Thursday Oct 2nd

SIT WITH YOUR GROUP TODAY!

TOPIC # 8 Part II –LAWS OF THERMODYNAMICS & MOTION

TEST #2 is NEXT TUESDAY Oct 7th

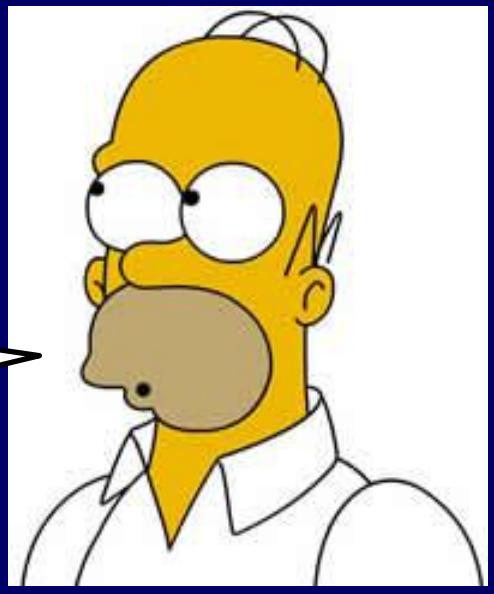
The "Top 10" is now posted in D2L under Study Guides and Quick Links

A Study Session will be held from
4:30 – 5:30 pm Monday Oct 6th

The MIDTERM EXAM is 2 weeks from today on
Thursday Oct 16th
(a complete study guide will be provided)

Ready for some more SCIENCE Homer?

**Alright brain,
you don't like me
and I don't like you;
but let's get through this
and I can get back
to killing you
with beer!**



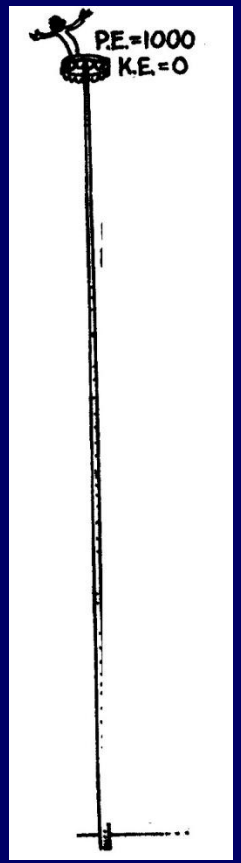
Homer gives his brain a pep talk

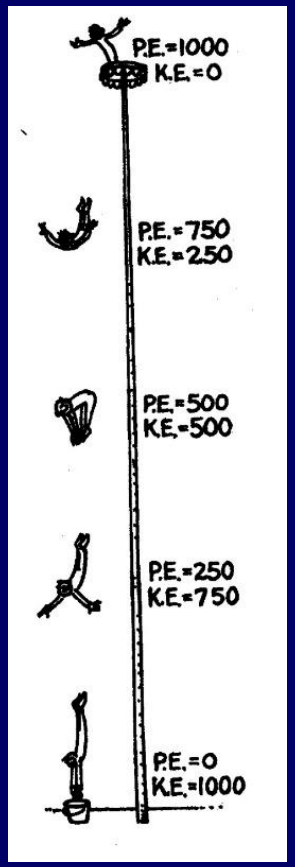
Disclaimer: Homer's approach to learning science is not endorsed by Dr H!

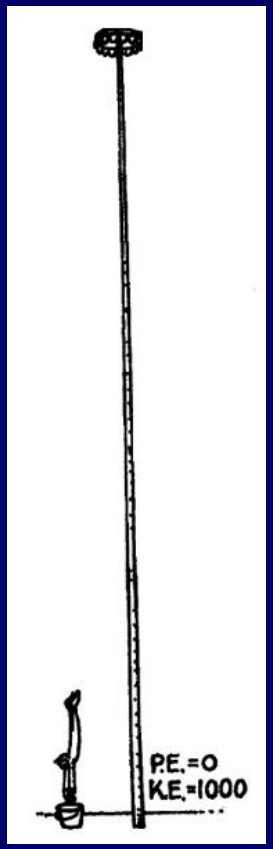
THE LAWS!

"Everything that happens can be described as energy transformations"

(A repeat quote: was discussed earlier under ENERGY (p 22)







THE FIRST LAW OF THERMODYNAMICS

(It's the same as the "Law of Conservation of Energy")

Energy can be transformed
(changed from one form to another),
but the **TOTAL AMOUNT**
always remains the same.

PART D – The Laws Of Thermodynamics

Whoops! Homer just dropped his Global Change textbook . . .

The falling book
illustrates
The 1st Law of Thermodynamics
which is also known as
The Law of Conservation of Energy

HOW???

PART D – The Laws Of Thermodynamics

Gravitational Potential Energy (GravE)

Has potential energy due to its elevated position

Kinetic Energy (KinE)

Converts to energy of motion as it falls

Also jiggles the air molecules as it falls through the air

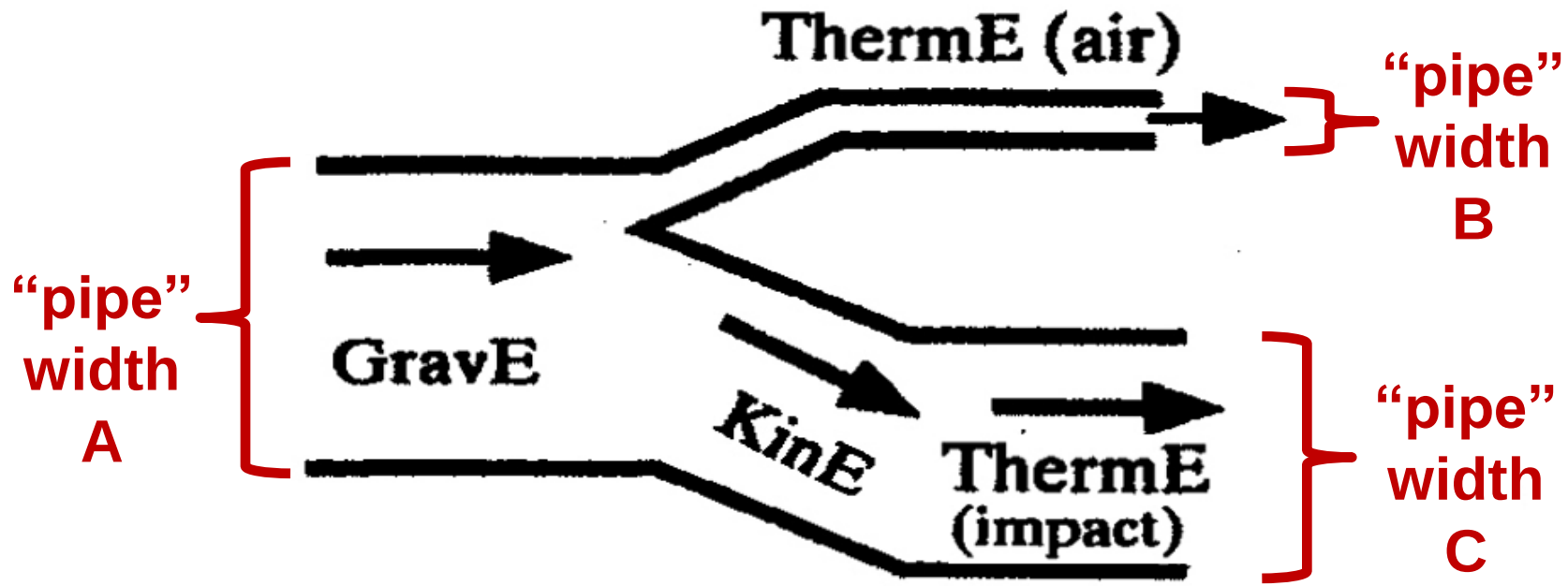
Thermal Energy (ThermE)

Converts to thermal energy on impact by jiggling the molecules of the floor it hits

➔ *slight increase in temperature*

An "Energy Flow Diagram"

Energy flow for a falling book, with air resistance.



Width A = Width B + Width C

1st Law of Thermodynamics!

FIRST LAW OF THERMODYNAMICS

(another way of saying it)

In an isolated system
the <u>total amount of energy</u>
(including heat energy)
is
<u>CONSERVED</u>,

although energy may change from one form to another over and over again.

THE SECOND LAW OF THERMODYNAMICS

There are 3 different ways
to state or describe this Law . . . .

1st way to state it: **as the "Law of Heating"**

Heat will not flow spontaneously from a cold to a hot body

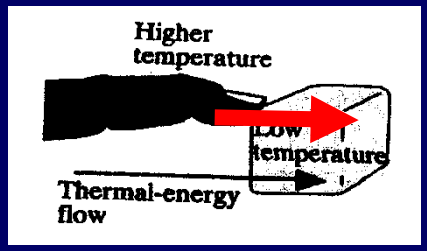
More detail:

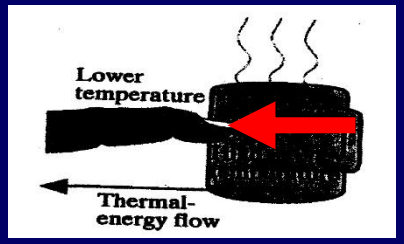
Thermal energy flows spontaneously (w/o external assistance) from a higher temperature object to a lower-temperature object and it *will not spontaneously flow the other way!*

What to remember about this version of Law #2:

HEAT flows from hot to cold; COLD doesn't flow!

