Notes - Energy

- Anything that can cause a change to itself or the environment are said to have energy. If the object is moving or has motion the energy is called kinetic energy. If the object is not moving but has energy then the energy it has is called potential energy.

- To find how much energy an object with motion has we use the equation $E_k = \frac{1}{2} m\vec{v}^2$ where m is mass and $\vec{v}$ is velocity. Please note that the energy is proportional to the mass. If two objects are moving with the same velocity but one is more massive, then that one will have more energy. As well, note that an object will double the velocity will have four times the kinetic energy.

- We know from Newton's second law that $\vec{F}_{net} = m\vec{a}$ and $W = \vec{F}d$ so $W = (ma)d$.

- If the object starts from rest then $v^2 = 2\vec{a}\vec{d}$ or $\vec{d} = \frac{v^2}{2\vec{a}}$ SO $W = ma(\frac{v^2}{2\vec{a}})$ which is $\frac{1}{2} m\vec{v}^2$

-This shows that $W = E_k$.

The work done on an object equals the kinetic energy gained by the object.

- This work is how the work-energy theorem came about. It's summarised as *the net work done on an object is equal to its change in kinetic energy.* Simplified as $W_{net} = \Delta E_k$.

- Ex. – A shotputter heaves a $7.26\ kg$ shot with a final speed of $7.5\frac{m}{s}$. What is the kinetic energy of the shot?

Answer –

- Ex. – The shot was initially at rest. How much work was done on it to give it this kinetic energy?

Answer –

- When you throw a ball up if has kinetic energy you gave it energy as it leaves your hand. The ball decelerates due to gravity and then ultimately stops at the top. At this point the ball has zero kinetic energy. The ball now has potential energy as gravity will do work on it. The AMOUNT of potential energy is equal to the amount of kinetic energy it started with.

- If we measured the energy anywhere through the flight of the ball we would find that the total energy is a combination of the kinetic and the potential energy. This is because as the ball goes up kinetic energy is decreasing while the potential energy is increasing. All of this means that

$$E_{total} = E_k + E_p$$

- We know that $E_k = \frac{1}{2} m\vec{v}^2$ and $E_p = mgh$. The formula for gravitational potential energy $E_p = mgh$, only applies near the surface of the earth as gravitational strength changes to much in high altitudes.

- Ex. – A $2.00\ kg$ textbook is lifted from the floor to a shelf $2.10\ m$ above the floor. What is its gravitational potential energy relative to the floor?

Answer –

- Ex. –What is the gravitational potential energy relative to a $1.65\ m$ tall person?

Answer –

Conservation of Energy

- Much like the section on momentum, energy can change form but in a closed, isolated system energy always remains constant. This understanding is called the law of conservation of energy.

- A closed, isolated system would not be a ball alone, but could be a ball on earth. This is true because the kinetic or potential energy the ball contains could increase or decrease but the sum of the two energies is constant!

- If we look at this ball fall these ideas should come clear. If the weight of the ball is $10\ N$ and it is on a shelf $2.00\ m$ above the ground the ball has energy because of gravity. In fact the ball has potential energy only as it is not moving. The E_p = mgh so the ball has $20\ J$. If the ball rolls and falls half way down the E_p has changed to $10\ J$. How can the energy be less? The energy is NOT less just the E_p has decreased. As the E_p dropped the ball gained speed which means E_k increased. The amount of E_p lost is equal to the amount of E_k gained. So the OVERALL energy is still $20\ J$. This conservation of energy (not counting friction) leads to a formula to solve for energy.

- $E_{ki} + E_{pi} = E_{kf} + E_{pf}$ This says that the initial kinetic plus the initial potential equals the final kinetic plus the final potential.

- Ex. – A chunk of ice of mass $15.0\ kg$ falls of Big Whites Chalet roof which is $8.00\ m$ off the ground. What is the kinetic energy of the ice when it reaches the ground?

Answer –

- Ex. – What is the speed when the ice reaches the ground?

Answer -

Energy of Heat

- If you remember from last year heat is the energy that flows as a result of a temperature difference between substances.

- Specific heat (c) is the amount of energy needed to be added to raise one kilogram one Kelvin. An example would be that $903 \frac{J}{kg} \times K$ is the specific heat capacity of aluminum. Water on the other hand takes $4180\ J$ of energy to increase its energy by one Kelvin. The heat capacity is a constant for each material regardless of the amount of material.

- What we see from this difference is good conductors take less energy to raise the temperature.

- The heat (energy) needed to raise the temperature of a substance can be calculated using the equation $E_h = mc\Delta T$ where E_h is the energy of heat, m is the mass of the sample, c is the specific heat capacity and T is the temperature change.

- Ex. – A $0.400\ kg$ block of iron is heated from $295\ K$ to $325\ K$. How much heat is absorbed by the iron?

Answer –

- Often when working with the energy of heat, a hotter object will be immersed into a medium that is cooler. Ultimately the energy from the hotter object will flow into the cooler object until the overall temperature of both is equal. In these types of problems one needs to realize that the energy being lost from one of the objects is being absorbed by the other. Therefore the overall energy change of the **system** is ZERO!! If this is true then I can set up an equation of the E_h of both items being equal to zero and then substitute what is given to solve for my unknown.

Ex. - A $0.500\ kg$ mass of carbon ($c = 710 \frac{J}{kg} K$) at $50°C$ is placed in $1.00\ kg$ of mercury ($c = 140 \frac{J}{kg} K$) at $80°C$. What will the final temperature of the mixture be?

Answer –

Ex. – A $5.00\ kg$ mass of carbon ($c = 710 \frac{J}{kg} K$) at $373\ K$ is placed in $1.00\ kg$ of water ($c = 4180 \frac{J}{kg} K$) at $293\ K$. What will the final temperature of the mixture be?

Answer –