bar graphs.

b. Quantitative Energy Conservation Equation:

c. Determine the greatest height the rock could reach.

Thursday, May 14

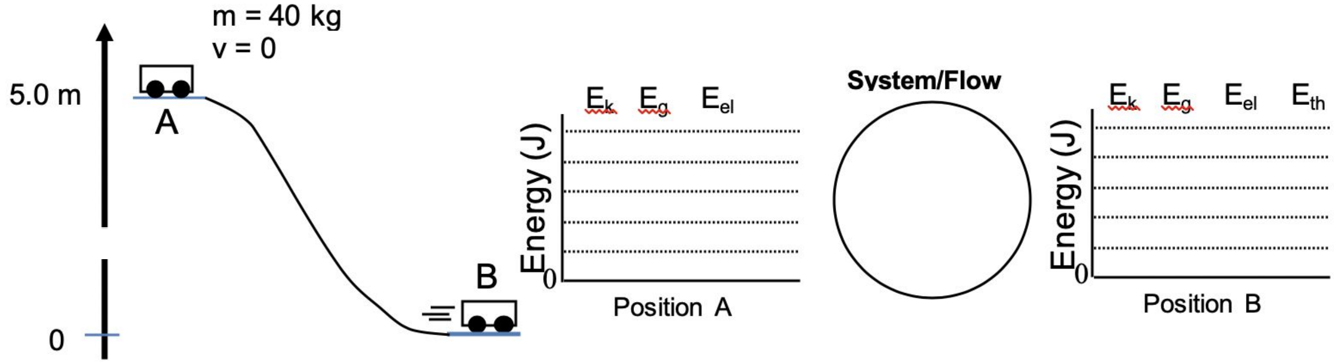
➔ Review *Unit 8 Part 6* of *Miss Weisse's Own Physics Textbook*

➔ Complete Worksheet 4 #3-4

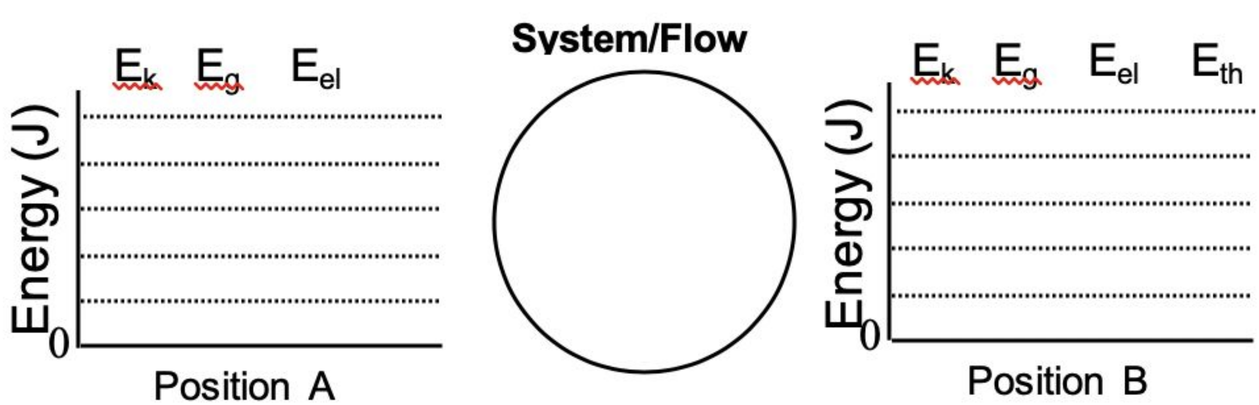
➔ Email Miss Weisse with Questions and to Ask for Solutions

Energy Storage and Transfer Model Worksheet 4 #3-4:
Quantitative Energy Conservation

3. Determine final velocity of the rollercoaster, assuming a 10% loss to friction.



4. The moon could be an ideal spaceport for exploring the solar system. A moon launching system could consist of a magnetic rail gun that shoots items into moon orbit. How much energy would be needed from the rail gun to get a 10,000 kg capsule into an orbit 100 km above the moon surface? The moon's gravitational field strength is 1.6 N/kg and the orbital velocity for this altitude is 1700 m/s. Hint: Put the rail gun outside of the system.



Unit 8 - Energy
Part 7
Conservation of Energy Bar Graphs, Work, and System Flow Diagrams

Conservation of Energy

A few times, now, Conservation of Energy has come up – in the momentum unit, in making energy pie charts, and in justifying our $E_i = E_f$ assumption in the Kinetic Energy versus velocity lab.