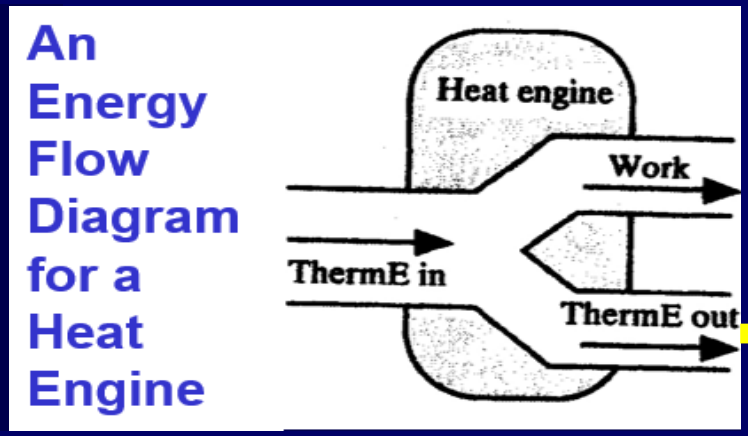
Example from p 40 ➔





2nd way to state it: **as the "Law of Heat Engines"**

*Any process that uses THERMAL ENERGY AS **INPUT** to do the work must also have THERMAL ENERGY OUTPUT . . . or **exhaust!***



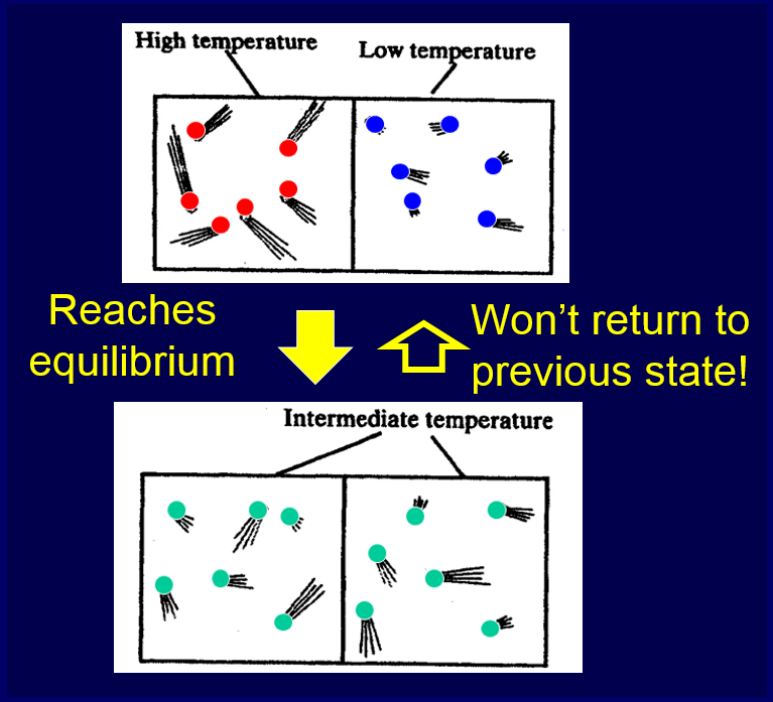
What to remember about this version of Law #2:

heat engines are always <u>less than 100 % efficient</u>!

➔ **IMPROVED ENERGY EFFICIENCY IS A KEY ASPECT OF GREEN TECHNOLOGIES!**

3rd way to state it: **as the "Law of Increasing Entropy"**

Energy of all kinds in our material world DISPERSES or DISSIPATES if it is not hindered from doing so!



"Entropy"
= the quantitative measure of this kind of spontaneous dissipating process

What to remember about this version of Law #2

"IRREVERSIBILITY"

There is an irreversibility about
any process that creates thermal energy.

Once a system creates thermal energy, that system will never "by itself" be able to return to its previous condition . . .

. . . and eventually can end up as

WASTED ENERGY!

Got all that Homer?

Clicker Q1.

Which of the LAWS is MOST CLOSELY related to this statement about energy resources ➔

"When the Earth's energy resources are used, energy is degraded from highly useful forms, (such as oil) to less useful forms such as thermal energy."

1. The Law of Conservation of Energy *(one way of stating it):*
   "energy cannot be destroyed but it can be conserved."

2. The 1st Law of Thermodynamics *(one way of stating it):*
   "energy cannot be created, but it can be destroyed and disappear from the system."

3. The 2nd Law of Thermodynamics *(one way of stating it):*
   "heat engines are always less than 100% efficient at using thermal energy to do work."

Clicker Q1.

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The next 3 slides briefly review
PARTS A, B, + C
of the
Thermodynamics Topic

TOPIC # 7 (cont.)

LAWS OF THERMODYNAMICS & MOTION

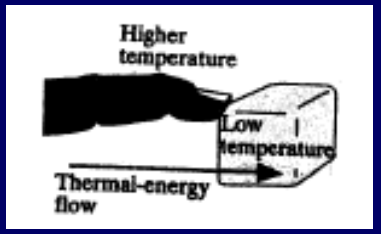
Keys To Energy Transfer & Energy Conservation

PART A - Thermal Energy Background

-- *Atoms & molecules are in constant motion*
-- *More molecular kinetic energy ➔ hotter substance*

HEAT = the **thermal energy that is *transferred*** from one body to another because of a temperature difference.

Heat will always pass from a substance of higher temperature to a substance of lower temperature, until both come to a common temperature.



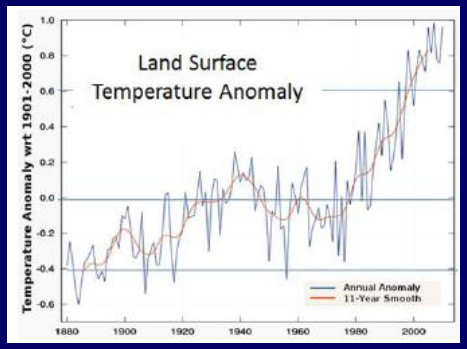
review

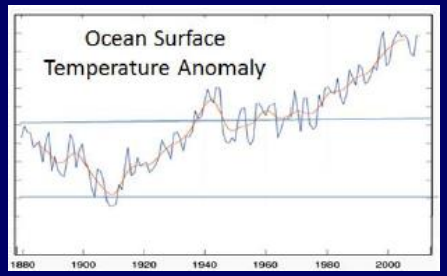
TOPIC # 7 (cont.)

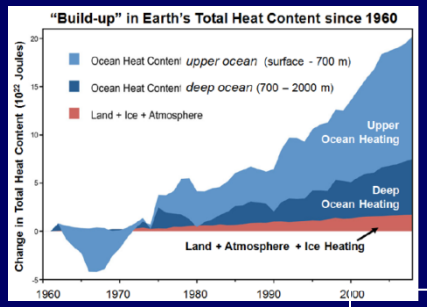
PART B – Temperature Responses & Thermal Energy Storage in Different Substances

Low Specfic Heat / Capacity = heats up quickly, loses heat quickly, cannot store large amounts of thermal energy *(air, sand, continents)*

High Specific Heat / Capacity = heats up slowly, loses heat slowly, can store large amounts of thermal energy *(water, ocean)*



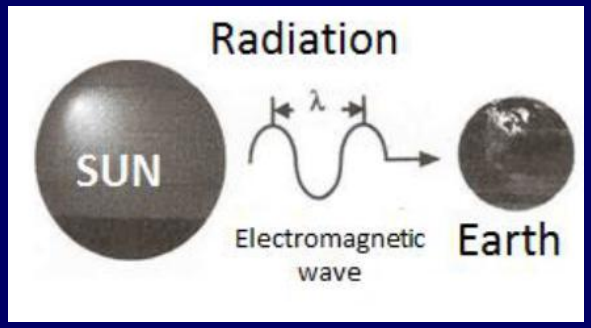




review

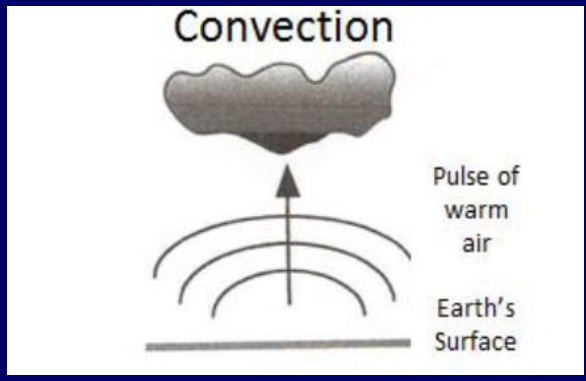
TOPIC # 7 (cont.)

PART C – Thermal Energy Transfer



Matter is <u>not</u> needed for transfer of Electromagnetic radiation – the thermal energy is sensed only <u>after</u> matter absorbs the radiation

Molecule-to-molecule transfer of energy through matter (solids esp.) via kinetic energy at the molecular & atomic scale



The matter itself moves – and the matter contains the energy (e.g., fast moving gas molecules)

review

Now back to Part D . . .

TOPIC # 7 (cont.)

PART D – The Laws Of Thermodynamics

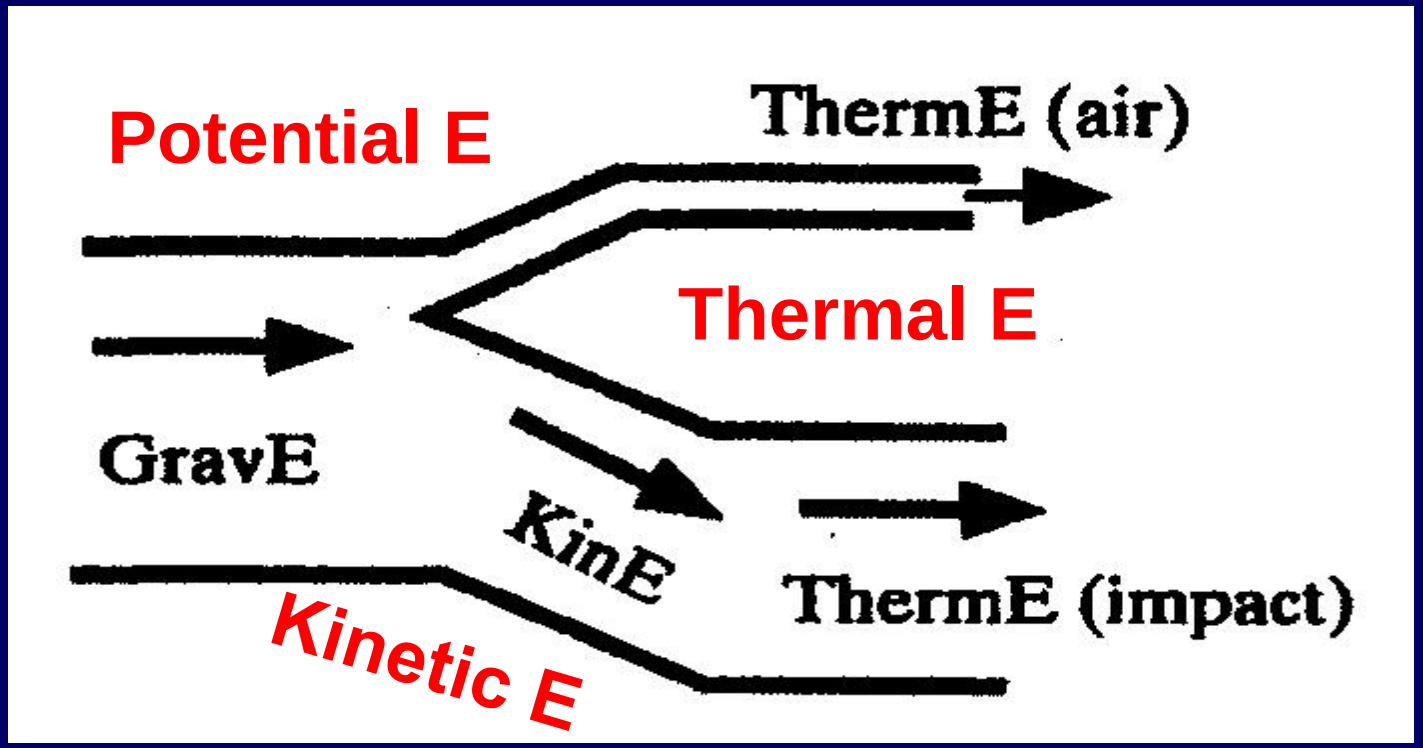
SUMMARY

The 1st Law of Thermodynamics
• Energy is conserved (knows as The Law of Conservation of Energy) • The amount of energy in the universe is constant. • Energy can be neither created nor destroyed. • It is impossible to build a machine that produces <u>more</u> energy than it uses

The 2nd Law of Thermodynamics
• Heat cannot flow from a cold object to a hot object on its own. • With each energy conversion from one form to another, some of the energy becomes unavailable for further use. • It is impossible to convert heat energy into work with 100 percent efficiency. • It is impossible to build a machine that produces <u>as much</u> energy as it uses. • The entropy of the universe tends to a maximum.

