Science 10 Energy Unit Name:_____ Block: ____

POTENTIAL ENERGY PROBLEMS

Gravitational potential energy ($\mathbf{E_p}$) is the energy of a mass due to its position in a gravitational force field. For example: when you hike up a hill, you are moving your mass away from the center of the Earth. You are lifting your mass up inside Earth's gravitational force field, and that means that you could fall back down in the future. Because your mass now has the ability to make things move (you falling) , you have more potential energy. You gain $\mathbf{E_p}$ as you climb.

To calculate the $\mathbf{E_p}$ of an object (relative to a place where h = 0), use the following formula:

$$\mathbf{E_p} = mgh$$

Where:

Mass (m) is measured in kilograms (kg)
Gravitational field strength (g) is measured in newtons per kilogram (N/kg)
Height (h) in measured in metres (m) [note: height is measured from some place where we have decided the height is zero]
$\mathbf{E_p}$ is measured in joules (J)

Note: To earn full marks when solving science word problems, you must **Show your work.** Please refer to the problem solving steps given in class. Don't forget to convert units into the proper base units before calculating.

Example Problem:

A ball of mass 1.30 kg is thrown upward and reaches a height of 24.0 m above the ground. What is the potential energy ($\mathbf{E_p}$) of the ball relative to the ground?

Known Values:

m = 1.30 kg
h = 24.0 m
g = 9.80 N/kg (on Earth)
[we can assume we are on Earth unless otherwise mentioned]

Formula: $\mathbf{E_p} = mgh$
$= (1.30)(9.80)(24.0)$
$= 305.76$ (not rounded)
$= 306$ J (rounded, with units)

Practice Questions: (Your solutions should be organized similar to the example problem. Show all your steps please)

1. A goat jumps up in the air and reaches a height of 39.0 m above the surface of the Earth. How much potential energy will the 31.0 kg goat have at this height?

2. If a rock has 250 MJ of potential energy while sitting on the edge of a cliff 42.0 m above the valley floor, what is its mass?

3. The International Space Station is 405 km above the Earth's surface and has a mass of 419 000 kg. If the gravitational field strength is only 8.72 N/kg at this altitude, how much potential energy does the ISS have?

4. If you had a job lifting books from the floor up onto a bookshelf (h = 1.70 m), and the average book had a mass of 1.20 kg, and you had 1000 books to put away, how much extra potential energy would all those books have when you were done? Where did this energy come from?

5. If 9.75 kJ of $\mathbf{E_p}$ was given to a lemon while lifting it, and the lemon had a mass of 218 g, how high was it lifted?

6. How high could a 60.0 kg pole vaulter get above the ground if she could convert 2975 J of energy into $\mathbf{E_p}$?

7. What is the mass of one chocolate chip if throwing it 2.10 m vertically into the air requires 68.5 mJ of energy? (ignoring energy lost to friction)

8. An astronaut jumping on the moon could get his 140 kg of mass (body plus space suit) to a height of 1.73 m above the surface (measured to his center of mass). At this point, his $\mathbf{E_p}$ was only 412 J. What must the gravitational field strength be on the moon?

9. If the mass of an object were to suddenly double, what would happen to it's $\mathbf{E_p}$?

10. If the height of an object were to suddenly double, what would happen to it's $\mathbf{E_p}$?