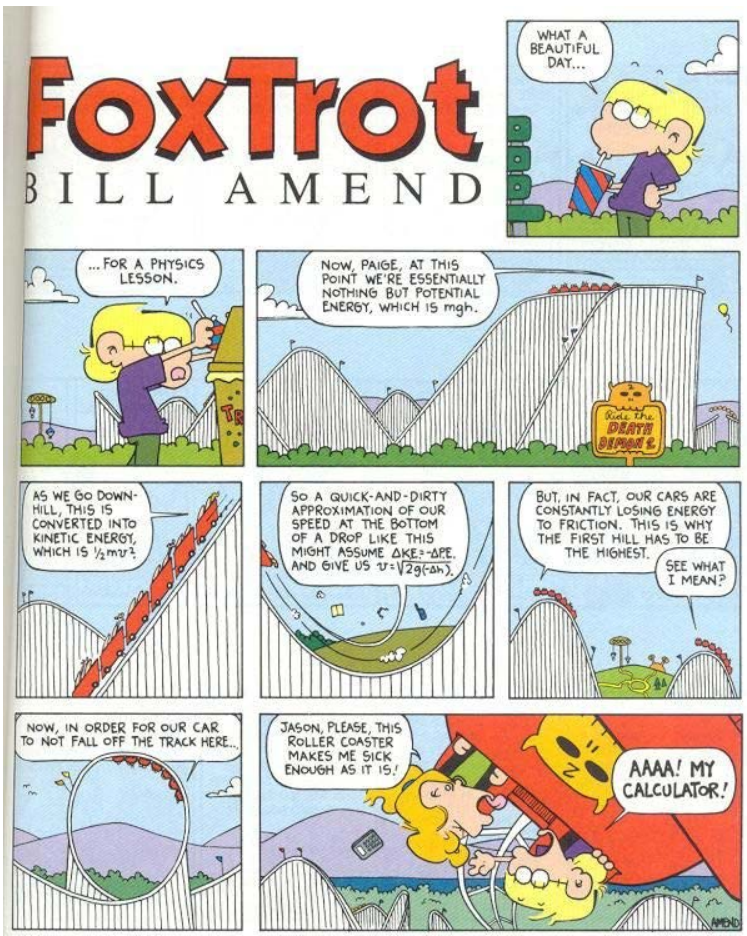
SCIENCE 10

unit 3:physics



book 2: energy transfer + transformations

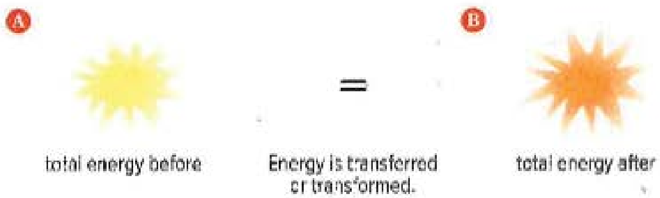
NAME: Key BLOCK: ______

part a-energy can be transferred or transformed

Over time, scientists have conducted thousands of experiments to investigate the properties of energy. And the results are always the same:

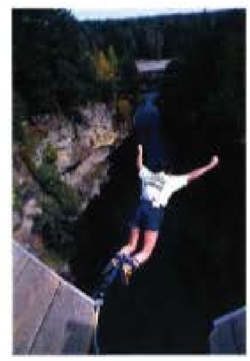
The total amount of energy present before energy is transferred or transformed, is always exactly equal to the total amount of energy present afterwards.

In otherwards, energy is neither created nor destroyed.



The **LAW OF CONSERVATION OF ENERGY**:
Energy is neither created nor destroyed. Instead it is transformed form one form of energy to another, or transferred from one object to another

Energy + Systems



- Anything under observation is referred to as a system
- This is defined by the experimenter, and can vary
  - *For example, the bridge, bungee cord + person are the* ***system*** in the diagram *(shown right →)*
- Everything that is NOT part of the system that the experimenter defines, is considered to be the surroundings

UNIVERSE = system **+** surroundings

- Energy produces change in a system. In the case of the bungee jumper, the system is moving from a greater height to a lesser height. This causes a direct change in the potential energy of the system *(recall, PE = mg**h**, where h=height)*
- Energy may be added to the system from the surroundings or released from the system to its surroundings.
  - *Energy would be added to the system from the surroundings if wind pushed the person*
  - *Energy would be released from the system to its surroundings as air resistance provides friction that slows the jumper down.*

Useful & Not Useful Energy:

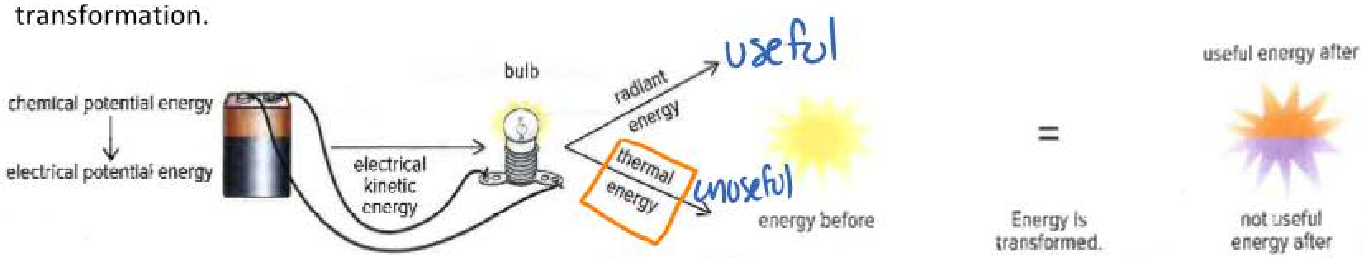
While the transfer and transformation of energy often enables useful tasks to be carried out, no energy transformation is 100% efficient.

Each time that energy changes form, some of it becomes unuseable.

ALL energy transformations result in some amount of unusable energy.

eg. in many cases energy is "lost" as heat (thermal energy)

For example, the system below is designed to transform chemical potential energy into light energy. Thermal energy is an unusable byproduct of this energy transformation.



Sometimes "non-useful" energy is described as "lost".

Recall, the ***Law of Conservation of Energy***. We know energy cannot be "lost". → just being transferred to another object or place.

Whether this energy actually leaves the system depends on which type of system it is...

Types of Systems:

1. Open System: *can exchange both energy and matter with it's surroundings*

Open System
An uncovered pot of potatoes boiling on the stove is an open system. Thermal energy is transferred from the stove burner to the pot and its contents, as well as to the surrounding cooler air. As the water boils, thermal energy is also transformed into the mechanical kinetic energy of rising steam. As the steam leaves the pot, the system loses both matter and energy to the surroundings.

2. **closed system:** *can exchange energy,* but NOT matter *with its surroundings*

Closed System
A pressure cooker with potatoes boiling represents a closed system, because the tightly sealed lid prevents loss of matter and energy to the surroundings in steam. Thermal energy can be transferred into the system from contact between the pot and the stove. It also can be transferred out of the system where the pot contacts the surrounding cooler air and through transformation into radiant energy.