As a formal definition

> Energy cannot be created or destroyed in a closed system, but can be altered from one form to another.

It is important to point out the idea of a SYSTEM again. We get to define our system however we want to (or however the problem tells us to). The energy in the system remains constant unless it is an open system which means either

1) something outside the system does WORK on the system

·OR·

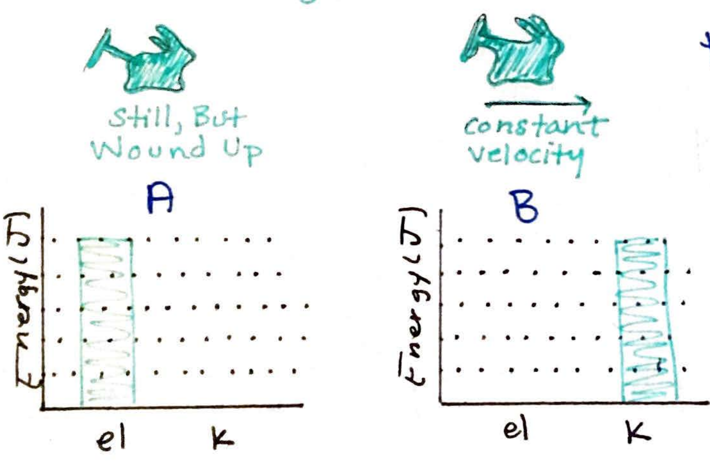
2) the system does WORK on something outside the system

In both of these cases, if we made our system more inclusive, if we made it bigger, energy would be conserved. BUT, by this argument we might find ourselves in the position of saying the universe is our system so nothing is left out and energy has to be conserved... but the math would be a little trickier with some very large sums. Moral of the story - WE LIKE SMALL SYSTEMS.

Energy Bar Graphs

Thus far we have used pie charts to track energy in a system. Now we are going to use bar graphs because bar graphs can be more easily quantified. Let us jump (hop?) into an example with our old friend the wind-up bunny toy.

The wind-up bunny toy is fully wound up and being held at rest at Point A. The toy is let go (on a frictionless surfaces) and at point B we see it is moving at a constant speed. Draws bar graphs tes quantitatively show the conservation of energy.

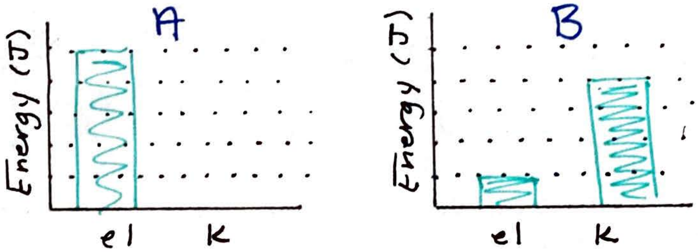


It is important that we define our system. Our system includes the bunny and the frictionless floor.

We can also now write an equation:

$$(E_{el})_A = (E_K)_B$$

Let us change the scenario so that the bunny is still increasing speed at point B. If there is Δspeed, there is acceleration, and if there is acceleration, there is a net Force. It makes sense to assume that net force comes from the elastic force.



notice the sum of all bars at B equal the bars at A

$$(E_{el})_A = (E_{el} + E_K)_B$$

Work & System Flow Diagrams

Earlier in this section it was mentioned that energy is conserved in a system UNLESS WORK is done to or done by the system.

What is WORK?

In non-physics terms, you are doing work right now as you complete your physics assignment. We can think about the work you are doing in two ways. First, you are focusing your energy, using your energy, to think about these concepts. Second, you are accomplishing something; when you finish the assignment something will have changed from before you started the assignment.

The same is true in physics terms. WORK is energy transferred by force.