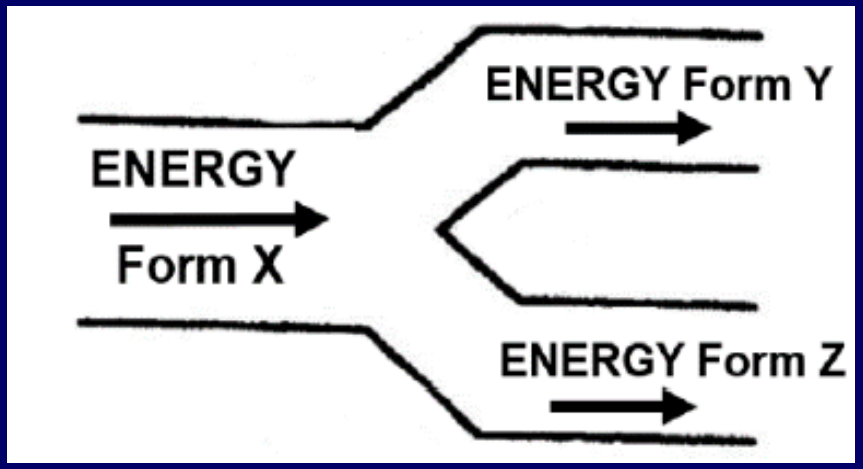
Remember this?
An "Energy Flow Diagram"

Energy flow for a falling book, with air resistance.



1st Law of Thermodynamics

The WIDTH of the "pipes" is proportional to AMOUNT of energy in each Energy From



$X = Y + Z$

CLICKER Q2: In the energy flow diagram above, which Law of Thermodynamics tells us that:

The amount of energy in Pipe **X** MUST BE EQUAL to the amount of energy in Pipe **Y + Pipe Z**?

(a) LAW #1 or (b) LAW #2

PART D – The Laws Of Thermodynamics

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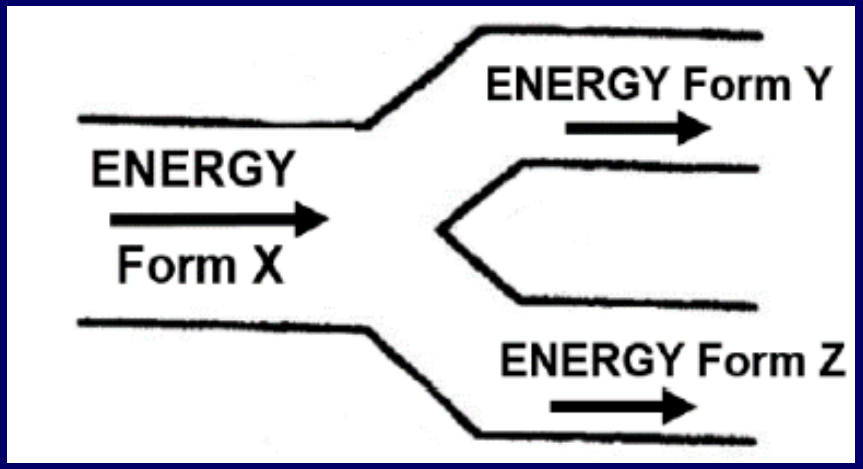

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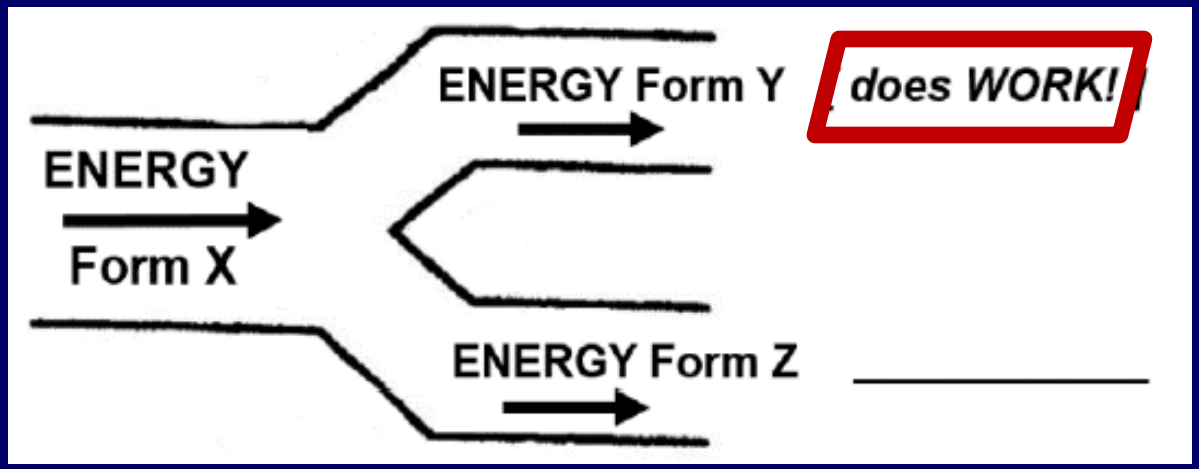
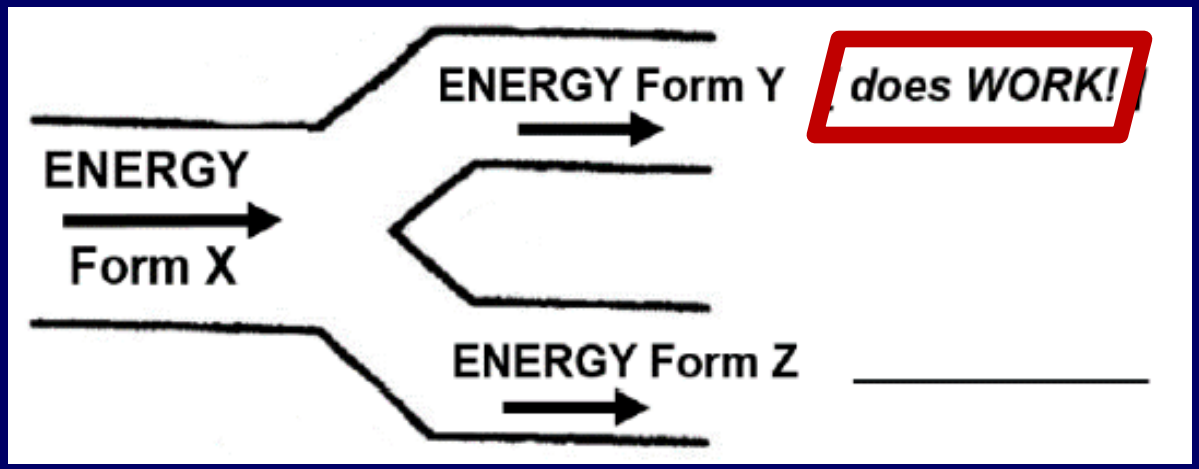


Clicker Q3. In the energy flow diagram above, which Law of Thermodynamics tells us that:

It would be IMPOSSIBLE for **Energy Form Z** to do as much work as **Energy Form Y** ?

(a) LAW #1 or (b) LAW #2



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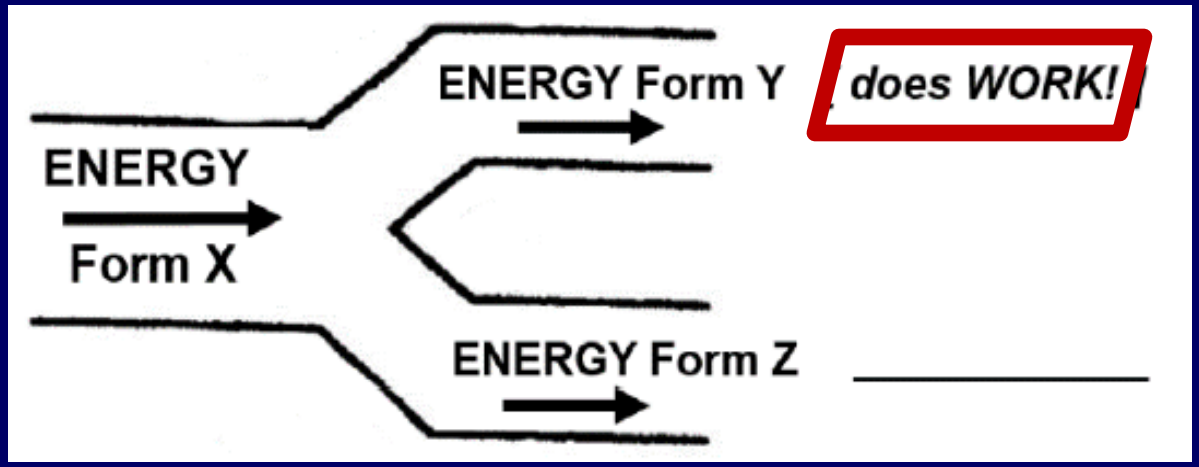
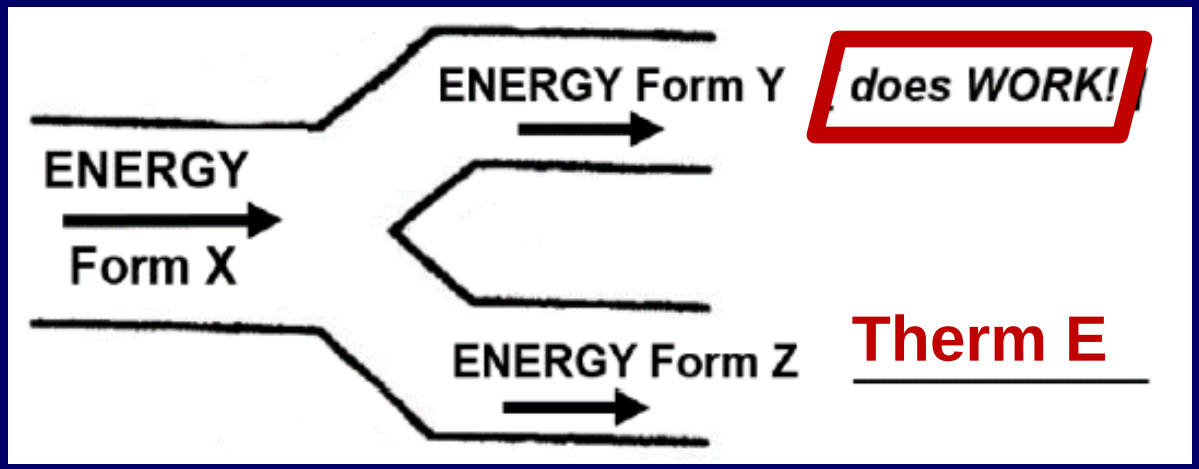


Thought Q: What form of energy do you think Z is?