3. isolated **system:** cannot *exchange energy or matter with it's surroundings*

"system"

Isolated System
The pot of potatoes inside an insulated container represents an isolated system. In theory, the insulation prevents the exchange of any energy or matter between the system and its surroundings. In reality, energy exchange is significantly reduced, but not eliminated entirely. This is because it is hard to completely isolate a system.

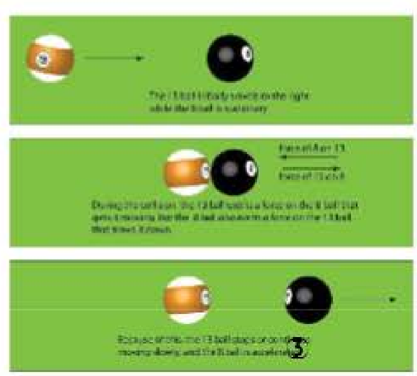
Energy Transfer vs Transformation

When a system releases energy, the surroundings absorb it. Or, when a system absorbs energy, the surroundings must in turn release it. This process can involve either energy transfer, energy transformation or BOTH!

Energy Transfer: *when energy moves between objects and remains in the* SAME TYPE (of energy)

Energy Transformation: *when energy moves between objects and the form of energy* CHANGES!

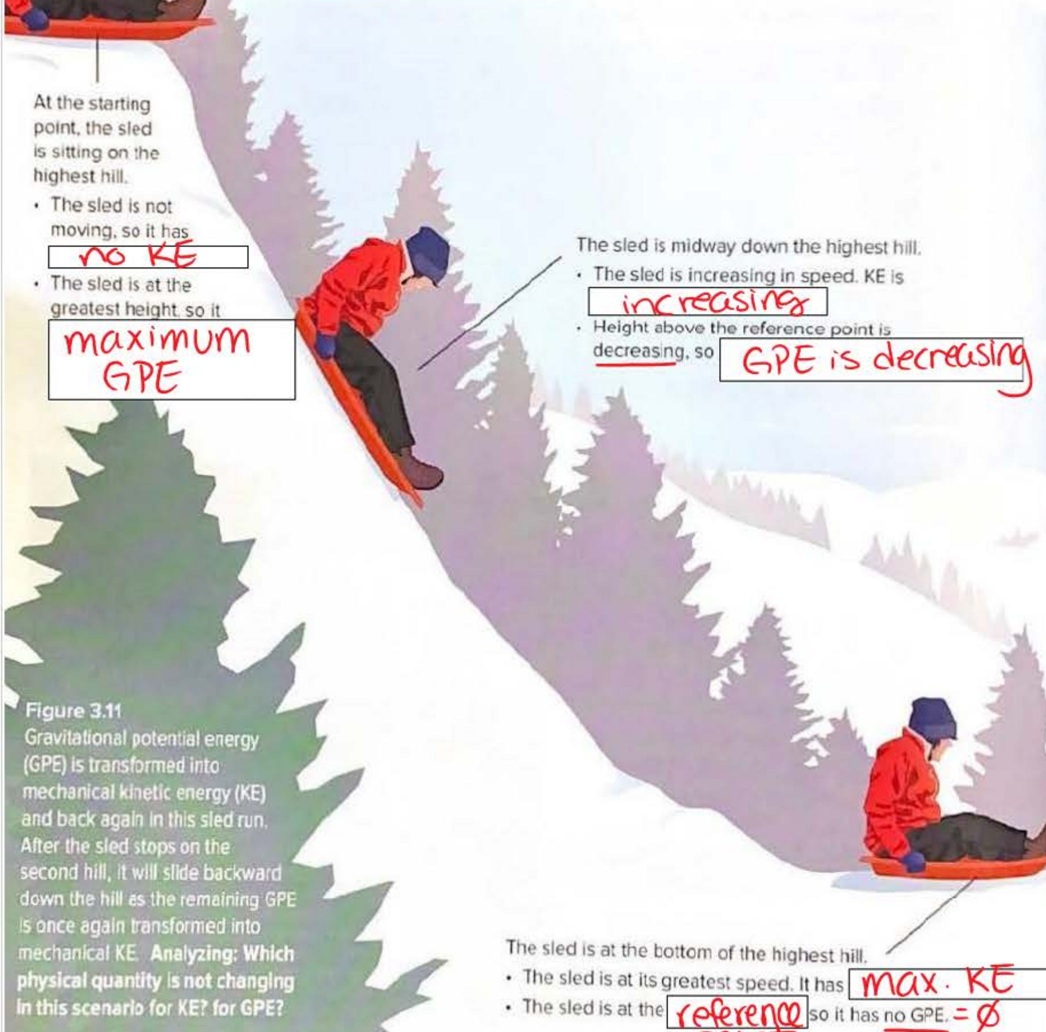
Recall our billiard ball example: *when one pool balls trikes another,* mechanical *kinetic energy is* transferred *from one ball to the other. It is also* transforms *into sound and thermal energy which are* "lost" / unuseable *by the surroundings.*



Visualizing Physical Quantities That Affect Kinetic and Potential Energy

Gravitational PE is being [transformed] into mechanical KE and back again as teh sled travels down one hill and up another.

Note, the GPE is always compared to a *reference position*, in this case h=0 at the



At the starting point, the sled is sitting on the highest hill.

- The sled is not moving, so it has [no KE]
- The sled is at the greatest height, so it [maximum GPE]

The sled is midway down the highest hill.

- The sled is increasing in speed. KE is [increasing]
- Height above the reference point is decreasing, so [GPE is decreasing]

The sled is at the bottom of the highest hill.

- The sled is at its greatest speed. It has [max. KE]
- The sled is at the [reference point] so it has no GPE. = ∅

Figure 3.11 Gravitational potential energy (GPE) is transformed into mechanical kinetic energy (KE) and back again in this sled run. After the sled stops on the second hill, it will slide backward down the hill as the remaining GPE is once again transformed into mechanical KE. **Analyzing: Which physical quantity is not changing in this scenario for KE? for GPE?**