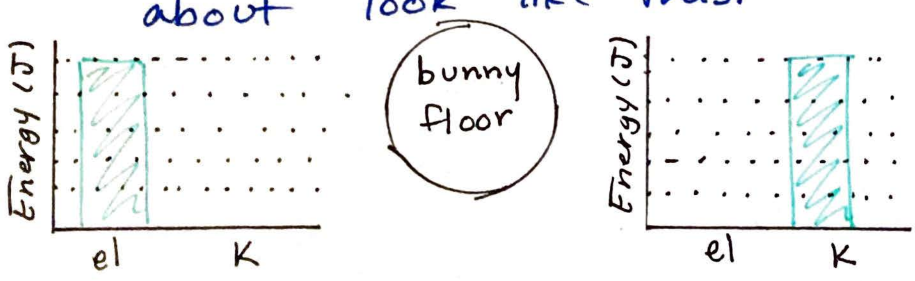
As an equation

$$W = \Delta E$$
$$W = F \cdot d$$

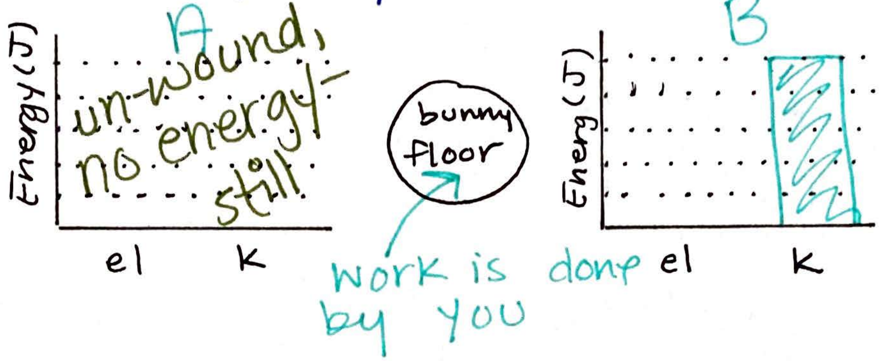
System Flow Diagrams show work being done to or done by a system by showing energy coming into or out of a system.

We draw our system flow diagrams as circles (kind of like our pie charts) and we put in in between two bar graphs showing the conservation of energy. Inside the circle we list everything that is included in the system. If energy is coming into the system between points A and B, we show this with an arrow pointing into the circle (we also want to mark where that energy is coming from/ what is doing the work).

With the System Flow Diagram, the examples we were just thinking about look like this:



Let us change the problem so work is done. The wind-up bunny toy is sitting, unwound on a frictionless surface. You then wind up the bunny and at point B we again see the bunny traveling at a constant speed. But YOU are NOT part of the system.

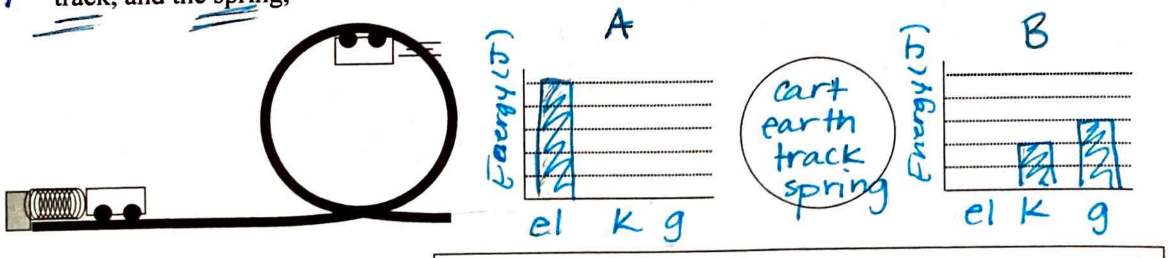


$$W = (E_K)_B$$

Even though the bars of the bar graphs don't add up at points A and B, we are accounting for the energy by showing work was done to the system, therefore adding energy to the system.

Now let us do a bunch of examples.

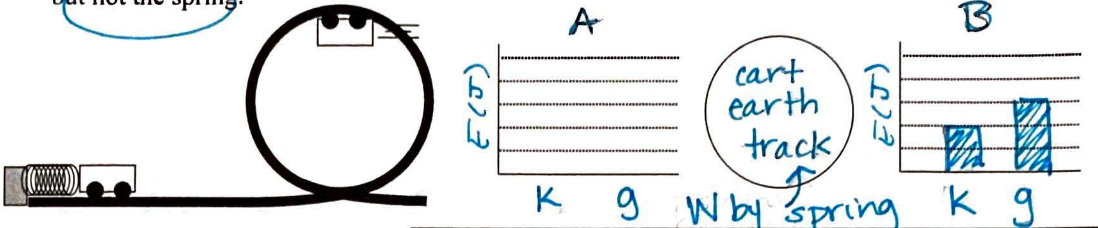
Ex 1a) In the situation shown below, a spring launches a roller coaster cart from rest on a frictionless track into a vertical loop. Assume the system consists of the cart, the earth, the track, and the spring,



$$(E_{el})_A = (E_K + E_g)_B$$

Ex 1b)

