MR. JOHN SAINS.

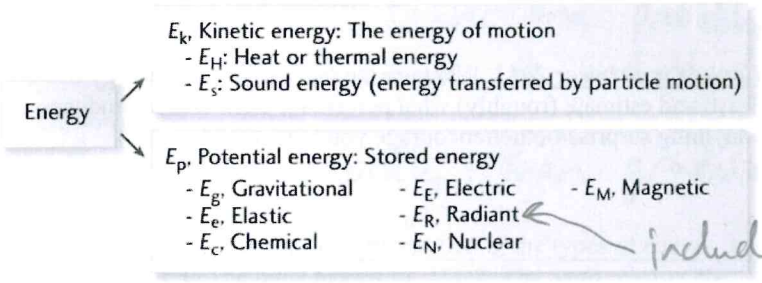
Energy – An introduction

This link (https://bit.ly/343Lgsp) can be useful. We group energy into two broad categories:

potential energy: is stored, and might not be being used right now

kinetic energy: energy associated with motion/movement

Within these broad categories there are more specific types of energy…



Use the following resource to identify one or two examples of each type of energy.

Thermal/heat/sound (K): boiling water, whistling kettle	Gravitational (P): waterfalls @ top, book on shelf
Elastic (P): elastic band, spring	Chemical (P): unlit match, sandwich, gas
Electric (P): clothing sticking after drying	Magnetic (P): fridge magnet
Radiant (P): sun's rays	Nuclear (P): inside nucleus of atoms

Using various technologies, we are able to transform energy from one form to another. For example, a hydroelectric damn:
Kinetic energy of water → electrical energy

For each of the following processes, identify the energy transformations that are taking place. Note that there can be multiple transformations, or multiple types of energy produced.

a) A match is burning chemical → thermal	b) A gas lawnmower cuts the grass chemical → kinetic
c) A computer electric →	d) A hairdryer electric → kinetic + thermal
e) A battery powered flashlight chemical → electric → radiant (light)	f) A wind turbine kinetic → electric
g) A bow and arrow shoots an arrow elastic → kinetic	h) A nuclear bomb explodes nuclear → thermal + radiant
i) A wrecking ball demolishes a house potential → kinetic	j) Solar panels power signs on the highway radiant → electrical → radiant (light)
k) A gas furnace heats your home chemical → thermal	l) Someone jumps on a trampoline potential → kinetic → elastic → kin → pot.

Unfortunately, when we transform energy from one form to another the transformation is not perfect. Some of our input energy gets transformed into other unneeded/undesired/unusable forms of energy, and is essentially wasted.

Tracking Energy

Energy is a mysterious quantity. If we can find where energy is hidden and how much is there, it becomes a very powerful tool for understanding our universe.

A: The Pullback Car

Your teacher will demonstrate the motion of ***a pullback car***.

1. **Reason.** Two identical carts are moving: one fast and the other slow. Which one has more energy? Describe what you could measure to help decide. faster one probably has more energy, but its mass is probably important too.

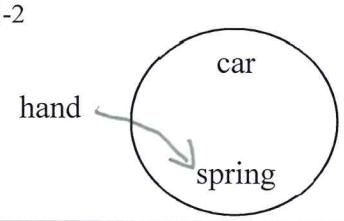
2. **Observe.** The car will be pulled back and let go. Describe the motion of the car. Accelerates rapidly, then gradually slows down.

3. **Interpret.** Complete the chart below listing the types of energy the car has at each moment in time.

Events	1. The hand begins to pull back on the car	2. The hand releases the car	3. The car reaches its top speed	4. The car stops
Type of Energy (P/K/None)	Neither	potential	kinetic	Neither
Evidence	no motion, no stored energy	starts moving	I see motion	No motion, no stored energy.

Energy Flow Diagram. An *energy flow diagram* shows the movement of energy between different objects. Only write the names of objects that interact and participate in a flow of energy. Circle the objects that are part of the *system*. Draw arrows between objects to show the flow of energy. Objects outside the system are in the *environment*.

4. **Interpret**. Complete the chart below showing the transfers of energy for each interval.