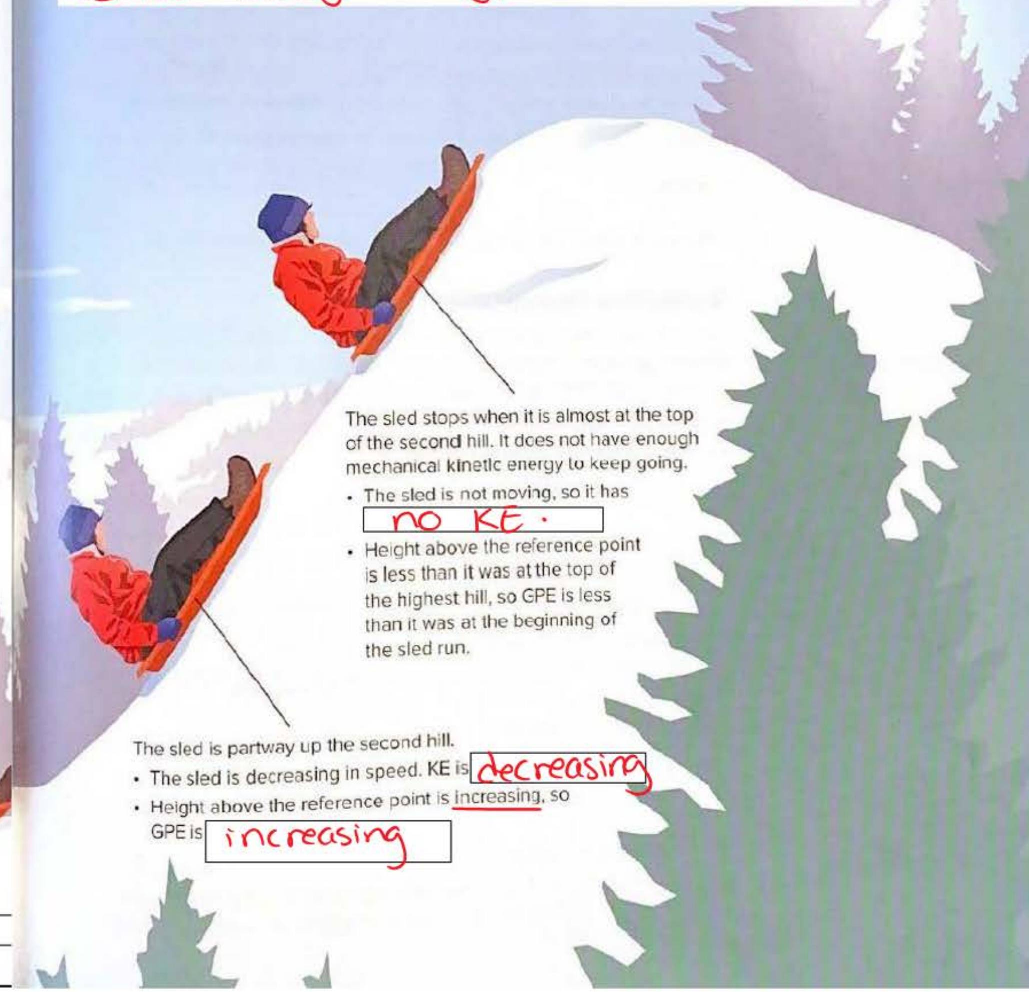
Why doesn't the sled make it up the second hill?

as the sled moves...

GPE → KE

→ thermal energy, sound energy (due to friction)

- The further the sled travels, the more unuseable energy is "LOST".
- when it reaches the 2nd hill, there is not enough energy to make it up.



The sled stops when it is almost at the top of the second hill. It does not have enough mechanical kinetic energy to keep going.

- The sled is not moving, so it has [no KE.]
- Height above the reference point is less than it was at the top of the highest hill, so GPE is less than it was at the beginning of the sled run.

The sled is partway up the second hill.

- The sled is decreasing in speed. KE is [decreasing]
- Height above the reference point is increasing, so GPE is [increasing]

PRACTICE ▸ **Complete the following practice problems**

Use the equations for mechanical kinetic and gravitational potential energy to determine how they are affected in the following problems. ***Explain*** your answer in each case.

1. Two cars are driving at the same velocity, but one has twice the mass of the other. Is the mechanical kinetic energy of the larger car two times, three times, or four times that of the smaller car?

$KE_1 = KE_2$

$\frac{1}{2} m_1 v^2 = \frac{1}{2}\, 2 \times m_2 v^2$ ← The KE would be 2 × larger.

2. You are skateboarding to school and realize that you are late. If you double your pace, by what factor would your mechanical kinetic energy increase?

$KE = \frac{1}{2} m v^2 = \frac{1}{2} m (2 \cdot v)^2$ $\quad (2 \times v)^2 \quad 2^2 = 4$ ← KE will be 4x larger.

3. Two rock climbers of the same mass are climbing a cliff.

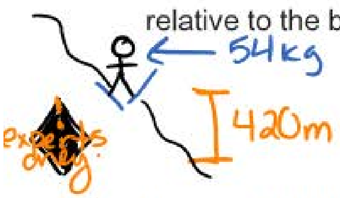
a. One stops to rest at a position that is 50 m above the ground. The other climber stops at a height of 25 m above the ground. Which one has. greater gravitational potential energy?

$GPE = mgh$ ← the ↑ height = ↑ GPE ∴ the person @50m has more GPE

b. Would the climbers have more or less gravitational potential energy if they were climbing a cliff on the Moon?

Less, because the force of gravity (g) on the moon is less than on Earth.

4. A 54 kg skier, including equipment, stands at the top of a black diamond ski run. The vertical distance to the bottom of the run is 420 m. What is the gravitational potential energy of the skier relative to the bottom of the ski run?



$GPE = mgh = (54\,kg)(9.81\,\frac{m}{s^2})(420\,m)$

$= 222\ 490.8\ J$

5. A satellite has a mass of 689 kg and travels at a speed of 27 000 km/h (7500 m/s). How much mechanical kinetic energy does the satellite have?

$KE = \frac{1}{2} m v^2 = (0.5)(689\,kg)(7500\,m/s)^2$

$= (0.5)(689)(56\,250\,000)$

$= 1.94 \times 10^{10}\ J$

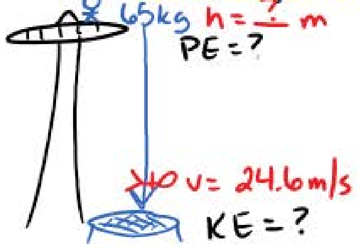
6. A bowling ball is rolling down the lane at 2.8 m/s. If it has a mechanical kinetic energy of 25.5 J, what is it's mass?

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

$\therefore m = \frac{2 \cdot KE}{v^2}$

$m = \frac{(2)(25.5\,J)}{(2.8\,m/s)^2} = \frac{(51)}{(7.84)} = 6.51\ kg$

7. A person who has a mass of 65 kg goes on the Sky Tower ride at an amusement park . The ride is simply a free fall from the top of a tower into a net below. If the person reaches a final velocity of 24.6 m/s just before hitting the net, from what height did the rider drop? (Ignore friction with the air)



energy is conserved ∴ $PE = KE$

(mass cancels) m = m $\quad \cancel{m}gh = \frac{1}{2}\cancel{m}v^2$

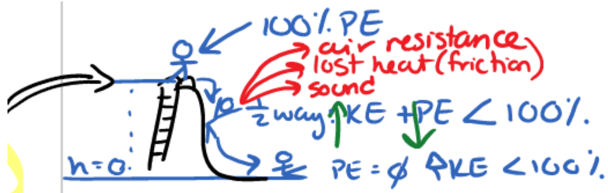
÷ g to cancel $\quad \frac{gh}{g} = \frac{\frac{1}{2}v^2}{g}$

$h = \frac{\frac{1}{2}v^2}{g}$

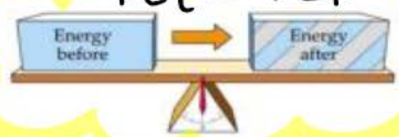
$h = \frac{(0.5)(24.6\,m/s)^2}{(9.81\,m/s)}$

$h = 30.84\ m$

Part B - Transformation of Kinetic & Potential Energy



$KE_i = KE_f$
$PE_i = PE_f$



Law Conservation of Energy

- ☐ Remember the law of conservation of energy from chemistry? Energy can not be created or destroyed
- ☐ Energy can, however, be converted from one type to another, and can be transferred from one object to another (stay the same type of energy.)