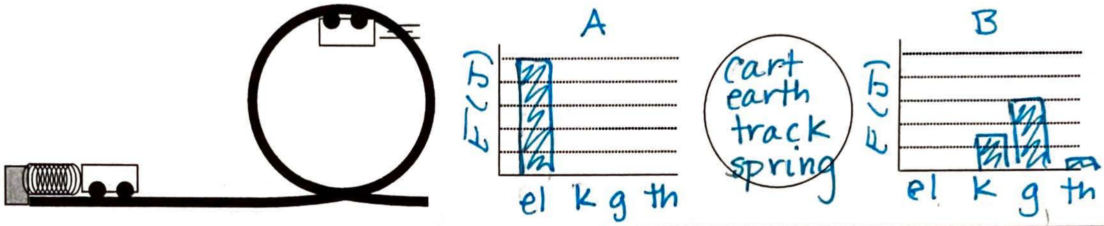
Repeat problem 1a for a frictionless system that includes the cart, the earth, and the track, but not the spring.



$$W_{spring} = (E_K + E_g)_B$$

Ex 1c)

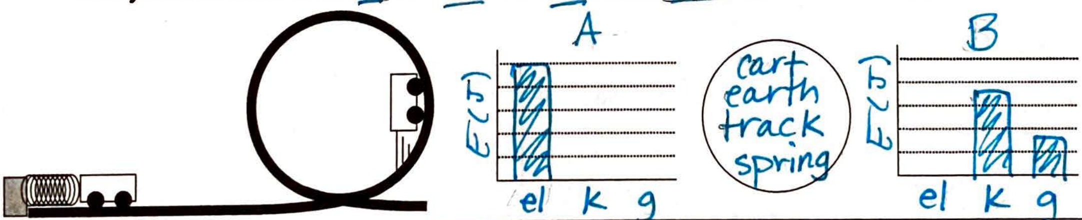
Use the same system as problem 1a, but assume that there is friction between the cart and the track.



$$(E_{el})_A = (E_K + E_g + E_{th})_B$$

Ex 1d)

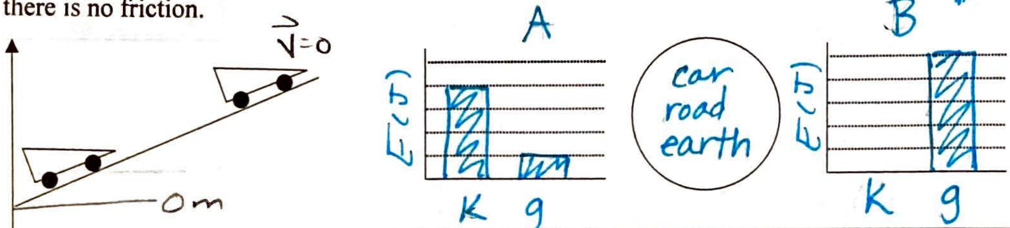
This situation is the same as problem 1a except that the final position of the cart is lower on the track. Make sure your bars are scaled consistently between problem 1a and 1d. Assume the system consists of the cart, the earth, the track, and the spring.



$$(E_{el})_A = (E_K + E_g)_B$$

Ex 2a)

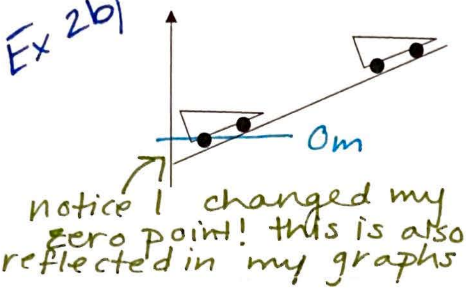
A moving car rolls up a hill until it stops. Do this problem for a system that consists of the car, the road, and the earth. Assume that the engine is turned off, the car is in neutral, and there is no friction. ‖ no force forward

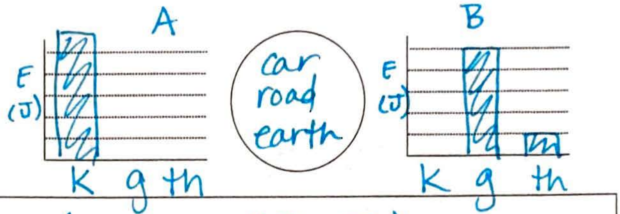


$$(E_K + E_g)_A = (E_g)_B$$

Repeat problem 2a for the same system with friction.

