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FOCUS: Energy

ESSENTIAL QUESTION: Can you describe the relationship between kinetic, potential, and mechanical energy? Can you describe the transformations in kinetic and potential energy within a mechanical system?

What do we already know?

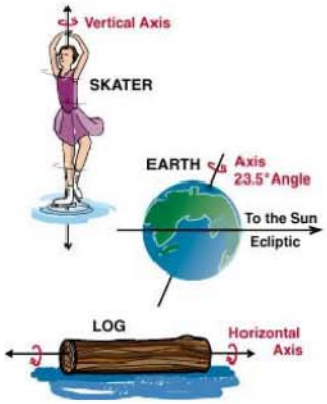
- Energy is the ability to do work.
- Mechanical energy is the energy that is possessed by an object due to its motion (Kinetic energy) or due to its position (potential energy).
- An object that possesses mechanical energy has the ability to do work
- Work is calculated by multiplying force times distance.

What is the difference between kinetic and potential energy?

- Kinetic energy is the energy of motion.

  It can come in many forms:

  - Vibrational kinetic energy: energy of vibrating molecules (Ex: thermal energy, sound waves, light waves, ringing cell phone)



  - Rotational kinetic energy: energy of a turning object (Ex: wheel on a bicycle, Earth spinning on its axis)
  - Translational kinetic energy: energy of an object moving from one position to another (Ex: punted football, coasting skier, falling apple)

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- Potential is the stored energy an object has due to its position. It can also come in many forms:
  - Gravitational potential energy: energy an object has due to its height above Earth's surface (Ex: skydiver in a plane, child hanging on the monkey bars, egg sitting on the counter)
  - Elastic potential energy: energy of an elastic object under tension or compression (Ex: drawn bowstring, stretched rubber band, compressed spring)
  - Chemical potential energy: energy stored within the chemical bonds in a molecule (Ex: food, fuel)
  - Nuclear potential energy: energy stored between the protons and neutrons in an atom's nucleus (Ex: released when Uranium atoms are split to produce nuclear energy in power plants)

So then, what is mechanical energy?

- The mechanical energy of an object is the sum of the object's kinetic and potential energies, or the sum total of all of its ability to do work.
- In other words: ME = KE + PE

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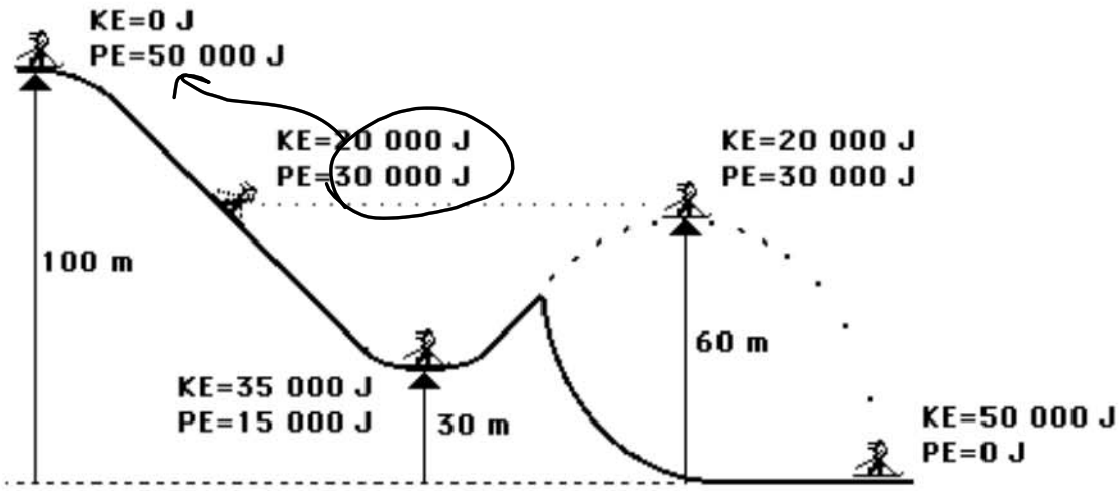
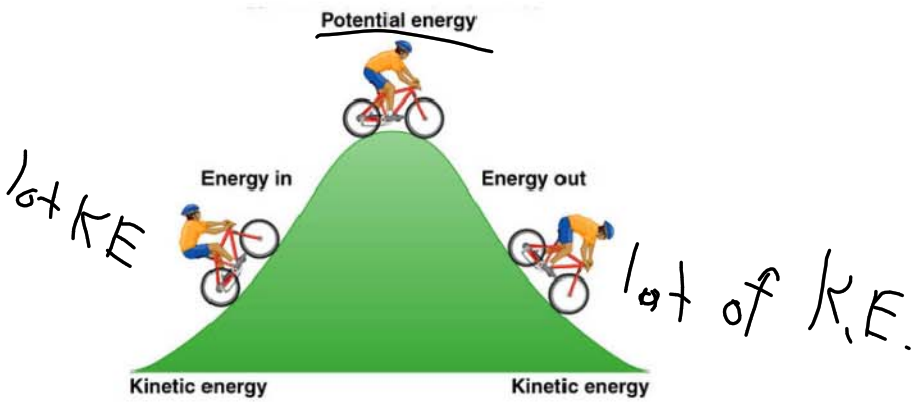
- For example: The diagram below depicts the motion of a ski-jumper as she glides down a slope.