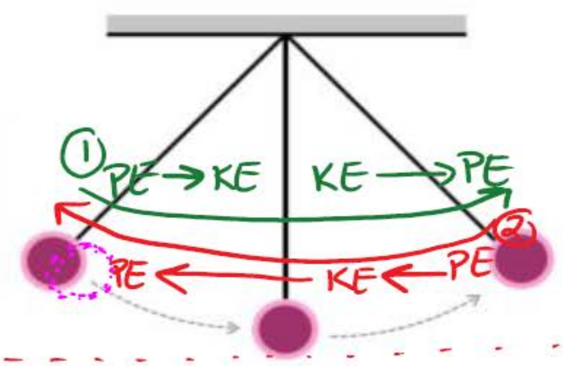
***Example*: Energy Transformation in a Pendulum**

- ☐ A pendulum is a mass on the end of a string which is free to swing in 2 dimensions ⟷
- ☐ At the top of the swing, the mass has no kinetic energy (it is not moving) but has potential energy (equal to its mass and height remember)
- ☐ As it falls, the PE of the mass is transformed into kinetic energy as the pendulum gains velocity due to the acceleration in gravity ($a = 9.81 m/s^2$)
- ☐ As it swings upwards again, the KE of the mass is transformed back into PE as the mass slows down and gains height back to the top of the swing

$KE = \frac{1}{2}mv^2$

Top

PE =	MAX
velocity =	0 m/s
KE =	0 J

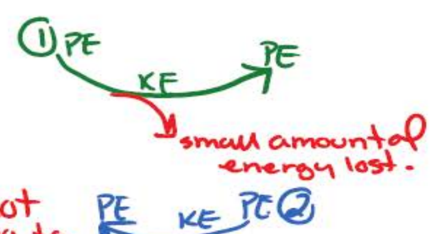


Top.

PE =	MAX
velocity =	0 m/s
KE =	0 J

bottom.

PE =	0 J (h=0)
velocity =	MAX
KE =	MAX



* not going to go as far

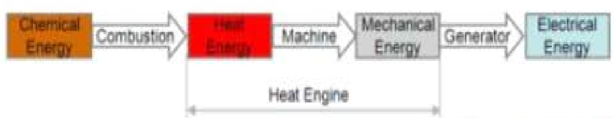
energy lost
- elastic (string)
- friction (air)

energy is lost with each swing.

***Example:* Energy Transformation in Engines**

- ☐ Internal combustion engines, like those in cars, take in the organic molecules in gasoline (→ chemical energy (fuel)) into sealed chambers called cylinders
- ☐ Combustion (require O_2) reactions inside the cylinders convert the gasoline into carbon dioxide (CO_2) and water (H_2O)
- ☐ The gas products take up more space and so the combusting materials expand, transforming the chemical energy in the gas into kinetic energy
- ☐ Combustion reactions are exothermic so energy is transformed into heat
- ☐ KE of the moving cylinders turns a shaft which then turns wheels, etc.

Transfer: KE → KE (example), same type
Transform: chemical → KE, different type.



Solving Energy Transformation Problems one energy type ⟹ different energy type.

- ☐ To solve questions with energy transformations you may need to chain together two or more of the formulas we have already seen for KE and PE
- ☐ Always start with the formula that uses the information in the question then choose the next formula to solve the problem, using the same three-step method we have been practicing
- ☐ The variable that is in BOTH formulas is the (m) mass $KE = \frac{1}{2}mv^2$ $PE = mgh$
- ☐ Remember that energy cannot be created or destroyed. This means that sometimes KE = PE

Law of Conservation of Energy.

diagram

Practice: A baseball is thrown straight upward with a velocity of 5.63 m/s. If its KE is 2.3 J, how high does it travel?	**Practice**: A 15 kg coyote is at the top of a 205 m cliff. What velocity will it reach if it misses the roadrunner and falls to the ground?
h=? ; v=5.63 m/s ; KE (throw) = PE (top) ; ① $\frac{1}{2}mv^2 = mgh$; $2.3J = mgh$; ② $KE = \frac{1}{2}mv^2$; $m = \frac{KE}{\frac{1}{2}v^2}$; $m = \frac{2.3J}{(0.5)(5.63)^2}$; $m = \frac{2.3}{15.8}$; m = 0.145 kg ; ③ $PE = mgh$; $h = \frac{PE}{mg}$ (KE=PE conservation of energy) ; $h = \frac{2.3J}{(0.145)(9.81)}$; $h = \frac{2.3}{1.42}$; h = 1.6 m	V=? ; h = 205 m ; PE_{max} PE = mgh ; KE_{max} $KE = \frac{1}{2}mv^2$; PE = KE ; ① PE = mgh ; PE = (15 kg)(9.81 m/s²)(205 m) ; PE = 30165.75 J ; ② if PE = KE, then KE = 30165.75 J ; ③ solve for velocity $KE = \frac{1}{2}mv^2$; $v = \sqrt{\frac{KE}{\frac{1}{2}m}}$; $v = \sqrt{\frac{30165.75}{(0.5)(15)}}$; $v = \sqrt{4022.1}$; v = 63.42 m/s

g = 9.81 m/s²; $a = \frac{\Delta v}{\Delta t} = \frac{m/s}{s} = \frac{m}{s^2}$

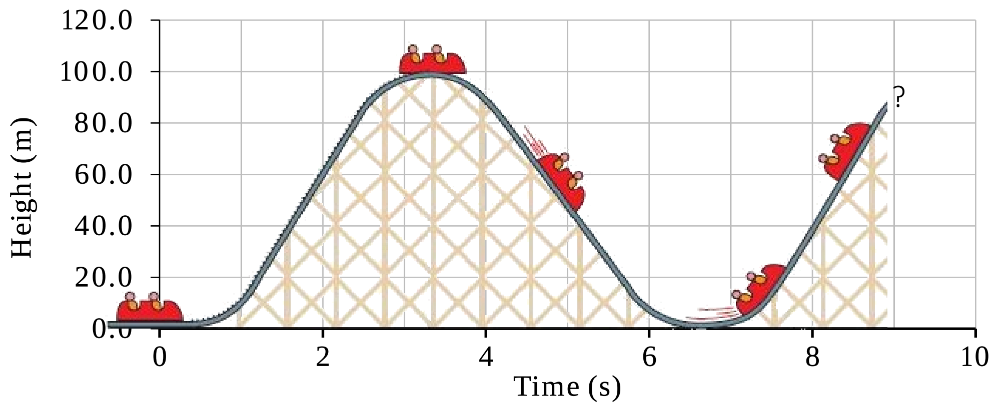
Option #2 (baseball): $KE = PE$; $\frac{1}{2}mv^2 = mgh$; $\frac{\frac{1}{2}v^2}{g} = \frac{gh}{g}$; $h = \frac{\frac{1}{2}v^2}{g}$; $h = \frac{(0.5)(5.63\,m/s)^2}{(9.81)}$; h = 1.6 m

Option #2 (coyote): $PE = KE$; $mgh = \frac{1}{2}mv^2$; $\frac{gh}{\frac{1}{2}} = v^2$; $v = \sqrt{\frac{gh}{\frac{1}{2}}} = \sqrt{\frac{(9.81)(205)}{(0.5)}}$; v = 63.42 m/s

Homework

Assignment #2: Complete the following worksheet in the space provided below

Part 1 – The movement of a 535 kg rollercoaster car has been graphed below. Use the graph to answer the questions below. We will ignore the very real effects of friction and air resistance. Don't forget to show your work in the space provided.



