Answer Key

Kinetic and Gravitational Potential Energy Problems

An object positioned above the ground has **gravitational potential energy, E_p.** It can be calculated using the equation:

$$E_P = mgh$$

Where m is the mass of the object (kg), g is the acceleration due to gravity ($9.8 m/s^2$ for objects near Earth) and h is the height (m).

An object that is moving has the ability to do work. The energy of moving objects is called **kinetic energy, E_k.** It is calculated using the following equation:

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

Where m is the mass of the object (kg) and v is its speed (m/s).

1. Find the potential energy of a ball with a mass of 0.5 kg when held at the top of a 6 m ladder.

$E_p = ?$
$m = 0.5kg$
$g = 9.8\ m/s^2$
$h = 6m$

$E_p = mgh$
$= 0.5 \times 9.8 \times 6$
$= 29.4\ J$

2. Calculate the gravitational potential energy of an 8 kg rock placed 8 m above the ground.

$E_p = ?$
$m = 8kg$
$g = 9.8\ m/s^2$
$h = 8m$

$E_p = mgh$
$= 8 \times 9.8 \times 8$
$= 627.2\ J$

3. A crane lifts a 10 kg crate off the ground to a height of 2 m. How much potential energy does the crate have?

$E_p = ?$
$m = 10\ kg$
$g = 9.8 m/s^2$
$h = 2m$

$E_p = mgh$
$= 10 \times 9.8 \times 2$
$= 196\ J$

4. Tony stands on a diving board 11 m above the surface of the water. If he has 6468 J of energy, what is his mass?

$E_p = 6468\ J$
$m = ?$
$g = 9.8\ m/s^2$
$h = 11m$

$E_p = mgh$

$m = \frac{E_p}{gh}$

$= \frac{6468}{9.8 \times 11}$

$= \frac{6468}{107.8}$

$= 60kg$

5. A 2.5 kg textbook is on a desk that is 70 cm high. How much potential energy does the book have? (hint: remember to change cm into m)

$E_p = ?$
$m = 2.5kg$
$g = 9.8m/s^2$
$h = 70cm = 0.7m$

$E_p = mgh$
$= 2.5 \times 9.8 \times 0.7$
$= 17.15J$

6. Matthew has a mass of 65 kg and he is standing on an observation deck looking over the city. If he has 159.25 kJ of energy, how high is the observation deck? (hint: remember to change kJ into J)

$E_p = 159.25kJ = 159\,250J$
$m = 65kg$
$g = 9.8m/s^2$
$h = ?$

$E_p = mgh$
$h = \frac{E_p}{mg}$
$= \frac{159\,250}{65 \times 9.8}$
$= \frac{159\,250}{637}$
$h = 250m$

7. Maggie is flying a plane at a height of 9500 m. Her mass is 55 kg.
   a. How much potential energy does she have in joules?

$E_p = ?$
$m = 55kg$
$g = 9.8m/s^2$
$h = 9500m$

$E_p = mgh$
$= 55 \times 9.8 \times 9500$
$= 5120500J$

   b. How much potential energy does she have in kilojoules?

$J \rightarrow kJ$
$\div 1000$

$\frac{5120500}{1000} = 5120.5\ kJ$

8. Tanya has potential energy of 4900 J standing on a diving board. If her mass is 50 kg, how high is the diving board?

$E_p = 4900J$
$m = 50kg$
$g = 9.8m/s^2$
$h = ?$

$E_p = mgh$
$h = \frac{E_p}{mg}$
$= \frac{4900}{50 \times 9.8}$
$= \frac{4900}{490}$
$= 10\ m$

9. Find the kinetic energy of a family car that has a mass of 980kg when travelling at a speed of 20m/s.

$E_k = ?$
$m = 980\ kg$
$v = 20\ m/s$

$E_k = \frac{1}{2} m v^2$
$= \frac{1}{2} \times 980 \times 20^2$
$= \frac{1}{2} \times 980 \times 400$
$= 196\,000J$

10. What is the kinetic energy of a 2 tonne truck travelling at a speed of 90 km/h? (Hint: remember to change mass into kg and speed into m/s)

$E_k = ?$
$m = 2t = 2000kg$
$v = 90km/h = 25m/s$

$E_k = \frac{1}{2} m v^2$
$= \frac{1}{2} \times 2000 \times 25^2$
$= \frac{1}{2} \times 2000 \times 625$
$= 625\,000J$