What is the relationship between potential and kinetic energy?

- Within a mechanical system, As PE ↑, KE ↓ and as PE ↓, KE ↑.
- Kinetic energy increases with motion. Potential energy increases with height.



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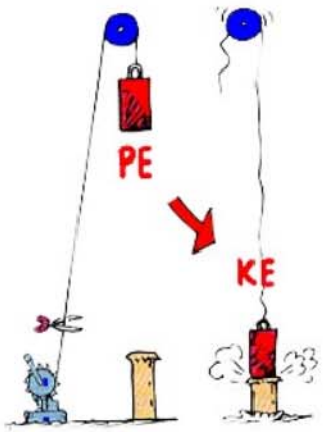
- As more potential energy is stored up in an object, it gives it a greater ability to do work once it is converted to kinetic energy.



How can we study kinetic and potential energy?

- It's easiest to study these transfers of energy within simple mechanical systems.
  - Mechanical System: a system of parts that interact to use a power source in order to accomplish a task using force & motion
- Examples:
  - roller coaster
  - elevator
  - catapult
  - pendulum

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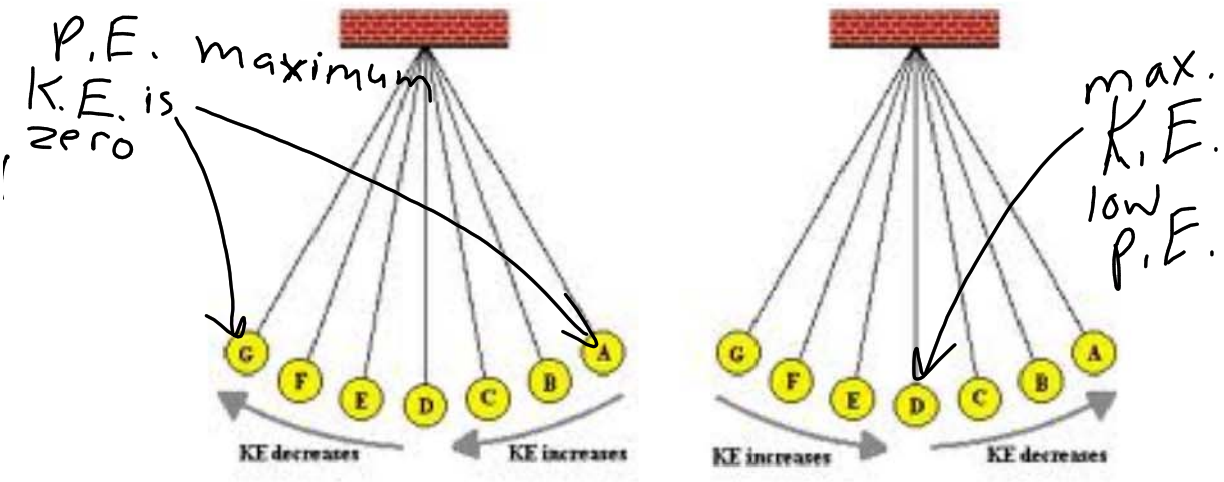

How can kinetic, potential, and mechanical energy be calculated?

- Kinetic Energy = $\frac{1}{2} \times mass \times velocity^2$
  - Units: $K.E. = \frac{1}{2} mv^2$
    mass = kg
    velocity = m/s
    K.E. = J
- Potential Energy = mass x acceleration due to gravity x height
  $P.E. = mgh$
  - Units: mass = kg
    g = m/s^2
    h = m
    P.E. = J
- Mechanical Energy = K.E. + P.E.

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Let's Practice!