Ex 2b)



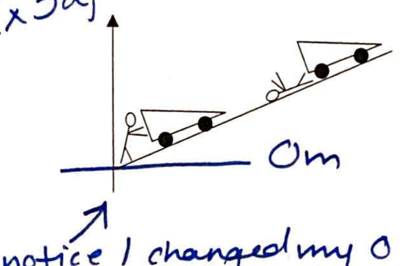


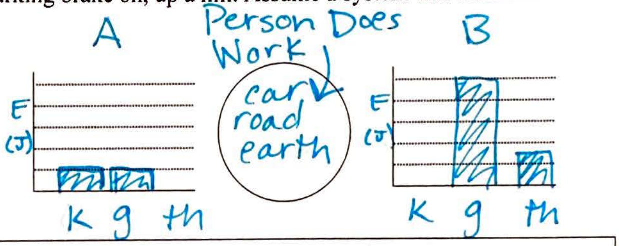
$(E_K)_A = (E_g + E_{th})_B$

In this example compared to example (2a), if the car is going to make it to the same height WITH friction, it must have started with more energy OR work was done on the system.

A person pushes a car, with the parking brake on, up a hill. Assume a system that includes the car, the road, and the earth, but does not include the person.

Ex 3a)





$W_{person} + (E_K + E_g)_A = (E_g + E_{th})_B$

Ex 3b) Let's add numbers to problem 3a. You are pushing a 1500kg car up a hill with a force of 10,000N. The car is initially at a height of 1m and moving at 0.5m/s, and by the time you collapse in exhaustion having pushed the car 3.5m, its final height is 3m and, thanks to that parking break, is at rest. Find the amount of thermal energy in the system at B.

$$W_{person} + (E_K + E_g)_A = (E_g + E_{th})_B$$

$$F \cdot d + \frac{1}{2}mv^2 + mgh = mgh + E_{th}$$

$$(10{,}000N)(3.5m) + \frac{1}{2}(1500kg)(0.5m/s)^2 + (1500)(10)(1m) = (1500)(10)(3m) + E_{th}$$

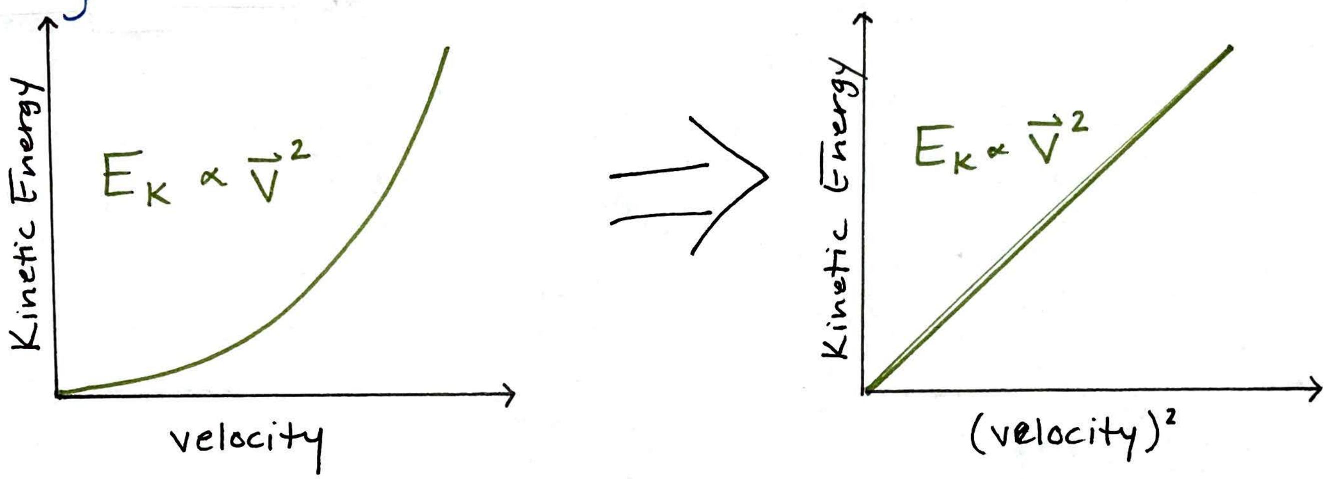
$$3500 + 250 + 15{,}000 = 45{,}000 + E_{th}$$

$$-45{,}000 \qquad 45{,}000$$

$E_{th} = 5{,}187$ J

Unit 8 - Energy
Part 6
Kinetic Energy Post-Lab Discussion

In the kinetic energy versus velocity lab we determined $E_K \propto \vec{V}^2$ and, hopefully, $E_K \propto$ mass. The first relation came from the shape of our graph. The second relation came from the analysis of the slope of the linearized graph. If done correctly, the data would form graphs like below –



The y-intercept being at (or near with the 5% rule) makes sense. If there is no motion, there is no E_K creating that lack of motion.