1-2	2-3	3-4
		

5. **Describe**. During interval 1-2, there are three objects that might participate in a flow of energy: the hand, the spring (inside the car) and the car (the rest of the cart). According to the energy flow diagram shown:
   (a) Which objects are system objects? Which are environment objects?

   car, spring → hand

   (b) Which object is gaining energy? Which is losing energy? Draw an arrow showing the transfer of energy.

   Spring gaining energy from hand

6. **Describe.** During the interval 3-4 (event 3 the car reaches its top speed and event 4 the car comes to rest):
   (a) Describe the movement of the car.

   Gradually slows down

   (b) What is happening to the amount of kinetic energy? Where did the kinetic energy go? What could we measure to help find the "missing" energy?

   → to the world, in the form of kinetic energy (vibrations, heat, sound)

Thermal Energy. Energy can be stored in the random vibrations of an object's atoms, which we perceive at *thermal* energy. This often happens when surfaces are rubbing against one another and interact through friction.

The Idea of the Conservation of Energy. Energy cannot be destroyed and energy can't be created. This powerful idea is called the *conservation of energy*.

B: Going Up the Hill

Your teacher has a cart set up at the bottom end of an inclined track. It has a built-in spring that is initially compressed. There are three events: (1) the cart begins to move (the spring begins to expand), (2) the spring is fully expanded, and (3) the cart reaches its highest point on the track. We will assume that the force of friction on the cart is zero.

1. **Represent and Explain.** Draw an energy flow diagram for interval 1-2. Describe any energy transfers or flows.

Potential energy of spring becomes kinetic energy of car.

1-2

2. **Reason.** During interval 2-3, how is the amount kinetic energy changing? Are any other characteristics of the cart changing?

↳ decreasing, since car slowing down

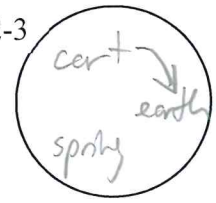
↳ its height/elevation.

Gravitational Energy. Gravitational energy is stored energy that exists due to the gravitational interaction with Earth. This energy exists in the Earth-object system. Therefore, we always include Earth as part of the system.

3. **Represent and Explain.** Draw an energy flow diagram for interval 2-3. **System = cart, spring, Earth.** Describe any energy transfers or flows.

Kinetic energy of car becomes potential energy of earth-object system

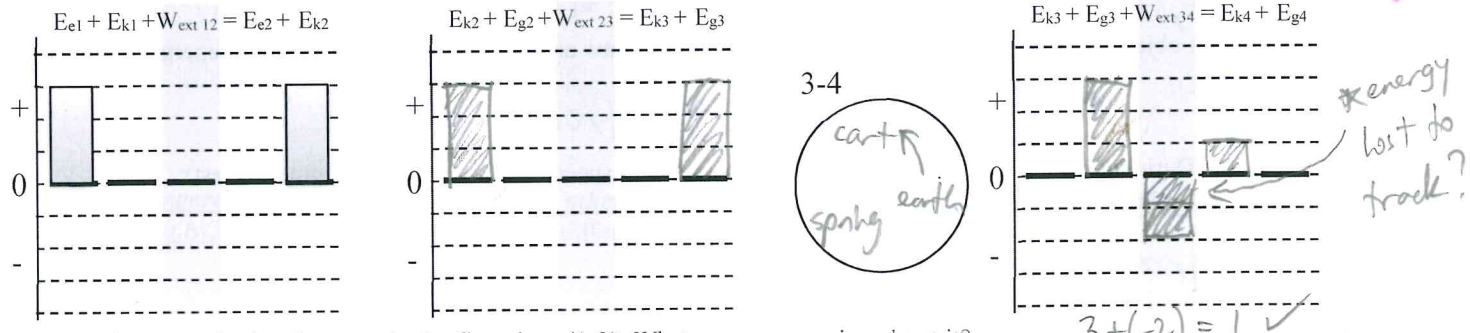
2-3



Energy Bar Chart. An *energy bar chart* uses a bar graph to show the relative amount of energy stored in the system objects at two moments in time. The height of the bars is usually not important as long as the bars clearly show the right energy ideas. The middle bar in the chart, W_{ext}, represents the energy flow into or out of the system during the interval of time. Each energy symbol uses a subscript to indicate how the energy is stored.