11. Calculate the kinetic energy of a 50 g tennis ball travelling at 5 m/s.

$E_k = ?$

$m = 50g = 0.05kg$

$v = 5 m/s$

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

$= \frac{1}{2} \times 0.05 \times 5^2$

$= \frac{1}{2} \times 0.05 \times 25$

$= 0.625 J$

12. Calculate the kinetic energy of a 156 g cricket ball travelling at 72 km/h.

$E_k = ?$

$m = 156g = 0.156kg$

$v = 72 km/h = 20 m/s$

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

$= \frac{1}{2} \times 0.156 \times 20^2$

$= \frac{1}{2} \times 0.156 \times 400$

$= 31.2 J$

13. Calculate the mass of a bird flying at 10 m/s with a kinetic energy of 50 J.

$E_k = 50J$

$m = ?$

$v = 10 m/s$

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

$2E_k = mv^2$

$\frac{2E_k}{v^2} = m$

$m = \frac{2 \times 50}{10^2}$

$= \frac{100}{10^2}$

$= \frac{100}{100}$

$= 1 kg$

14. A skateboarder has 2025 J of kinetic energy. If his mass if 50 kg, at what speed is he travelling?

$E_k = 2025 J$

$m = 50kg$

$v = ?$

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

$2E_k = mv^2$

$\frac{2E_k}{m} = v^2$

$\sqrt{\frac{2E_k}{m}} = v$

$v = \sqrt{\frac{2 \times 2025}{50}}$

$= \sqrt{\frac{4050}{50}}$

$= \sqrt{81} = 9 m/s$

15. A person on a bridge drops a 3 kg stone into the water 5 m below. If the surface of the water is taken as the baseline, calculate:

a. The initial gravitational potential energy of the rock.

$E_p = ?$

$m = 3kg$

$g = 9.8 m/s^2$

$h = 5m$

$E_p = mgh$

$= 3 \times 9.8 \times 5$

$= 147 J$

b. Its kinetic energy just prior to striking the water.

$E_p = E_k$

so $E_k = 147 J$

c. Its speed just prior to striking the water.

$E_k = 147 J$

$m = 3kg$

$v = ?$

$v = \sqrt{\frac{2E_k}{m}}$

$= \sqrt{\frac{2 \times 147}{3}}$

$= \sqrt{\frac{294}{3}}$

$= \sqrt{98} = 9.9 m/s$

16. A 2 kg bag of rice sits on a shelf 2 m above the floor.

a. What is its potential energy?

$E_p = ?$
$m = 2\,kg$
$g = 9.8\,m/s^2$
$h = 2\,m$

$E_p = mgh$
$= 2 \times 9.8 \times 2$
$= 39.2\,J$

b. If the bag of rice fell, how much kinetic energy would the bag of rice have gained by the time it reaches the ground?

$E_p = E_k$

So it gains 39.2 J of kinetic energy

c. What would be the velocity of the bag of rice when it hits the ground?

$E_k = 39.2\,J$
$m = 2\,kg$
$v = ?$

$v = \sqrt{\frac{2E_k}{m}}$
$= \sqrt{\frac{2 \times 39.2}{2}}$
$= \sqrt{\frac{78.4}{2}}$
$= \sqrt{39.2}$
$= 6.3\,m/s$

17. A helicopter is hovering 200 m off the ground when a loose object from inside the cabin falls out. Assuming the initial velocity of the object while in the cabin is 0 m/s and ignoring air resistance, calculate the velocity of the object just before it hits the ground.

$E_p = ? = E_k$
$m = ?$
$g = 9.8\,m/s^2$
$h = 200\,m$
$v = ?$

$E_{p(start)} = E_{k(end)}$
$mgh = \frac{1}{2}mv^2$
$gh = \frac{1}{2}v^2$
$2gh = v^2$
$\sqrt{2gh} = v$

$v = \sqrt{2gh}$
$= \sqrt{2 \times 9.8 \times 200}$
$= \sqrt{3800}$
$= 61\,m/s$

18. In archery, the bow can store 50 J of elastic potential energy. If all of this is converted to the kinetic energy of the 0.25 kg arrow, find the arrow's speed just after being fired.

$E_p = 50\,J = E_k$
$m = 0.25\,kg$
$v = ?$

$v = \sqrt{\frac{2E_k}{m}}$
$= \sqrt{\frac{2 \times 50}{0.25}}$
$= \sqrt{\frac{100}{0.25}}$
$= \sqrt{400}$
$= 20\,m/s$