1. What is the potential energy of the rollercoaster car at time 4 s?

$m = 535 kg$ (3 sf)
$h = 90.0 m$ (3 sf)
$g = 9.81 m/s^2$ (3 sf)
$PE = ?$

$PE = mgh$
$= (535)(9.81)(90.0)$
$= 472\,351.5$
$PE = 472000 J$
(or $4.72 \times 10^5 J$)

2. What is the velocity of the rollercoaster car when it reaches the bottom of the track at time 7 s?

– NO PE (all PE has been converted to KE)

$KE = 524300 J$ (3 sf)
$m = 535 kg$ (3 sf)
$v = ?$

$PE = mgh$
$= (535)(9.81)(100)$
$= 524300 J$

$v = \sqrt{\frac{KE}{\frac{1}{2}m}}$

$v = \sqrt{\frac{524300}{\frac{1}{2}(535)}}$

$v = 44.27...$
$v = 44.3 m/s$

3. What is the kinetic energy of the rollercoaster car at time 8s if it has a velocity of 13.0 m/s?

KE = ?
m = 535 kg (3 sf)
v = 13.0 m/s (3 sf)

$KE = \frac{1}{2}mv^2$
$= \frac{1}{2}(535)(13.0)^2$
$= 45207.5$
$= 45200\,J$
(or $4.52 \times 10^4\,J$)

4. How high is the rollercoaster car from question #3 able to coast up the hill between 8 to 10 s?

PE = 45207.5 J (3 sf)
m = 535 kg (3 sf)
g = 9.81 m/s² (3 sf)
h = ?

$h = \frac{PE}{mg}$
$= \frac{45207.5}{(535)(9.81)}$
$= 8.613...$
$h = 8.61\,m$

Part 2 –Word problems. . Don't forget to show your work in the space provided.

5. A 72 kg pole-vaulter running at 8.4 m/s completes a vault. If all of her kinetic energy is transformed into potential energy, what is the maximum height of her vault?

① Find KE:

m = 72 kg (2 sf)
v = 8.4 m/s (2 sf)
KE = ?

$KE = \frac{1}{2}mv^2$
$= \frac{1}{2}(72)(8.4)^2$
$= 2540.16$
$= 2500\,J$

② Find h:

PE = 2540.16 J (2 sf)
m = 72 kg (2 sf)
g = 9.81 m/s² (3 sf)
h = ?

$h = \frac{PE}{mg}$
$= \frac{2540.16}{(72)(9.81)}$
$= 3.5963...$
$= 3.6\,m$

6. A truck parked at the top of a 42.0 m hill has 2.69×10^5 J of potential energy. How fast will the truck be moving when it reaches the bottom of the hill?

① Find mass (from PE):

h = 42.0 m (3sf)
PE = 2.69×10^5 J (3sf)
m = ?
g = 9.81 m/s² (3sf)

$m = \frac{PE}{gh}$
$= \frac{2.69 \times 10^5}{(9.81)(42.0)}$
$= 652.88...$
$= 653 kg$

② Find v (from KE):

m = 652.88... kg (3sf)
v = ?
KE = PE = 2.69×10^5 J (3sf)

$v = \sqrt{\frac{KE}{\frac{1}{2}m}}$
$= \sqrt{\frac{2.69 \times 10^5}{\frac{1}{2}(652.88..)}}$
$= 28.70...$
$= 28.7$ m/s

7. Schwab fires a handgun straight upwards into the air (very foolishly). If the bullet leaves the muzzle of the gun with a velocity of 240 m/s and a kinetic energy of 284 J, how high will the bullet travel?

① Find mass (from KE):

v = 240 m/s (2sf)
KE = 284 J (3sf)
m = ?

$m = \frac{KE}{\frac{1}{2}v^2}$
$= \frac{284}{\frac{1}{2}(240)^2}$
$= 0.00986...$
$= 0.0099 kg$

② Find h (from PE):

m = 0.00986...kg (2sf)
PE = 284 J (3sf)
g = 9.81 m/s² (3sf)
h = ?

$h = \frac{PE}{mg}$
$= \frac{284}{(0.00986..)(9.81)}$
$= 2936.11..$
$= 2900 m$

8. A boulder with a mass of 682 kg is resting on the edge of a 85 m cliff. If it falls off the cliff and lands on top of the coyote, what is its velocity as it strikes the ground?

① Find PE:

m = 682 kg (3sf)
h = 85 m (2sf)
g = 9.81 m/s² (3sf)
PE = ?

$PE = mgh$
$= (682)(9.81)(85)$
$= 568685.7$
$= 570000 J$

② Find v (from KE):

m = 682 kg (3sf)
KE = 568685.7 J (2sf)
v = ?

$v = \sqrt{\frac{KE}{\frac{1}{2}m}}$
$= \sqrt{\frac{568685.7}{\frac{1}{2}(682)}}$
$= 40.837...$
$= 41$ m/s

PART C - ENERGY IS TRANSFORMED IN CHEMICAL REACTIONS

The amount of energy transformed in a chemical reaction is determined by the chemical bonds in the reactants and products.

Different compounds, store different amounts of energy, so when reactant bonds are broken *(requires energy)*, then product bonds are formed *(released energy)* the amount of energy depends on what the compound is.

eg. methane combustion (exothermic)

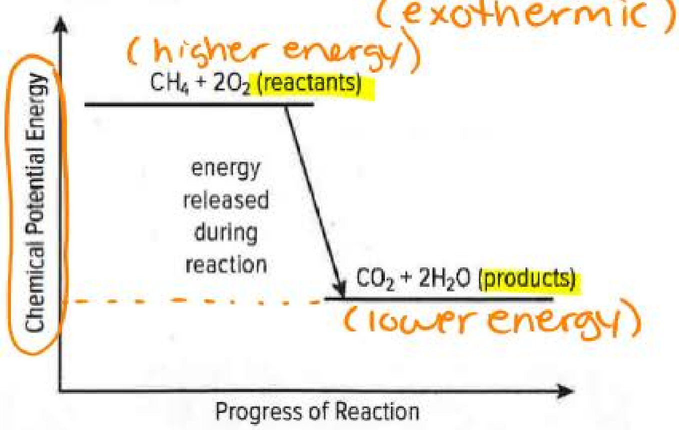
Remember:

- If the reactants are HIGHER in chemical potential energy than the products, energy is released by the system during the reaction.

  The reaction is **EXOTHERMIC**.