Label	Storage Mechanism	Measureable Characteristic
Kinetic (k)	Movement	speed
Thermal (th)	Vibration of microscopic particles	temperature
Gravitational (g)	The gravitational interaction between Earth and the object (the *field*)	vertical position
Elastic (e)	Stretching or deforming an object	length
Chemical (c)	The chemical bonds between particles	number of bonds/molecules

4. **Interpret.** Complete the energy bar charts for each interval. Event 4 is when the cart returns to the bottom of the incline.



5. There is no gravitational energy in the first chart (1-2). What are we assuming about it?

That starting height of car is reference point (no potential)

6. Based on the diagrams, how does the speed of the cart at moment 4 compare to the speed at moment 2.

Not travelling as quickly.

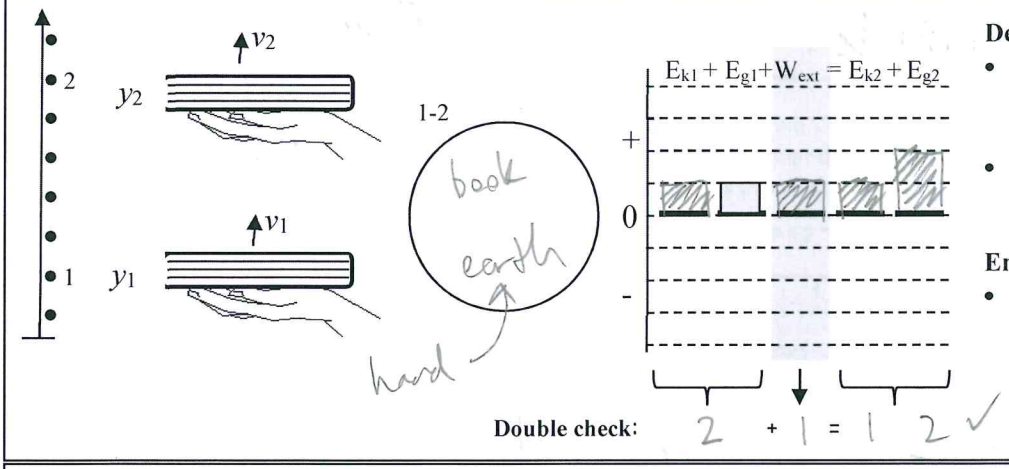
Homework: Tracking Energy — Name:

Energy Thinking Process: To track energy, we must answer two important questions:

(1) **Which characteristics of the system are changing?** Start by deciding whether characteristics like the object's *speed* or vertical position is changing. This helps you decide which energies increase, decrease, or stay the same and draw the bar chart. Double check the bar chart math!

(2) **Is energy flowing in or out of the system?** Are there any objects in the environment that are adding energy to or removing energy from the system? Then you are ready to draw the arrows showing the energy flows.

Represent and Explain. You are moving a book with your hand. Three different situations are shown below. For each, complete an energy flow diagram and bar chart. **System = book, Earth**. For each situation, describe the characteristics that are changing and any energy flows. Complete the bar chart double-check; after you count the number of block in each section, the equation at the top should make sense.



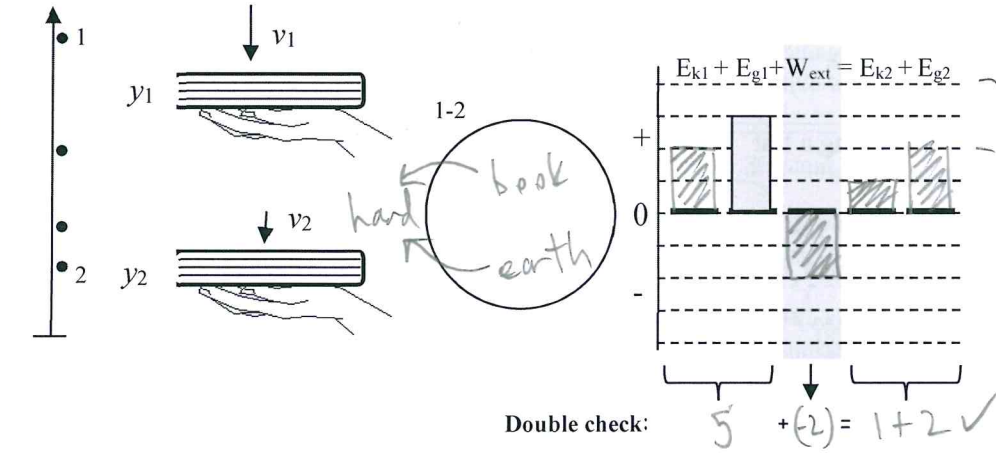
Describe changes:

- The velocity is constant, so E_k stays the same
- The book is going up, so E_g increases

Energy flow:

- Energy flows in because of the hand

Double check: 2 + 1 = 1 2 ✓



Describe changes:

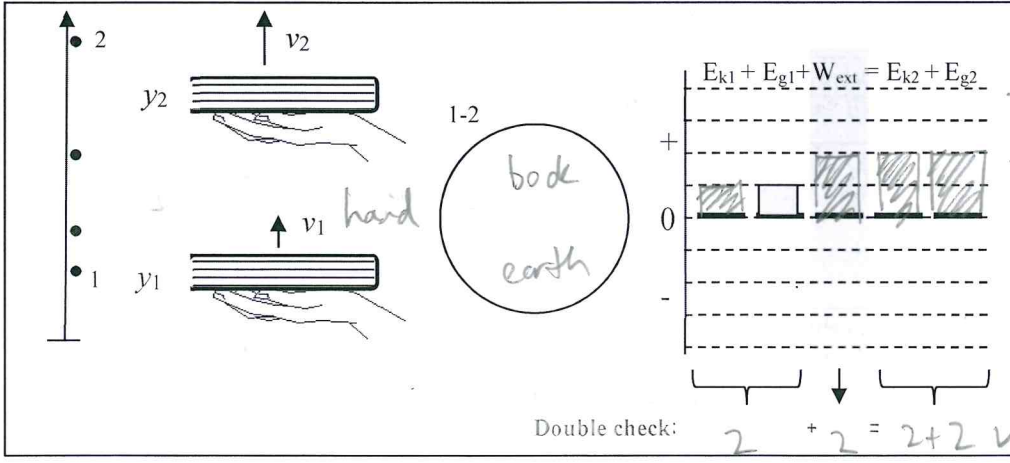
-Vel decreases, so E_k ↓

- height decreases, so E_G ↓

Energy flows:

out of system, into hand

Double check: 5 + (-2) = 1+2 ✓



Describe changes:

-vel ↑, so E_K ↑

- height ↑, so E_G ↑

Energy flows:

From hand, into system

Double check: 2 + 2 = 2+2 ✓

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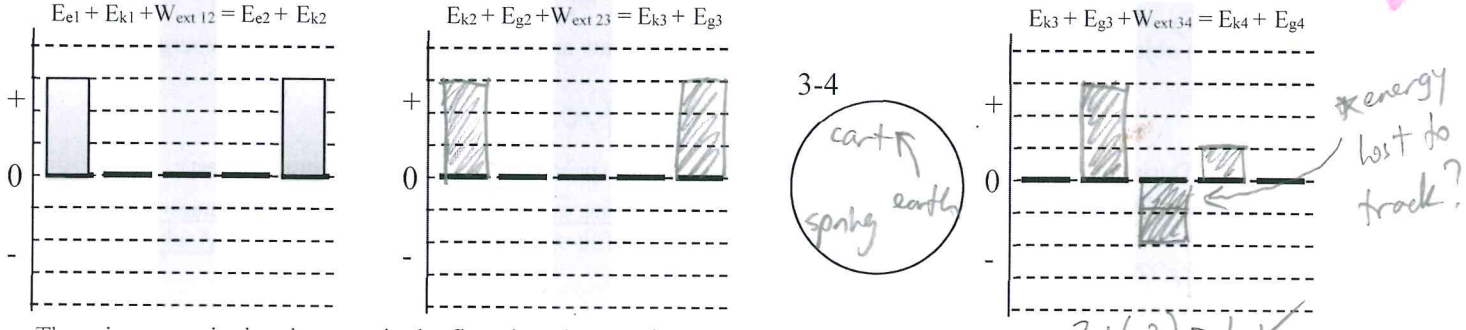