Is it doing work?

Is it useable energy, or not?



Thought Q. What form of energy do you think Z is?

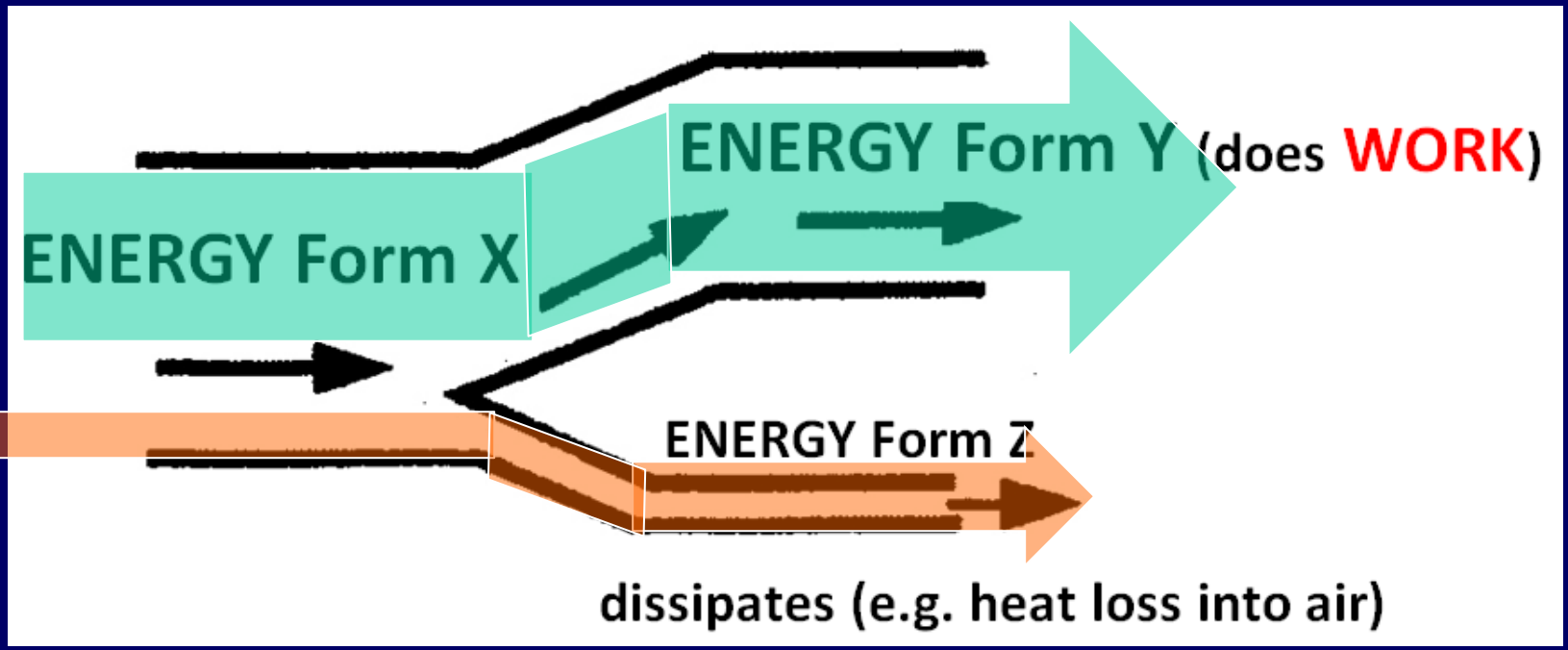
Is it doing work? **No**

Is it useable energy, or not?

Not usable; heat loss or exhaust

A KEY POINT:
IN EVERY ENERGY CONVERSION . . .

- Some of it goes where you want it:



- Some goes elsewhere:
  (usually as heat loss or “exhaust”)

Applying The Laws of Thermodynamics to Energy Efficiency . . .

Although ENERGY may not be destroyed,
it can become INEFFICIENT
(not easily used or available to do work!)

Efficiency = work done / energy used

PART E – ENERGY TRANSFORMATIONS & ENERGY EFFICIENCY

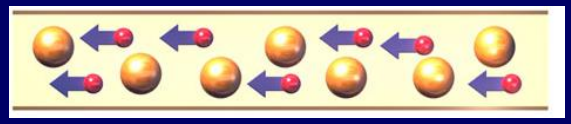
This concept is critically important for designing successful GREEN TECHNOLOGIES & for mapping out SOLUTIONS for addressing climate change

LINKING TO LIFE:
Efficiencies encountered in everyday processes & products:

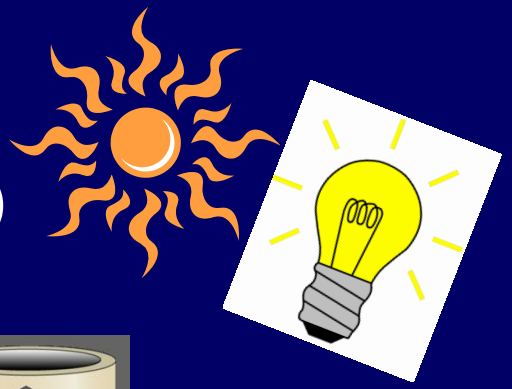
PART E – ENERGY TRANSFORMATIONS & ENERGY EFFICIENCY

ENERGY IN OUR EVERYDAY LIVES . . .

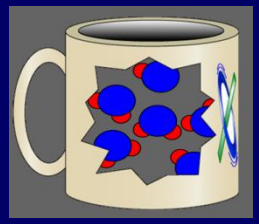
- **ELECTRICITY** (PE)
(electrons flowing though a wire)



- **LIGHT / ELECTROMAGNETIC ENERGY** (PE)
(solar radiation or light from a bulb)



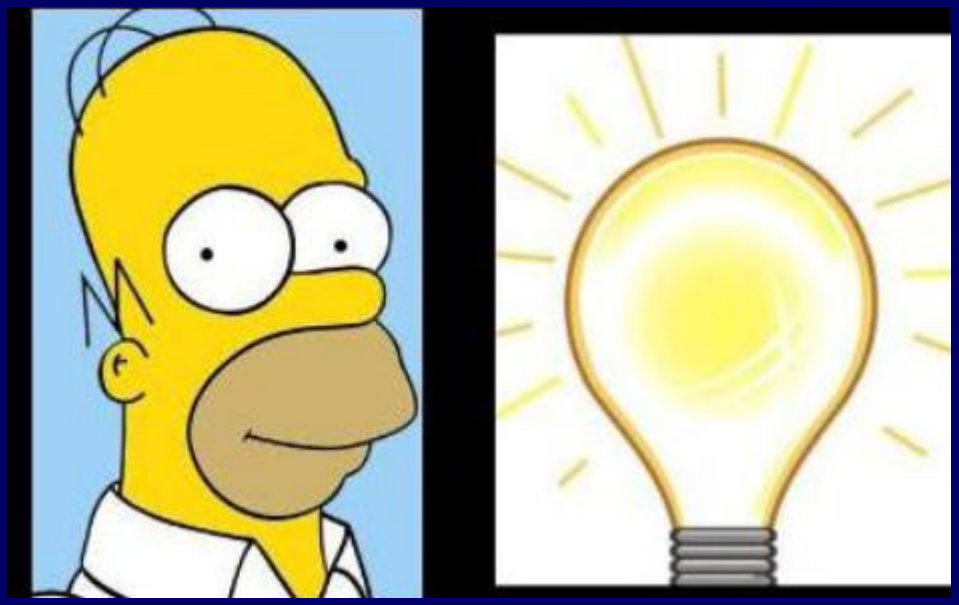
- **HEAT / THERMAL ENERGY** (PE)
(energetic jiggling molecules in a hot substance)



- **A MOVING MASS** (KE)
(a large truck going 80 mph)

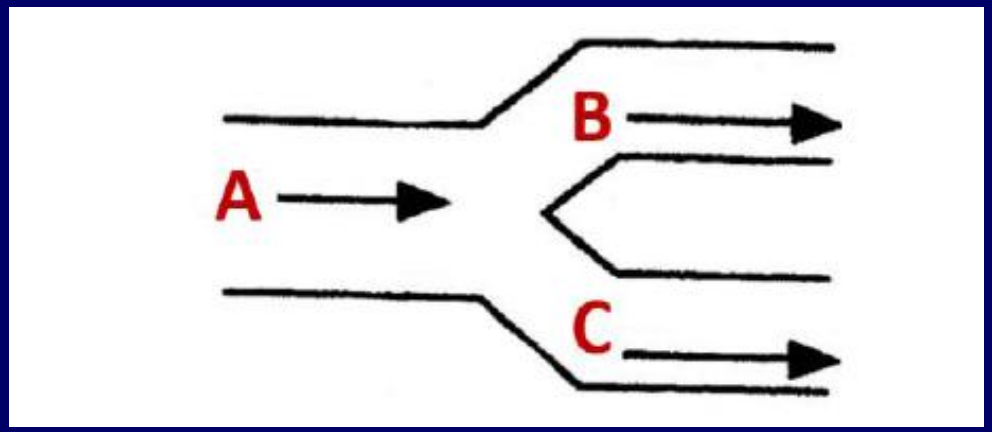
ENERGY EFFICIENCY & LIGHT BULBS

Which type of light bulb should Homer buy???



PART E – ENERGY TRANSFORMATIONS & ENERGY EFFICIENCY

Here is a simple and unlabeled ENERGY FLOW DIAGRAM.