- If the reactants are LOWER in chemical potential energy than the products, energy is absorbed from the surroundings during the reaction.

  The reaction is **ENDOTHERMIC**.

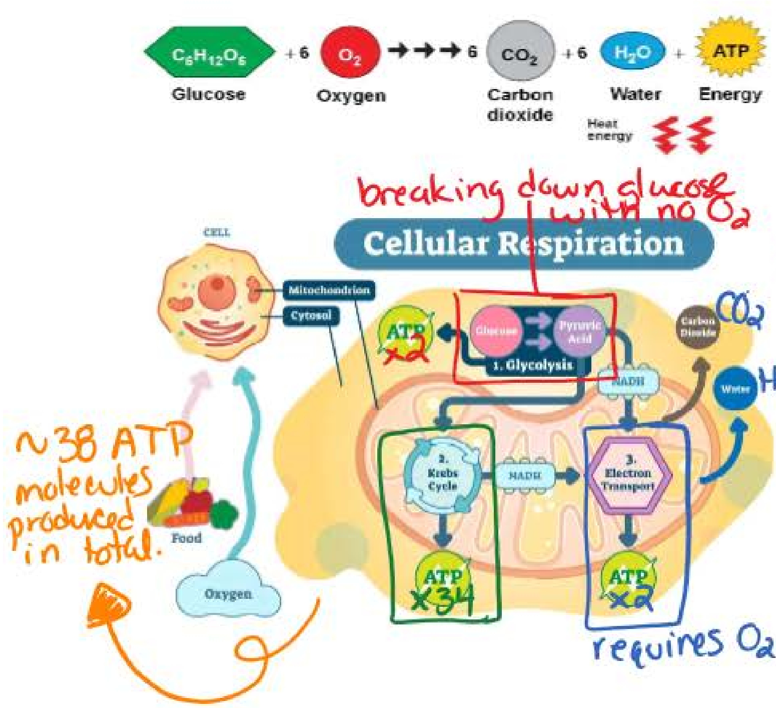


$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g) + \text{energy}$$

Example: When methane reacts with oxygen gas to product carbon dioxide and water, is energy released or absorbed? How can you tell?

• energy is released • products are lower energy than the reactants.

Example 1: Cellular Respiration - ***transforming*** chemical ***PE to carry out life's reactions***



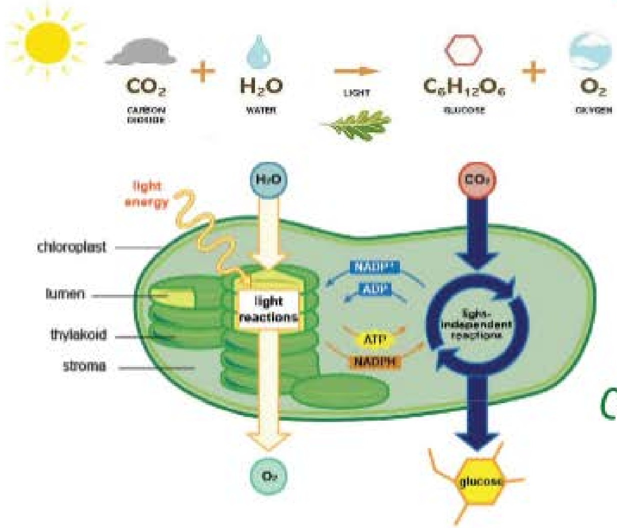
During cellular respiration, living things transform the chemical potential energy in glucose bonds into *adensosine triphosphate* (ATP) which is "cellular energy" used in nearly all reations that ~~requrie~~ require energy in living things.

For example:

ATP is converted to mechanical *KE in your muscle cells to make your muslces contract every time you move.*

ATP can also be converted into electrical *PE used to send signal throughout your nervous system.*

Example 2: Photosynthesis - *transforming* Radiant *KE to ATP in plants*



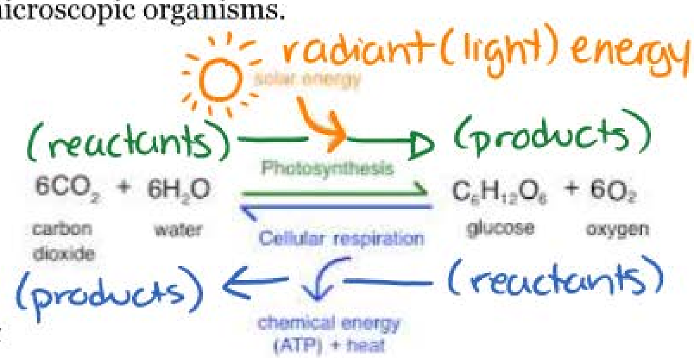
Light energy used during the chemical reaction of CO2 and H2O, to produce glucose and oxygen gas.

During photosynthesis, radiant KE *(light energy from the sun)* is transformed into chemical potential energy stored in the bonds of glucose molecules.

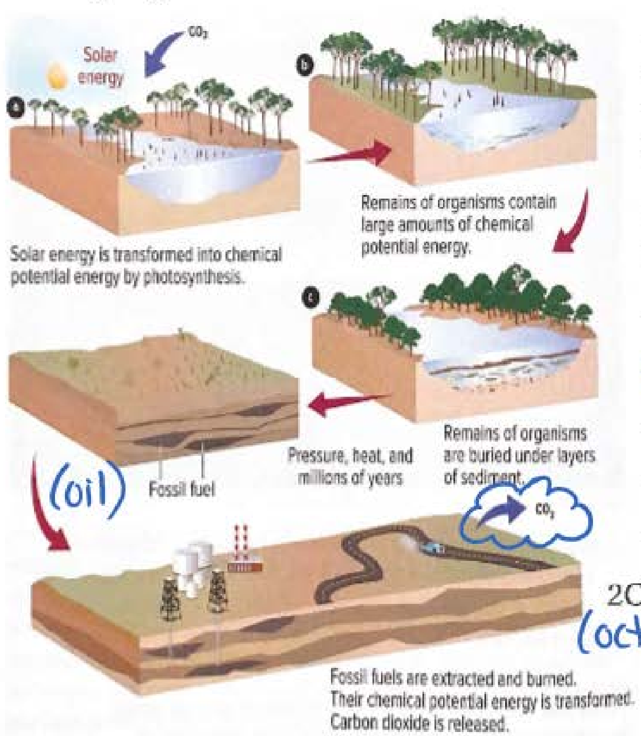
Photosynthesis requires *(orgnaelles)* chlorophyll containing structures called chloroplasts, so it occurs mainly in plants but also some algae and microscopic organisms.

If you thought the Cellular Respiration & Photosynthesis reactions looked similar, you're right!

- *Energy flows into an ecosystem as sunlight and leaves as heat.*
- *Photosynthesis generates O_2 and glucose which are used in cellular respiration.*
- *cells in living things use the chemical PE stored in glucose to regenerate ATP, which fuels cellular work*



Example 3: Fossil Fuel Combustion - *solar energy is transformed into chemical PE*



Fossil fuels contain large amounts of chemical PE that was transformed form solar energy by ancient plants.