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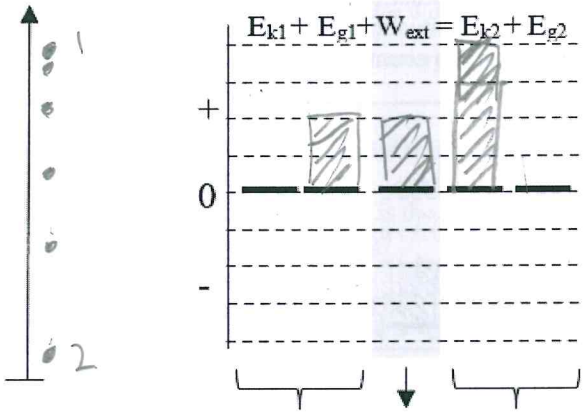
Not travelling as quickly.

$3 + (-2) = 1$ ✓

Tracking Energy Homework

For each description, complete the energy bar chart and motion diagram, then identify the energy transformations that occur.

a) A car starts from rest at the top of a hill, and the driver accelerates going down the hill

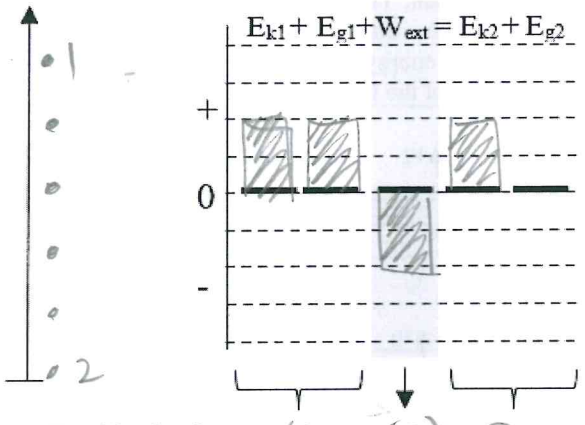


Double check: 2 + 2 = 4

External Energy Transformations ...

chemical → kinetic (gas)

b) A parachute glides smoothly to the ground at constant velocity.

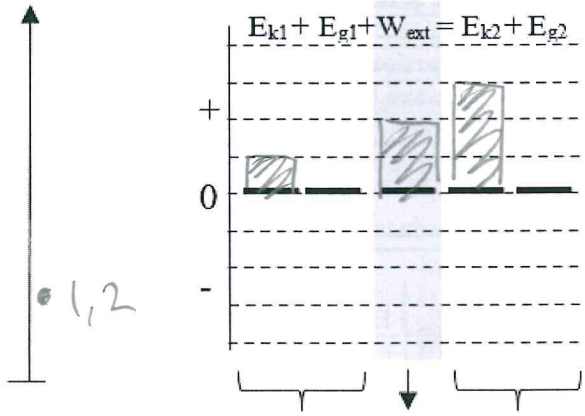


Double check: 4 + (-2) = 2

External Energy Transformations ...

potential (parachute) → kinetic (air molecules)

c) A race car accelerates quickly along a flat race track

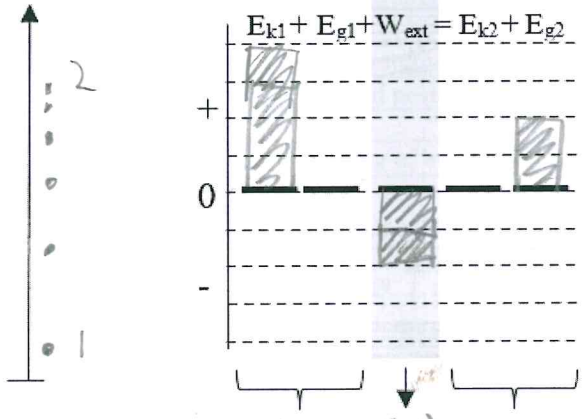


Double check: 1 + 2 = 3

External Energy Transformations ...

chemical → kinetic (gas)

d) A cannonball is shot upwards and smashes through a castle wall



Double check: 4 + (-2) = 2

External Energy Transformations ...

kinetic (cannonball) → kinetic, thermal (castle wall)