Imagine it is for a **LIGHT BULB**

Q. What 3 forms of energy are involved in the function of a light bulb?

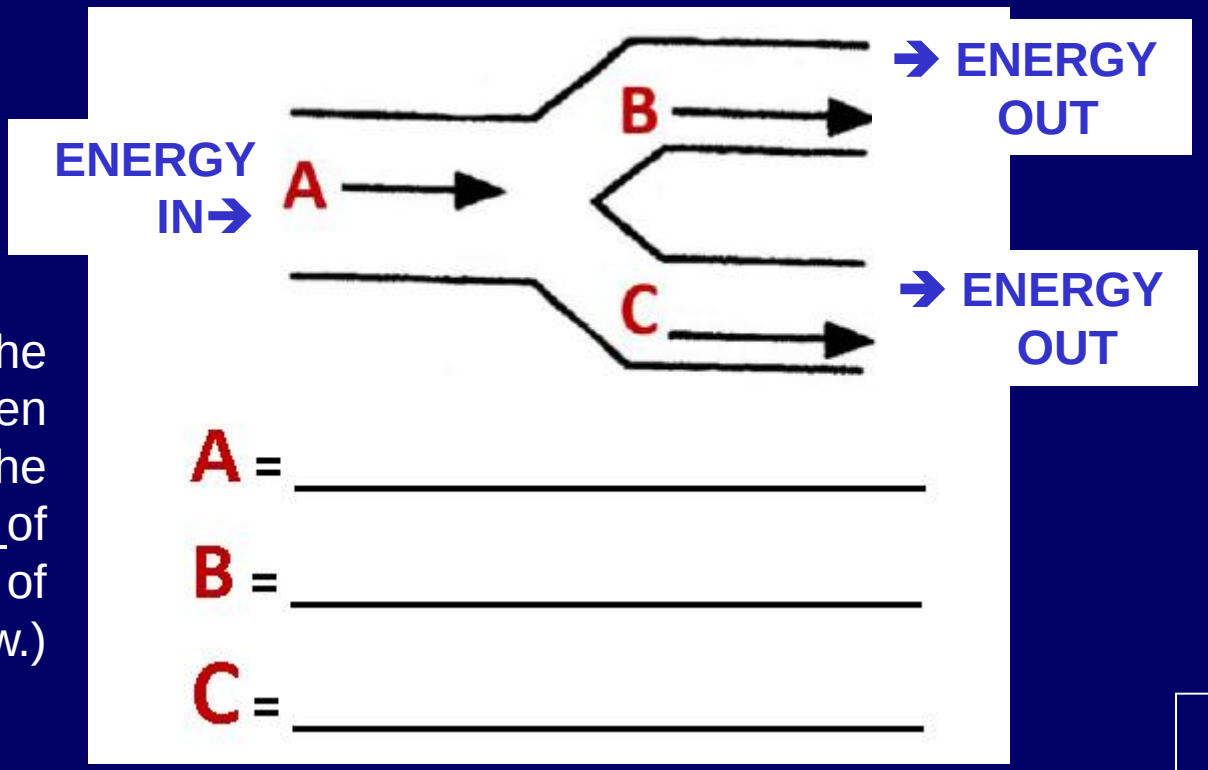
Match Pipes A, B and C with the FORMS OF ENERGY flowing through the different parts of the Diagram

FORMS OF ENERGY:

LIGHT *(electromagnetic energy)*

ELECTRICITY *(electrical energy)*

HEAT *(thermal energy)*



NOTE: the width of the arrows has not been adjusted to show the relative amounts of energy in each type of energy flow.)

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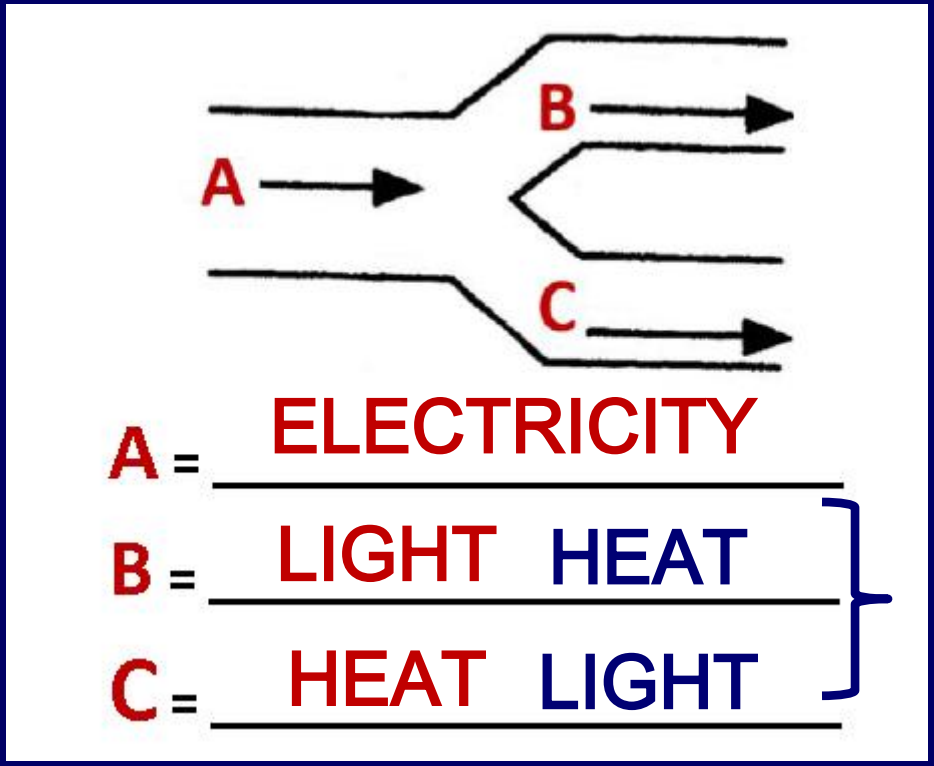
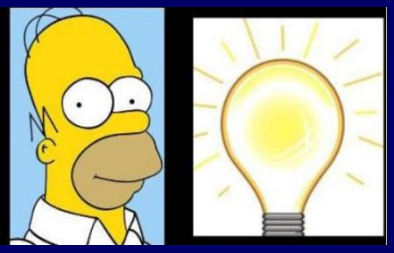
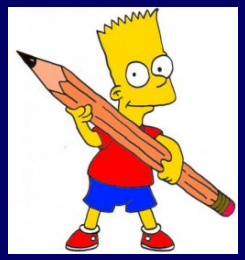


This arrangement is OK too

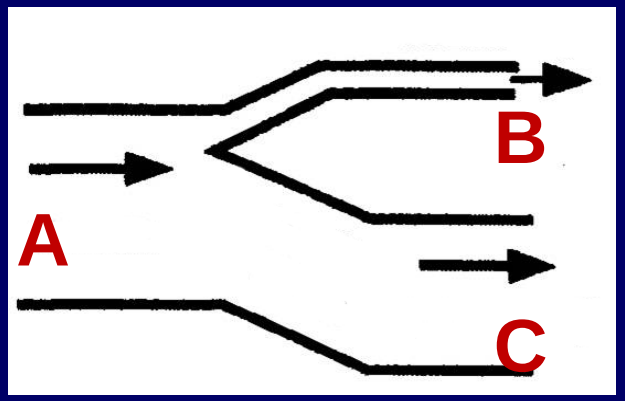
NOTE: the width of the arrows has not been adjusted to show the relative amounts of energy in each type of energy flow.)



Homer doesn't want to give up his incandescent light bulbs but they are very inefficient and lose 90% or their energy as heat!

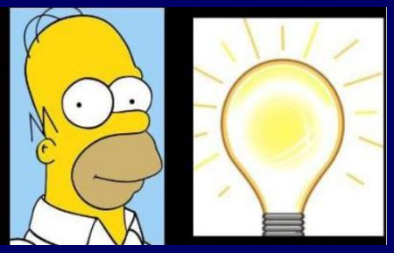


So Bart drew Homer this ➔ energy flow diagram for Homer's old bulb showing the different Energy Flow pipe widths involved!



Clicker Q4. Select the # with the correct labels for Bart's diagram:

1. A = Electrical E B = Thermal E C = Light E
2. A = Light E B = Thermal E C = Electrical E
3. A = Electrical B = Light E C = Thermal E
4. A = Thermal E B = Electrical E C = Light E



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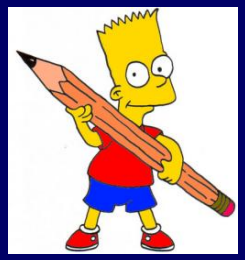

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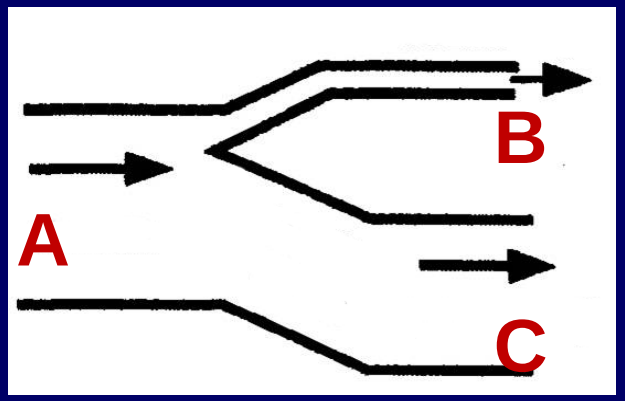

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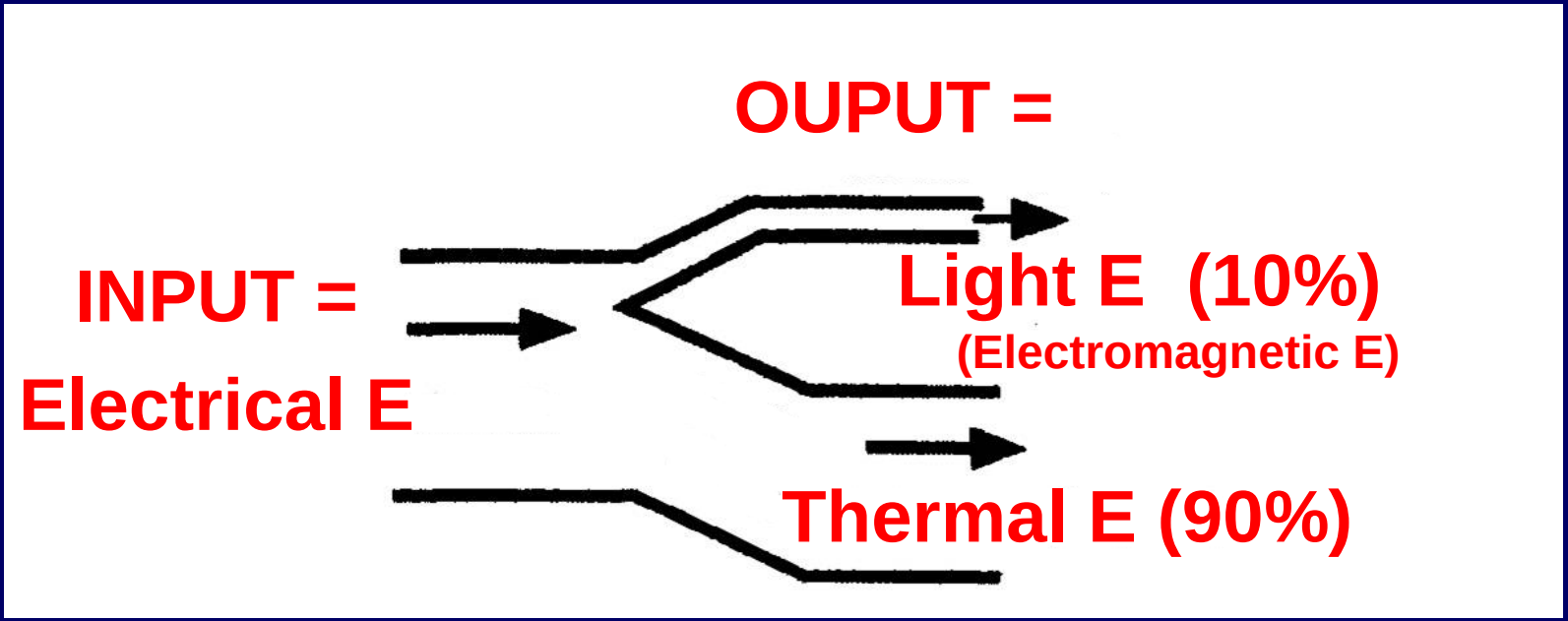
4. A = Thermal E B = Electrical E C = Light E