Millions of years and high pressure in the earth produces deposits of coal, oil and natural gas.

We extract these energy resources through combustion and processing, which produces a large amount of $CO_{2(g)}$

This gas plays a major role in atmospheric warming and contributes to natural and human-induced climate change

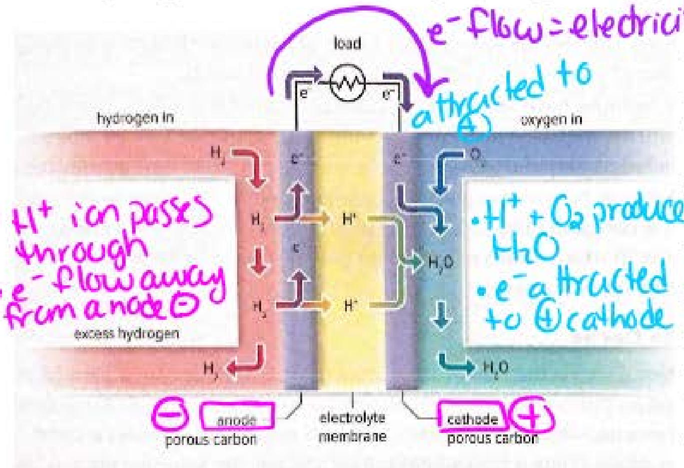
$$2C_8H_{18}(\ell) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(g) + \text{energy}$$

(octane)

↑ produced in large amounts

*also contain contaminants like sulphur + nitrogen which ↑pollution.

Example 4: Fuel Cells - ***other forms of energy with fewer pollutants***



In fuel cells, chemical PE is transformed into ___electrical___ energy when oxygen reacts with hydrogen.

if the fuel cell is 100% efficient, the only product is ___water___.

In this ___Proton___ ___Exchange___ membrane fuel cell, ___H_2___ in tanks and ___O_2___ in air provide a supply of reactants.

This fuel cell produces an electr___on flow (electricity)___ which can run a load, such as a vehicle motor.

An electrolyte membrane lets only hydrogen ions pass to the cathode (+). Electrons from the gas stay on the anode(-). Hydrogen ions that reach the cathode react with electrons and oxygen to form water. The electrons are drawn from the anode, through an external circuit, to the cathode.

Assignment #3: Complete the following questions in the space provided below

1. What factor determines the amount of energy transformed in a chemical reaction?

   The types of chemical bonds, and the type of compound

2. Indicate whether the following statements are true or false. Correct any statements that are false.

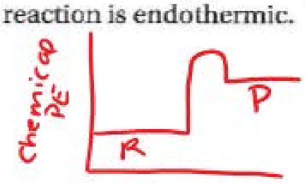
   a) More chemical potential energy is stored in the bonds of some compounds than in others. — True ✓

   b) The materials involved in a chemical reaction can be thought of as a system. — True ✓

   c) Energy released in a chemical reaction ~~is always~~ can be thermal energy (or several other types). — False ✗

   d) If the reactants are higher in chemical potential energy than the products, energy is ~~absorbed from~~ released to the surroundings during the reaction. (exothermic) — False

   e) If the reactants are lower in chemical potential energy than the products, the reaction is endothermic. — True



3. The amount of energy released in cellular respiration is similar to the amount released when methane reacts with oxygen. Why does your body not burn?

   1. It's NOT a combustion reaction
   2. It is "cellular energy" (ATP) a very specific type only used by the cells of living things.
   3. The energy produced is often immediately used by our body in various functions

4. Compare energy transformation in fossil fuel combustion and fuel cells.

   a) How are these processes similar?

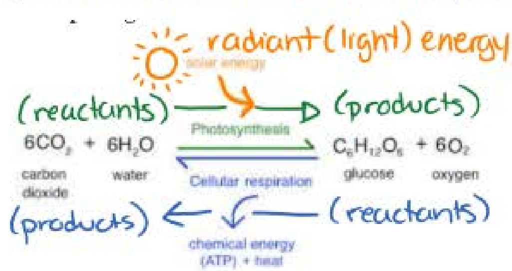
   b) How do they differ?

   a) Both produce large amounts of energy. Water is a product of both reactions. Both used to provide electrical KE.

   b) F.F Combustion (radiant KE-->chemical PE) produces large amounts of CO_2 gas and pollutants. Fuel cells are a more "clean" energy source (chemical PE-->electrical KE), ionization of Hydrogen creates the flow of electrons

7. Describe how the processes of cellular respiration and photosynthesis are connected.

   The products of photosynthesis are the reactants of cellular respiration. The 2 reactions need each other, it is a cycle.



part d - impacts of energy transformation

How Do We Use Energy Transformation?

1. **Powering Machines**
   - ☐ As we have seen, combustion engines transform the chemical PE energy in fuel into KE to turn wheels, spin propellers, and so on
   - ☐ these engines power cars, trucks, trains, lawnmowers and other machines that transport materials and perform difficult manual labour

2. **Generating Electricity**
   - ☐ Most electricity is made by turning electrical devices called generator (basically an electric motor), converting KE into electrical energy
   - ☐ Nuclear power plants use radioactive decay to convert nuclear energy into heat energy, the expansion of the steam creates KE which turns generators => electricity
   - ☐ Coal and natural gas power plants use chemical reactions to convert chemical PE. energy into heat energy, the expansion of the steam creates KE which turns generators => electricity
   - ☐ Hydroelectric dams store huge amounts of PE by keeping reservoirs of water behind the dam, when the water is allowed to flow out it is converted into KE which is used to turn generators => electricity
   - ☐ Wind turbines use the KE of moving air to turn generators => electricity.

Environmental Effects of Energy Transformation

1. **Pollution**
   - ☐ Collecting fuels from the environment (→ coal, natural gas, oil) and running machines releases dangerous substances into the environment that harm organisms, such as heavy metals, CO_2, carcinogens
   - ☐ Machines and electricity also pollute the environment with excess light, sound, heat

2. **Destruction**
   - ☐ Like humans, organisms require a place where they can survive
   - ☐ Fossil fuels (natural gas, oil, coal) and other sources of energy are found in the environment, and harvesting them usually damages or destroys the habitat in the area
   - ☐ As suitable habitats are removed, the species that live there become endangered and eventually go extinct.

hydrocarbons + O_2 → H_2O + CO_2

3. **Carbon Dioxide Production**

- ☐ As we know, the products of combustion reactions are water + carbon dioxide
- ☐ Human use of combustion to power machines and generate electricity has resulted in huge amount of CO_2 released into the atmosphere.
- ☐ Data show this is as much as 1500 Billion tons of CO_2 since 1751, or 1.4 x 10^{15} kg CO_2
- ☐ Some of this CO_2 is absorbed by water in oceans, rivers, and lakes, forming carbonic acid, this acidification harms aquatic organisms
- ☐ Some CO_2 remains in the atmosphere, trapping the Sun's heat and contributing to the natural greenhouse effect, this has resulted in a global temperature increase of about ~1.5°C

Where Do We Go From Here?