$P.E. = m g h$

$\frac{1920J}{60Kg \cdot 9.8m/s} = \frac{60Kg \cdot 9.8m/s \cdot h}{60Kg \cdot 9.8m/s}$

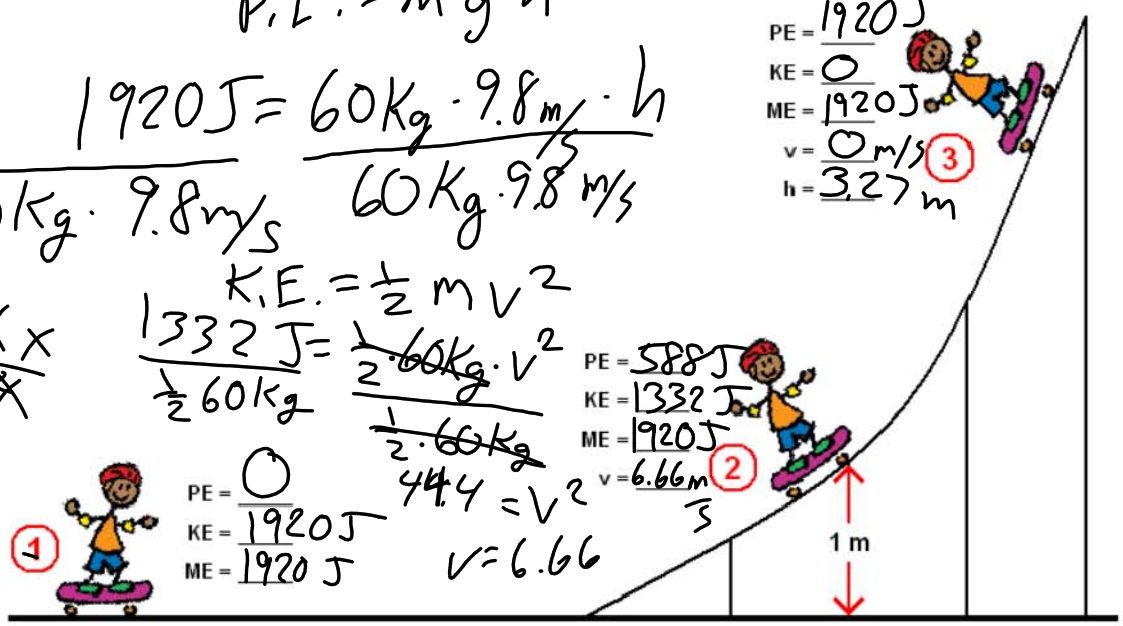
$h = 3.27m$

$K.E. = \frac{1}{2} m v^2$

$\frac{1332J}{\frac{1}{2}60Kg} = \frac{\frac{1}{2} \cdot 60Kg \cdot v^2}{\frac{1}{2} \cdot 60Kg}$

