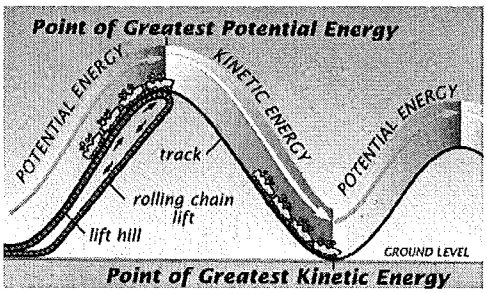
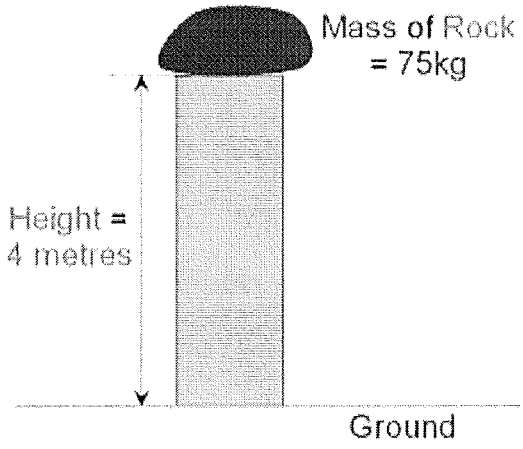
Lesson 5: Gravitational Potential Energy



Does Height affect Potential Energy?

The gravitational potential energy of an object is the energy an object has due to its position. Gravitational potential energy has the symbol PE and is measured in joules.

The equation for the gravitational potential energy is PE = mgh, where m is the mass of the object in kg, h is the height of the object in meters and g is the acceleration due to gravity 9.8m/s^2.



Example: How much gravitational potential energy does a 75kg rock have if it is lifted 4m?

PE = mgh

PE = 75kg x 9.8N/kg x 4m

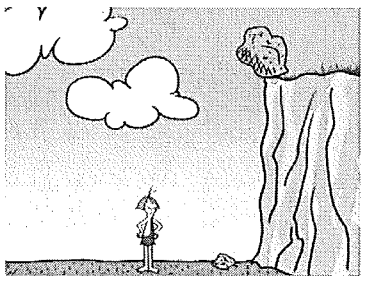
PE = 2940J

Relative potential energy assumes the lowest point in a scenario to have a zero height value. It can be calculated by:

PE = mgh, where h is the the height above a certain point.

Eg. 1: A 10.0kg rock is on top of a house 3.00m high. What is the gravitational potential energy of the rock:

PE = mgh
PE = 10.0kg x 9.80N/kg x 3.0 m
PE = 294J



Eg. 2: A 1500Kg car is lifted on a hoist until it gains 37,000J of potential energy. How high was the car lifted?

PE = mgh
PE/mg = h
h = 37,000J / (1500 kg x 9.80N/kg)
h = 2.6 m

Eg. 3: A bird flying at a height of 120m has 4600J of GPE. What is its mass?

PE = mgh
PE/gh = m
m = 4600J / (9.8N/kg x 120 m)
m = 3.9 Kg

Additional Practice:

Write the formula for potential energy here: PE = mgh

1. Determine the gain in the potential energy when a 4.0 kg rock is raised 18.000 m.

$PE = mgh = 4.0\,kg \times 9.8\,N/kg \times 18.000\,m$
$= 705.6\,J$

2. A leopard with a mass of 55.00 kg climbs 12.0 m up a tree. What is its gain in PE?

$PE = mgh = 55\,kg \times 9.8\,N/kg \times 12\,m = 6468\,J$

3. An aircraft is taking a group of skydivers up into the air. Mr. Vucko is dressed in his parachuting outfit, which brings his mass to a total of 120.0 kg. The aircraft takes the group to a height of 5000.00 m before the jump. How much PE does Mr. Vucko gain before jumping?

$PE = mgh = 120\,kg \times 9.8\,N/kg \times 5000\,m = 5{,}880{,}000\,J$
$5{,}880\,KJ$

4. An owl has a mass of 4.00 kg. It dives to catch a mouse, losing 800.00 J of its GPE. What was the starting height of the owl, in meters?