Here it is labeled:

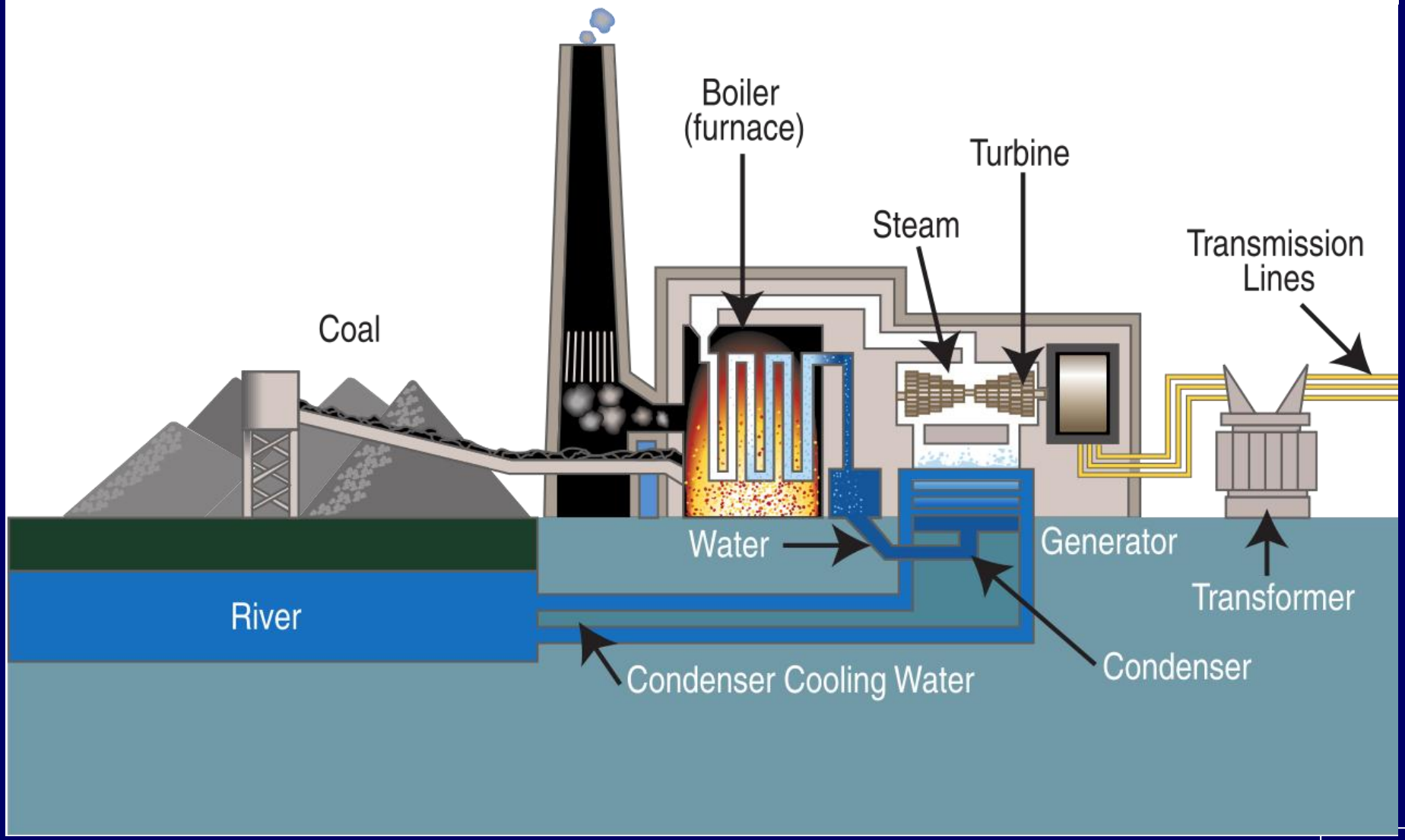


PART E – ENERGY TRANSFORMATIONS & ENERGY EFFICIENCY

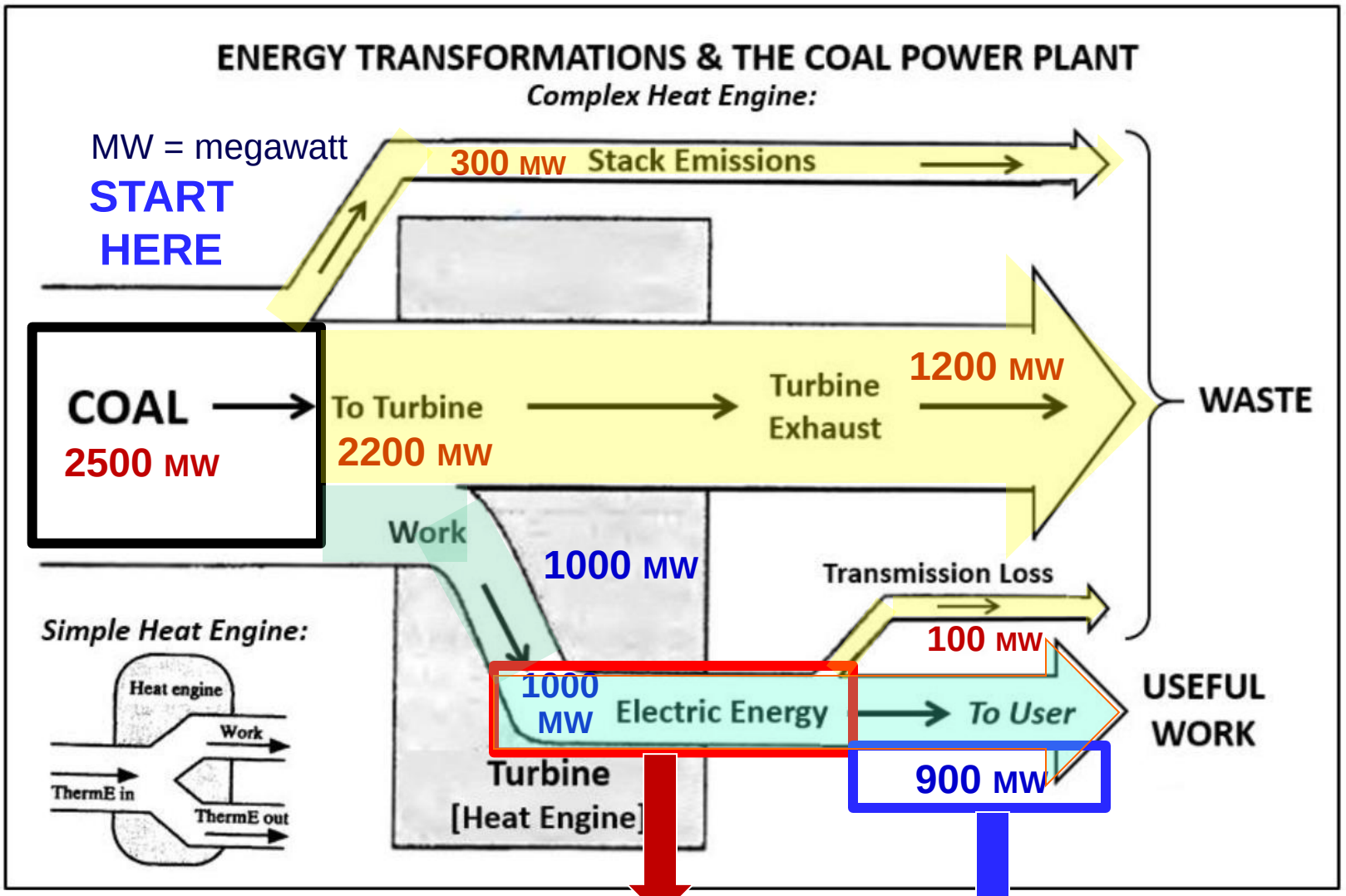
Now let's switch to
ELECTRICITY GENERATION
BY DIFFERENT METHODS . . .

A COAL POWER PLANT:

Coal burned ➔ Boiler heats water ➔ Steam ➔Spins Turbine ➔ Electricity



Source: Tennessee Valley Authority



p 44

Energy Efficiency of ELECTRICITY GENERATION = 40%:

(1000 MW electrical energy produced ÷ 2500 MW in coal fuel = 0.40 = 40%)

Energy Efficiency of PRODUCING USEFUL ELECTRICITY = ___%:

(900 MW electrical energy produced ÷ 2500 MW in coal fuel = 0.36 = 36%)

Dfferent Types of Electricity-Producing Power Sources:

- burning fossil fuel (coal) for electricity _____

Coal-fired electric power plant

- sunlight to electricity in a solar panel _____

Photovoltaic (PV) panel

- hydro power turbines _____

Hydroelectric plant

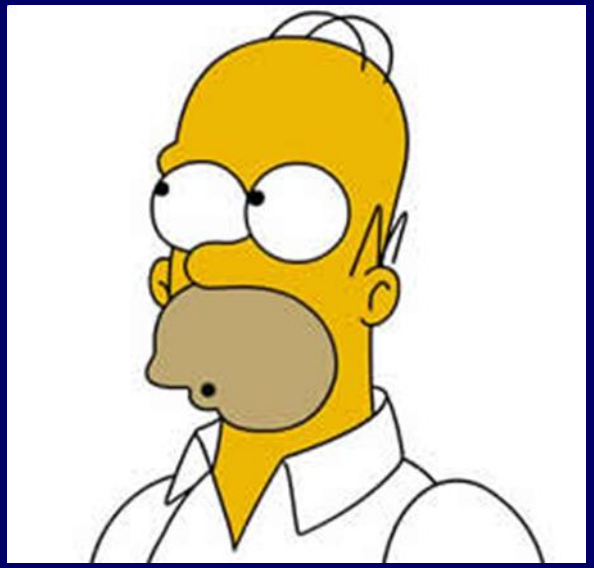
- wind turbines _____

Wind farm

FOR A BREAK . . .