- ☐ Steady progress is being made by people around the world to reduce the environmental effects of energy use, your generation needs to continue to improve
- ☐ Our dependence on combustion (→ CO_2) as a source of energy is creating a global environmental crisis: we need to develop and use other sources of energy (solar, wind, nuclear, geothermal, tidal, etc)

Assignment #4: Complete the following worksheet in the space provided below

Unit Review Package

Vocabulary: Referring to your notes, define each of the following vocabulary terms in a complete sentence:

Gravity	Force that attracts objects downwards (on Earth, it causes objects to accelerate at 9.81m/s² downwards).
Kinetic energy	The energy of an object as a result of its movement, measured in joules (J).
Mass	The amount of material inside of an object, measured in kilograms (kg).
Potential Energy	The energy of an object as a result of its position, stresses, or charge, measured in joules (J).
Weight	A force created by a mass experiencing gravity
Velocity	The change in position of an object over time, measured in meters per second (m/s).

Knowledge:

Identify the following as either potential energy or kinetic energy.

Scenario	Type of Energy
11. A bicyclist coasting down a hill reaches the bottom of the hill.	Potential Energy
12. An amusement park ride stops at the top.	Potential Energy
13. A bowling ball rolling down the alley.	Kinetic Energy
14. An archer with his bow drawn.	Potential Energy
15. Sitting in the top of a tree.	Potential Energy
16. A bowling ball sitting on the rack.	Potential Energy

17. What is the formula for kinetic energy? What do the symbols in the formula mean? What are the units for measuring kinetic energy?

$$KE = \frac{1}{2}mv^2$$

KE: Kinetic Energy (J)
m: Mass (kg)
v: Velocity (m/s)

18. What is the formula for potential energy? What do the symbols in the formula mean? What are the units for measuring potential energy?

$$PE = mgh$$

PE: Potential Energy (J)
m: mass (kg)
g: gravity (m/s^2)
h: height (m)

20. Missy Diwater, the former platform diver for the Ringling Brother's Circus had a kinetic energy of 15,400 J just prior to hitting the bucket of water. If Missy's mass is 58 kg, then what is her velocity before hitting the water?

KE = 15400 J (3sf)
m = 58 kg (2sf)
v = ?

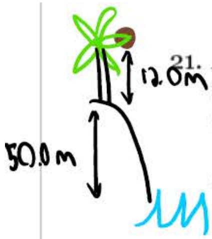
$$v = \sqrt{\frac{KE}{\frac{1}{2}m}}$$

$$= \sqrt{\frac{15400}{\frac{1}{2}(58)}}$$

$$= \sqrt{531.034...}$$

v = 23.044...

v = 23 m/s



21. A coconut of mass 0.870 kg is growing 12.0 m above the ground on a palm tree. The tree is right at the edge of a cliff whose height is 50.0 m above the sea. Calculate the potential energy of the coconut relative to:

a) The ground

$m = 0.870\,kg$ (3sf)
$h = 12.0\,m$ (3sf)
$g = 9.81\,m/s^2$ (3sf)
$PE = ?$

$PE = mgh$
$= (0.870)(9.81)(12.0)$
$= 102.4164$
$= 102\,J$

b) Sea level

$m = 0.870\,kg$ (3sf)
$h = 12.0 + 50.0 = 62.0\,m$ (3sf)
$g = 9.81\,m/s^2$ (3sf)
$PE = ?$

$PE = mgh$
$= (0.870)(9.81)(62.0)$
$= 529.1514$
$= 529\,J$

22. The potential energy of a 48 kg cannon ball on the Moon is 14500 J. How high was the cannon ball above the Moon's surface to have this much potential energy?

$m = 48\,kg$ (2sf)
$PE = 14\,500\,J$ (2sf)
$g = 1.62\,m/s^2$ (3sf)
$h = ?$

$h = \frac{PE}{mg}$
$= \frac{14500}{(48)(1.62)}$
$= 186.4711...$
$= 190\,m$

23. The kinetic energy of a golf ball is measured to be 143.3 J. If the golf ball has a mass of about 0.047 kg, what is its velocity?

$KE = 143.3\,J$ (4sf)
$m = 0.047\,kg$ (2sf)
$v = ?$

$v = \sqrt{\frac{KE}{\frac{1}{2}m}}$
$= \sqrt{\frac{143.3}{\frac{1}{2}(0.047)}}$
$= \sqrt{6097.87...}$

$v = 78.088...$
$v = 78\,m/s$

24. The greatest velocity that a meteoroid can have and still be pulled down to Earth's surface is 7.0×10^4 m/s. If a meteoroid traveling with this velocity has a kinetic energy of 2.56×10^{13} J, what is its mass?

$v = 7.0 \times 10^4$ m/s (2 sf)

$KE = 2.56 \times 10^{13}$ J (3 sf)

$m = ?$

$$m = \frac{KE}{\frac{1}{2}v^2} = \frac{2.56 \times 10^{13}}{\frac{1}{2}(7.0 \times 10^4)^2}$$

$m = 7314.85...$

$m = 73000$ kg

25. A piano with a mass of 272 kg is teetering on the edge of a 30.6 m balcony. If it falls off the balcony, what is its velocity as it hits the ground?

① Find PE:

$m = 272$ kg (3 sf)

$h = 30.6$ m (3 sf)

$g = 9.81$ m/s^2 (3 sf)

$PE = ?$

$PE = mgh$

$= (272)(9.81)(30.6)$

$= 81650.592$

$= 81700$ J

② Find v: (3 sf)

$KE = 81650.592$

$m = 272$ kg (3 sf)

$v = ?$

$$v = \sqrt{\frac{KE}{\frac{1}{2}m}} = \sqrt{\frac{81650.592}{\frac{1}{2}(272)}} = \sqrt{600.372}$$

$= 24.502...$

$= 24.5$ m/s

26. Explain the three environmental effects of human energy transformation.

Human energy transformation results in three main environmental effects:

1. **<u>Pollution</u> – collecting and using sources of energy causes the release of chemicals, light, sound, heat and other agents which negatively affect living organisms**
2. **<u>Habitat Destruction</u> – collecting and using sources of energy causes the destruction of habitat which organisms need to survive**
3. **<u>Carbon Dioxide Production</u> – the combustion of fossil fuels releases CO2 into the atmosphere; some of this is absorbed into the oceans and causes them to become more acidic, some remains within the atmosphere where it enhances the natural greenhouse effect and contributes to climate change** 4

27. A softball is thrown straight upwards into the air at 24.5 m/s, with a kinetic energy of 60.5 J. How high will the ball fly?

① Find m:

$v = 24.5$ m/s (3 sf)

$KE = 60.5$ J (3 sf)

$m = ?$

$$m = \frac{KE}{\frac{1}{2}v^2} = \frac{60.5}{\frac{1}{2}(24.5)^2}$$

$= 0.20158...$

$= 0.202$ kg

② Find h:

$m = 0.20158...$ kg (3 sf)

$PE = 60.5$ J (3 sf)

$g = 9.81$ m/s^2 (3 sf)

$h = ?$

$$h = \frac{PE}{mg} = \frac{60.5}{(0.20158...)(9.81)}$$

$= 30.593...$

$= 30.6$ m