The slope is more interesting. Let's first consider the units.

$$\text{slope} = \frac{\Delta E_K}{\vec{V}^2} \left(\frac{J}{\left(\frac{m}{s}\right)^2} \right)$$

we know a $(J) = N \cdot m$

$$= \frac{kg \cdot m}{s^2} \cdot m$$

$$= \left(\frac{kg \cdot m^2}{s^2} \right)$$

$$\Rightarrow \left(\frac{\left(\frac{kg \cdot m^2}{s^2}\right)}{\left(\frac{m}{s}\right)^2} \right)$$

$$\Rightarrow \frac{kg \cdot m^2}{s^2} \cdot \frac{s^2}{m^2}$$

$$\boxed{\Rightarrow kg}$$

THE UNIT OF SLOPE IS <u>KILOGRAMS</u>!

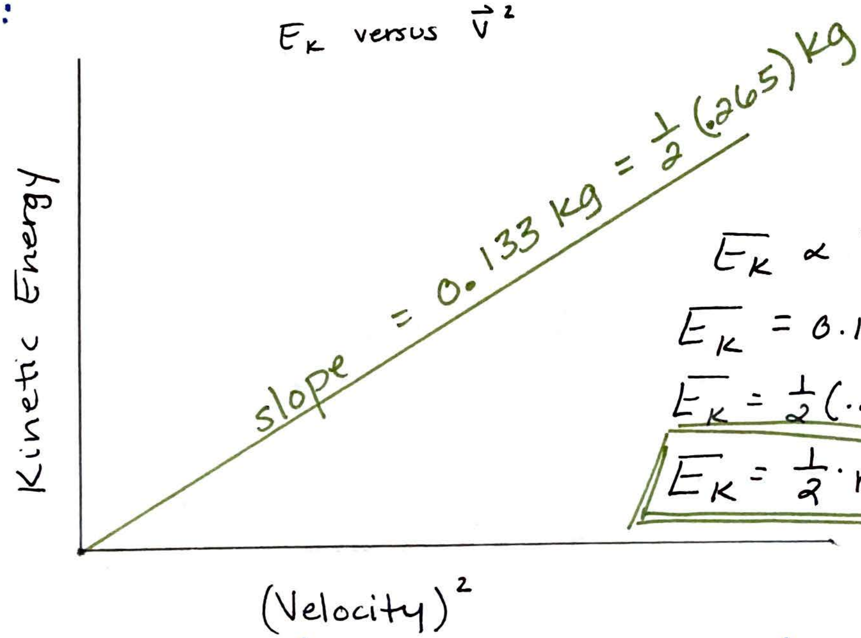
Since the unit of slope is kilograms it only makes sense that the slope is mass! If the slope is mass, is it the mass of our buggy?

* I have a confession to make. I was quickly making measurements and being very sloppy - I was eyeballing the heights, measuring to the back wheel at the top of the ramp and measuring to the front wheel at the bottom of our ramp, and, well,

OUR DATA IS BAD!

From our data, it does seem to be pretty close to the mass of our buggy... but it is supposed to be $\frac{1}{2}$(mass of the buggy).

So let's just say our linearized graph looks like this:



$$E_K \propto \vec{v}^2$$

$$E_K = 0.133 \cdot \vec{v}^2$$

$$E_K = \frac{1}{2}(.265) \cdot \vec{v}^2$$

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

Kinetic Energy = $\frac{1}{2}$(mass)(velocity^2).

It should not actually be very surprising that mass is part of the kinetic energy equation, we already knew it was part of the gravitational potential energy equation.

Now we know two equations to calculate different types of energies.

$$E_g = mgh$$
$$E_K = \frac{1}{2}mv^2$$

Side Note

Without getting too mathy – when you multiply two vector quantities the output is a scalar quantity (a number WITHOUT direction). For both of these energy calculations we have two vectors multiplied together:

$\vec{g} \cdot \vec{h}$ and $\vec{v} \cdot \vec{v}$.

Therefore, E_g and E_K are both scalars (they do not have direction) even though they are calculated with vectors.