How about a few practice questions for

TEST #2, Homer?



Clicker Q5 -The **"Goldilocks Problem"** refers to the question: "Why is Venus too hot, Mars too cold, and Earth's temperature just right!" Your textbook explains that . . .

1. Earth's temperature is "just right" because Earth has a **greenhouse effect** and Venus and Mars do not.

2. Earth's temperature is "just right" due to: (a) **the inverse-square law** (the Earth being just the right distance from the Sun), (b) the **greenhouse effect,** and (c) **the Earth's reflectivity** – all working together

3. Earth's temperature is "just right" because the Earth radiates like a black body and is just the right distance from the Sun – Mars is too close & Venus too far.

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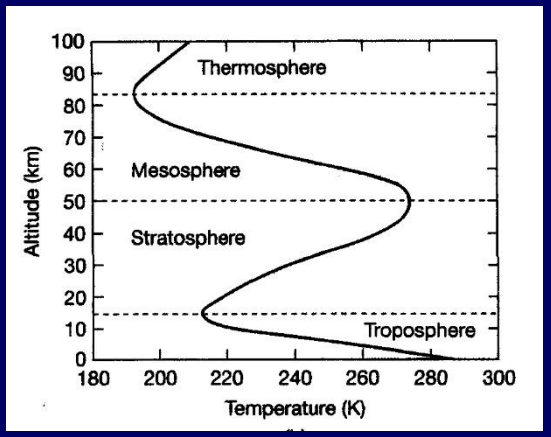
Clicker Q6 The atmospheric layer of **the troposphere** is important to global climate change because:



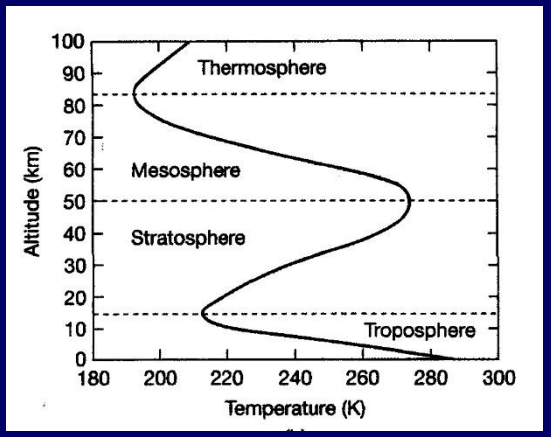
1. it is the layer that is heated up **primarily** by gases that can absorb high-energy **shortwave radiation** coming in directly from the Sun

2. it is the layer in which **temperature INCREASES with altitude** in the atmosphere

3. it is the layer with a high concentration of **ozone** that absorbs harmful **ultraviolet radiation**.

4. it is the layer in which most of the absorption by **greenhouse gases** occurs in the atmosphere

Clicker Q6 The atmospheric layer of **the troposphere** is important to global climate change because:



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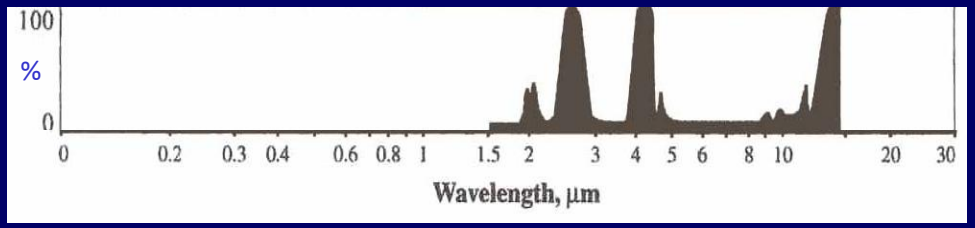
Clicker Q7 - Which of the following is a correct statement about this absorption curve:



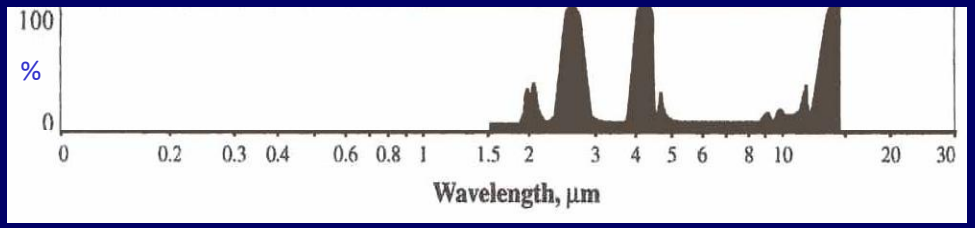
1. the curve represents absorption by a gas that can absorb both **visible light** and **infrared radiation**

2. **t**he curve represent absorption by a gas that is likely to be a **Greenhouse Gas.**

3. **t**he curve represents absorption by a gas that protects the Earth from **ultraviolet (UV) radiation**

4. **t**he curve represents absorption by a gas that can absorb **ultraviolet, infrared,** & **visible** light wavelengths of radiation.

Clicker Q7 - Which of the following is a correct statement about this absorption curve:



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Got all that Homer?

PART E – ENERGY TRANSFORMATIONS & ENERGY EFFICIENCY

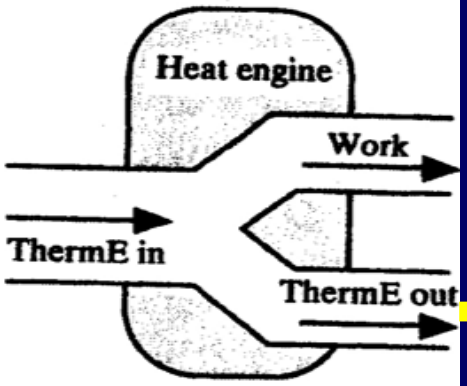
Applying The Laws of Thermodynamics & The Laws of Motion to TRANSPORTATION

vs.

Efficiency = work done / energy used

ENERGY TRANSFORMATIONS & NEWTONS LAWS OF MOTION

An Energy Flow Diagram for a Heat Engine



Car's Exhaust

review

1st Law of Motion
(Law of Inertia)

A moving object will continue moving in a straight line at a constant speed . . .

. . . and a stationary object will remain at rest . . . unless acted on by an unbalanced force.

Newton's Laws in everyday life:

1st LAW =

The LAW of INERTIA!

2nd Law of Motion
(Newton's Law of Motion)

The acceleration (a) produced on a body by a force (F)

is proportional to:
the magnitude of the force (F)

and inversely proportional to:
the mass (m) of the object.

a = F / m or F = ma

3rd Law of Motion
(Law of Force Pairs)

For every action there is an equal and opposite reaction.

3rd Law = "Law of Force Pairs"

- **Forces always occur in pairs**; an **action** and a **reaction**. To every action force there is an equal and opposite reaction force;

- whenever one body exerts a force on a second body, the second body exerts an equal and opposite force on the first body.

Application of the Law of "FORCE PAIRS" :

Momentum = inertia in motion
= mass x velocity = time x force

An opposite FORCE slows the truck in both cases:

Wall is opposite FORCE slowing down the truck over short TIME interval

MASS x VELOCITY = TIME x **FORCE**

Haystack is opposite FORCE slowing down the truck over long TIME interval

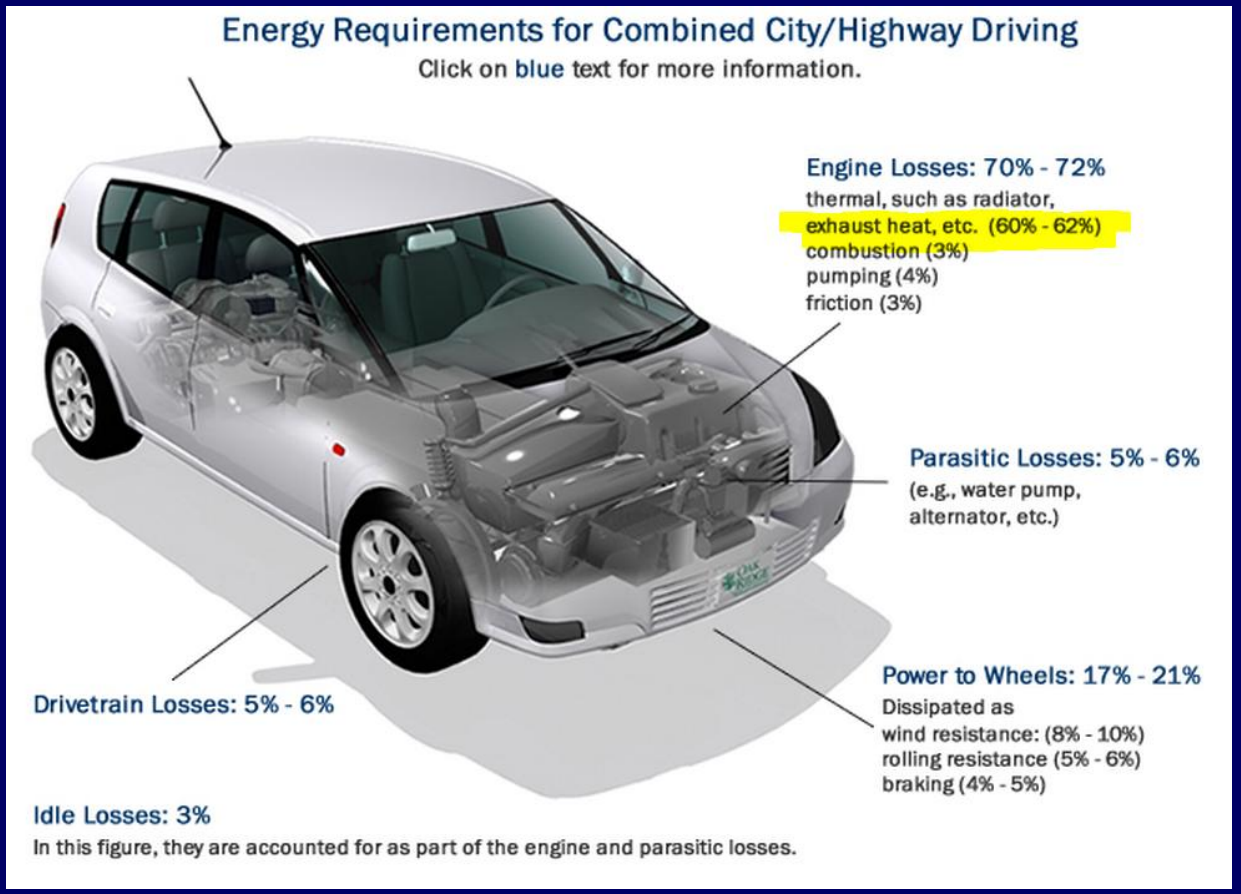
MASS x VELOCITY = **TIME** x FORCE

MOMENTUM IS CONSERVED before and after in each "crash" case above

A CLOSER LOOK AT A (Gas-Powered) AUTOMOBILE:

Fuel Economy: Where the Energy Goes

Only about 14%–26% of the energy from the fuel you put in your tank gets used to move your car down the road, depending on the drive cycle.