$44.4 = v^2$

$v = 6.66$



$K.E. = \frac{1}{2} m v^2$

$K.E. = \frac{1}{2} \cdot 60Kg \cdot (8 m/s)^2$

$K.E. = 1920J$

$P.E. = m g h$

$PE = 60Kg \cdot 9.8 m/s^2 \cdot 1m$

$PE = 588J$

$ME = KE + PE$

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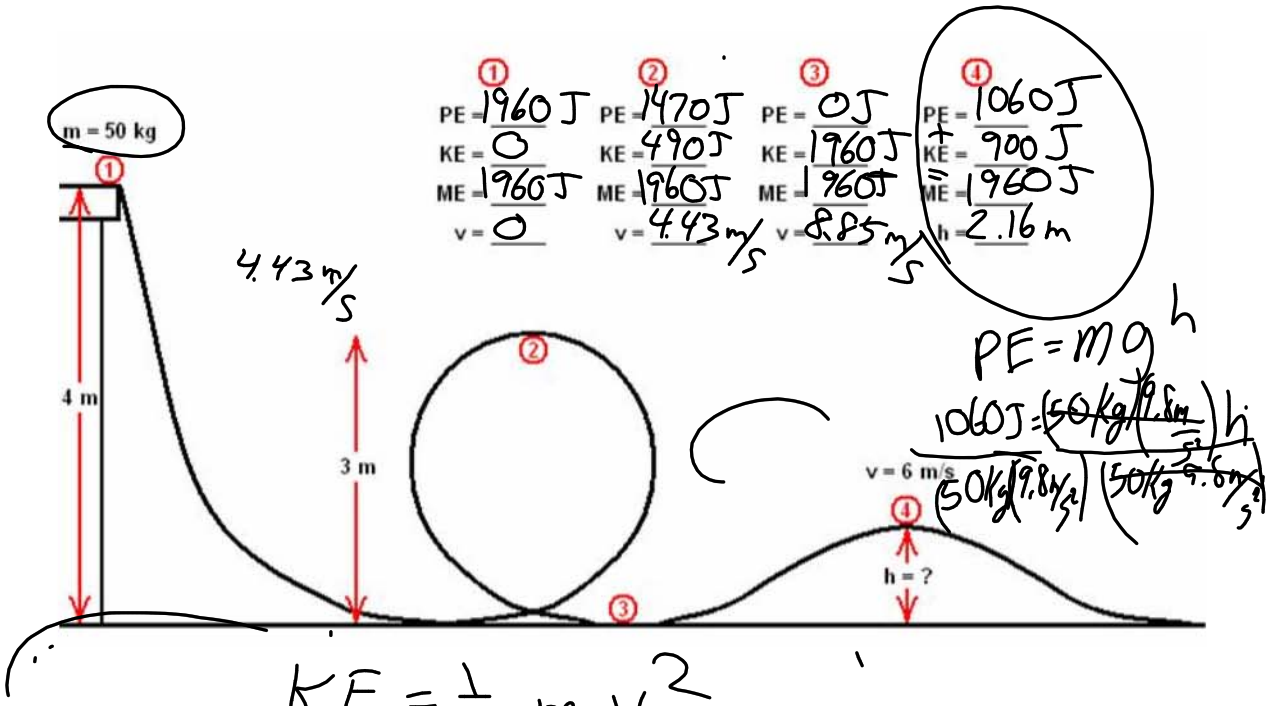


$PE = mgh$

$1060\,J = (50\,kg)(9.8\,m/s^2)h$

$\frac{1060\,J}{(50\,kg)(9.8\,m/s^2)} = \frac{(50\,kg)(9.8\,m/s^2)h}{(50\,kg)(9.8\,m/s^2)}$

$K.E. = \frac{1}{2}mv^2$

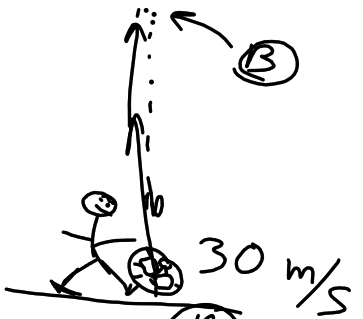
$\frac{1960\,J}{25\,Kg} = \frac{25\,Kg \cdot v^2}{25\,Kg}$

$78.4 = v^2$

$\frac{1}{25\,Kg} \quad 25\,Kg$

$19.6\,\frac{J}{Kg} = v^2$

$v = 4.43\,m/s$



$m = 1\ kg$

$h = 0\ m$

(A) PE = 0 J (B) PE = 450 J

KE = 450 J KE = 0 J

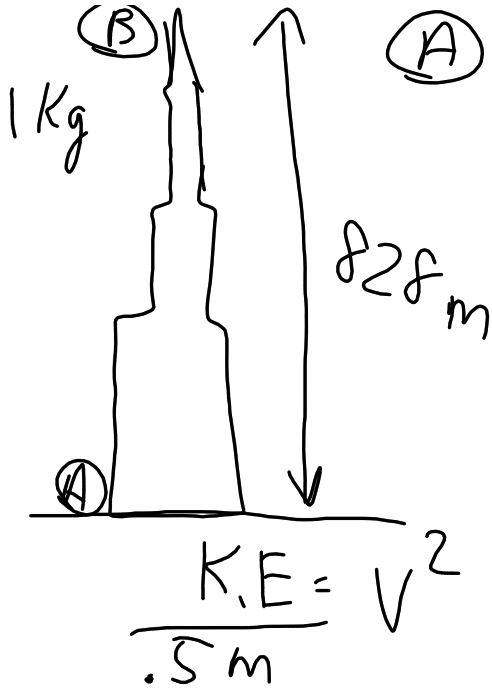
ME = 450 J ME = 450 J

h = _____

$$\frac{PE}{mg} = h$$

$$\frac{450\ J}{(1\ kg)(9.8\ m/s^2)} = h$$

$h \approx 45.92\ m$



(A) P.E = 0 J
K.E = 8114.4 J
M.E = 8114.4 J
V = _____

(B) P.E. = 8114.4 J
K.E. = 0 J
M.E. = _____
h = 828 m
V = 0 m/s

PE = mgh
PE = (1 kg)(9.8 m/s²)(828 m)