$PE = mgh \quad \frac{PE}{mg} = h = \frac{800\,J}{(4\,kg \times 9.8\,N/kg)} = 20.4\,m$

5. An astronaut with a mass of 110.0 kg visits the moon (which has a different gravitational force than Earth). The astronaut climbs 5.0 m up the ladder into his spacecraft and gains 880.0 J in GPE. What is the strength of gravity on the moon?

$PE = mgh \quad \frac{PE}{mh} = g = \frac{880\,J}{(110\,kg \times 5\,m)} = 1.6\,N/kg$

6. One of the tallest radio towers on Victoria island is 629.9 m tall. If a bird lands on top of the tower, so that the gravitational potential energy associated with the bird is 2033.76 J, what is its mass, in kilograms?

$PE = mgh$ $\quad \frac{PE}{gh} = m = \frac{2033.76\ J}{(9.8\ N/kg \times 629.9\ m)} = 0.329\ kJ$ or $329\ g$

7. The largest sea turtle found in North America had a mass of 860.24 kg. If the gravitational potential energy associated with the turtle as it was being lifted onto a ship was 20,320.7 J, how high above the water was the turtle when it was lifted?

$PE = mgh$ $\quad \frac{PE}{mg} = h = \frac{20,320.7\ J}{(860.24\ kg \times 9.8\ N/kg)} = 2.41\ m$

8. Which of the following has the most potential energy?

a. car at the top of a hill

b. A car speeding down the hill

c. A person at the top of a hill

Car at top of hill. (more mass and height)

9. One of Mr. Ewan's students went bungee jumping off of a building in China last summer. After several heart-pounding seconds, he leapt from a height of 233 meters. If his weight is 104 kilograms, what would his potential energy be just prior to jumping?

$PE = mgh = 104\ kg \times 9.8\ N/kg \times 233\ m = 237,474\ J$

10. He almost hit the ground but luckily he snapped back up towards the top of the building. What was his potential energy just before hitting the ground?

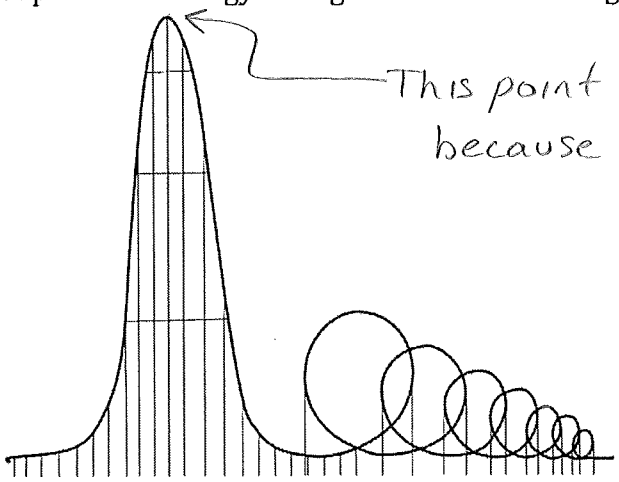
$PE = 104\ kg \times 9.8\ N/kg \times 0\ m = 0\ J$

No potential Energy at the ground.

11. An owl has a mass of 4 kg. It dives to catch a mouse losing 800 J of PE. How high was the bird to begin with?

$PE = mgh$ $\quad \frac{PE}{mg} = h = \frac{800\ J}{(4\ kg \times 9.8\ N/kg)} = 20.4\ m$

12. In the following image of a roller coaster. Label the point where you would have the highest amount of potential energy. Using the formula PE= mgh, explain how you came to that conclusion.



13. A marble is on a table 2.4 m above the ground. What is the mass of the marble if it has a GPE of 568 J.

$PE = mgh \qquad \frac{PE}{gh} = \frac{568\ J}{(9.8\ N/kg \times 2.4\ m)} = 24\ kg$

14. A cart at the top of a 300 m hill has a mass of 40 kg. What is the cart's gravitational potential energy?

$PE = mgh = 40\ kg \times 9.8\ N/kg \times 300\ m = 117{,}600\ J$

15. Find the gravitational potential energy of a light that has a mass of 13.0 kg and is 4.8 m above the ground.

$PE = mgh = 13\ kg \times 9.8\ N/kg \times 4.8\ m$

$= 611.52\ J$