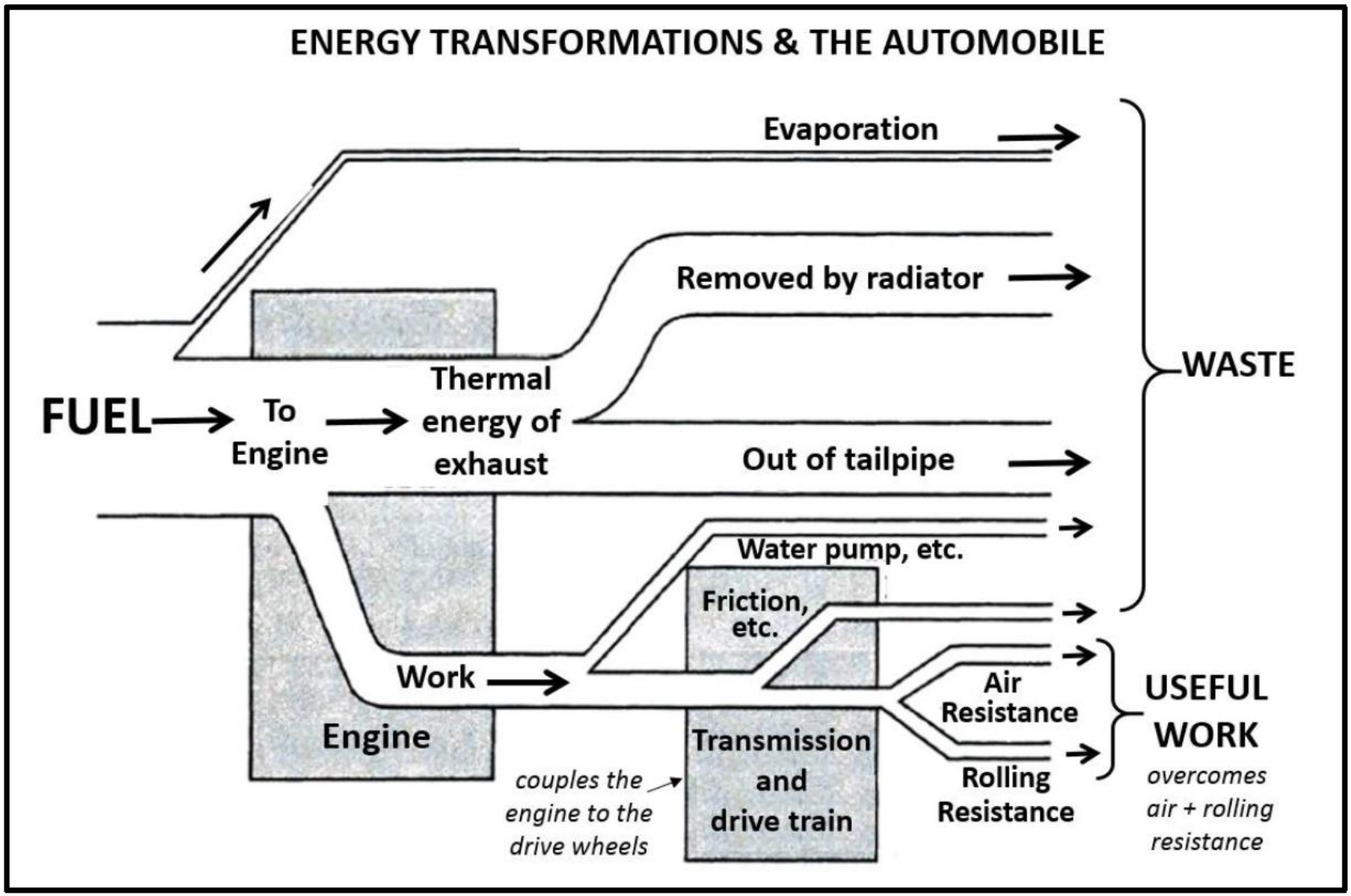
The rest of the energy is lost as exhaust heat or dissipated in various ways

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

www.fueleconomy.gov

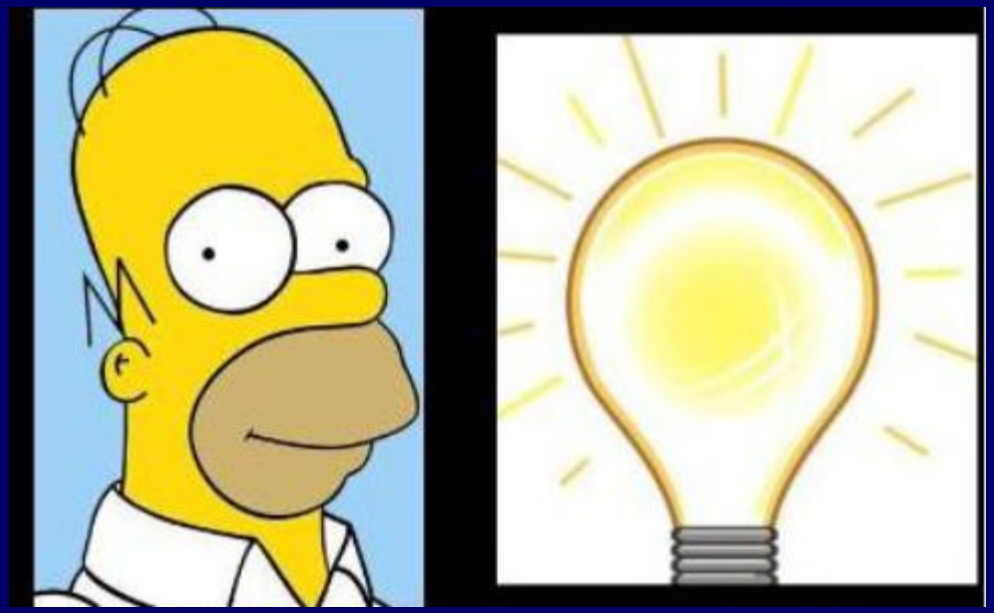
the official U.S. government source for fuel economy information

http://www.fueleconomy.gov/feg/atv.shtml


ENERGY TRANSFORMATIONS & THE AUTOMOBILE
Evaporation
Removed by radiator
WASTE
FUEL
To Engine
Thermal energy of exhaust
Out of tailpipe
Water pump, etc.
Friction, etc.
Work
Engine
Air Resistance
Rolling Resistance
USEFUL WORK
overcomes air + rolling resistance
couples the engine to the drive wheels
Transmission and drive train

ENERGY EFFICIENCY & LIGHT BULBS

Which type of light bulb should Homer buy???



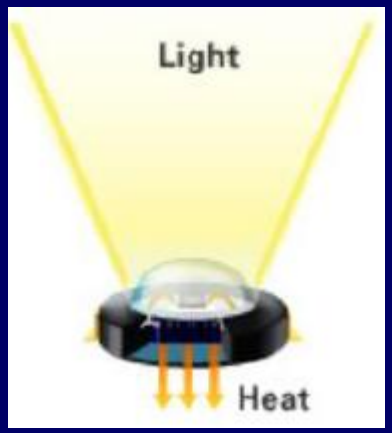
Flip to the Class Notes Appendix: p 115

INCANDESCENT BULBS: electricity passes through a metal filament until it becomes so hot that it glows.

Release 90% of their energy as heat.

COMPACT FLUORESCENT BULBS (**CFL**): electric current is driven through a tube containing gases. Reaction produces ultraviolet light ➔ visible light aided by the fluorescent coating on the inside of the tube.

Release about 80% of energy as heat.



LED bulbs use **LIGHT EMITTING DIODES** to produce light. The movement of electrons through a semiconductor material illuminates the tiny LED light sources.

LEDs can approach 80% efficiency

(i.e., 80% of the electrical energy is converted to light energy.)

OK
GET TO WORK
ON G-2

Draw a **proper** **ENERGY FLOW DIAGRAM** for each type of light bulb:

Width of the arrows should properly represent (**electrical energy**) converted into *light* (**electromagnetic energy**) and *heat* (**thermal energy**).

THE ARROW WIDTHS WILL BE DIFFERENT FOR EACH TYPE OF LIGHT BULB!

		RANK
	Diagram for Incandescent bulb:	
	Diagram for CFL bulb:	
	Diagram for LED w/ 80% efficiency:	

Then . . .
based on your Energy Flow Diagrams, RANK the amount of thermal energy being emitted by each bulb type based on the bulb's expected temperature -- from coolest (#1) to hottest (#3)

➔Turn to p 115

ANOTHER TEAM COMPETITION !

Rank the Efficiency of Each Type of Electricity-Producing Power Source:

Rank from 1 to 4 Rank #1 = Most Efficient

- **burning fossil fuel (coal) for electricity _____**

Coal-fired electric power plant

- **sunlight to electricity in a solar panel _____**

Photovoltaic (PV) panel

- **hydro power turbines _____**

Hydroelectric plant

- **wind turbines _____**

Wind farm

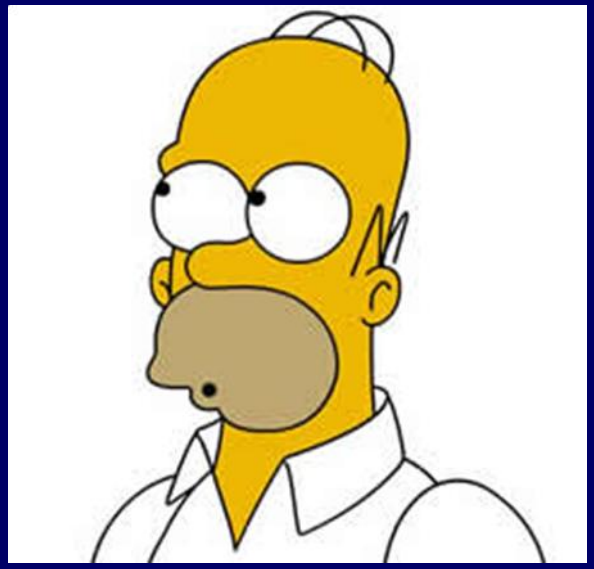
WITHIN EACH GROUP . . .

DISCUSS & RANK
the Energy Generating Sources,

then fill in your rankings
on the short form and turn it in . . .

Answers to be given when all forms are in.

Study hard for TEST #2 Homer!



GO CATS!
Beat the Ducks