

**Energy: Mechanical Energy**

• **Mechanical energy of an object = kinetic energy + potential energy.**

$E_M = E_k + E_p$

• **Law of Conservation of Energy** states that energy cannot be created or destroyed – it can only be converted from one form into another or transferred from one object to another.

• **Law of Conservation of Mechanical Energy:**

The **mechanical energy** (sum of potential and kinetic energy) of a body is conserved if it **moves under the influence of its weight only (or no unbalanced external force).**

• It is applied whenever an object changes height under the influence of its weight only.

• **( $E_k + E_p$ ) top = ( $E_k + E_p$ ) bottom** (Never use ( $E_p$ ) top = ( $E_k$ ) bottom!!)

• For pendulums, equations of motion may **not** be used, because equations of motion apply only to objects moving in a **straight line** with **constant acceleration**, which is not the case here.

However, the Law of Conservation of Mechanical Energy may be used for pendulums.

• For pendulums and free-falling objects (with velocity = 0 at highest point):

$(E_k + E_p)_{\text{top}} = (E_k + E_p)_{\text{bottom}}$

$0 + mgh = \frac{1}{2}mv^2 + 0$                        $mgh = \frac{1}{2}mv^2$

$v = \sqrt{2gh}$

**NB!** The **velocity at the lowest point depends on the height only and not the mass of the object or the path followed.**

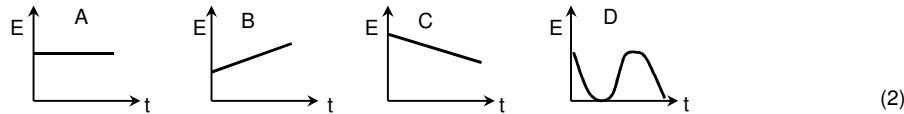
**Exercise 47:**

1 Give ONE word/term for

1.1 the law that states that the sum of the gravitational potential energy and the kinetic energy in a closed system remains constant when an object moves under the influence of its weight. (1)

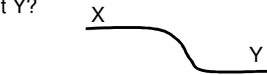
1.2 the sum of potential and kinetic energy. (1)

2 A trolley starts at rest from P and travels to S along a frictionless track, which is shaped as shown. Air resistance is negligible. Which graph best represents the total mechanical energy (E) of the trolley as it moves along the track?

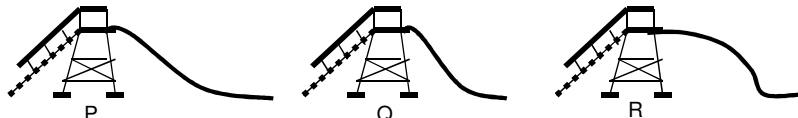


3 Two toy cars, one with a mass of M, and the other with a mass of 2M, start from rest at X. They are allowed to run down a smooth track to Y. The friction is negligible. How will the velocities of the cars compare when they reached point Y?

- A Both cars will have the same velocity.
- B The car of mass 2M will have the greater velocity.
- C The car of mass M will have the greater velocity.

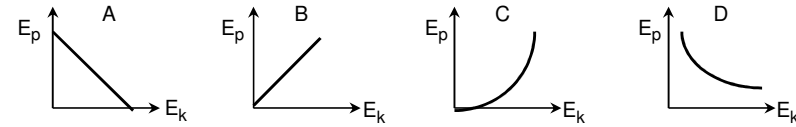


4 Three playground slides of different shapes are shown. A young girl slides down each one in turn. Ignoring friction, for which slide would her speed at the bottom be the greatest?

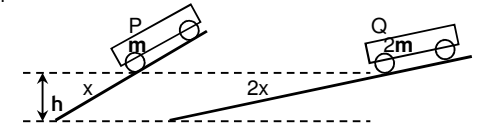


- A Slide P
- B Slide Q
- C Slide R
- D Her speed would be the same for all.

5 Which ONE of the following graphs best represents the relationship between the potential energy and the kinetic energy of a free falling object dropped from rest above the ground? (2)



6 Trolley P, mass m, and another trolley Q, mass 2m, are released from rest from the same vertical height h and run down two tracks of length x and 2x respectively. Disregard all frictional forces. What is the speed of Q at the bottom of its slope if P has a speed of v at the bottom of its slope?



- A  $4v$
- B  $2v$
- C  $\sqrt{2}v$
- D  $v$

7 A stone is dropped from the top of a building. After 2 s the stone will have ... than it had at the top of the building.

- A greater gravitational potential energy
- B less kinetic energy
- C greater kinetic energy
- D less mechanical energy

8 A ball of mass m is dropped from a height h above the ground. Air friction can be ignored. The speed with which the object strikes the ground is ...

- A directly proportional to the height of the fall.
- B directly proportional the mass of the ball.
- C independent of the mass of the ball.
- D directly proportional to the acceleration of the ball.

9 A ball, mass 0,2 kg, is dropped from a height of 3 m above the ground. Air friction can be ignored. The kinetic energy of the ball when it hits the ground, is ...

- A 0 J
- B 5,88 J
- C 0,65 J
- D 2,43 J

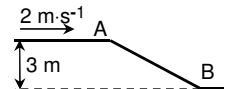
10 The mechanical energy of an object falling from a very high building against air resistance ...

- A increases.
- B decreases.
- C remains the same.
- D decreases and then increases.

11 A parachutist is descending towards the ground at a constant velocity of 7 m·s<sup>-1</sup>. At a height of 300 m above the ground, his watch of mass 40 g falls off.

- 11.1 Explain what is meant by the term 'conservation of mechanical energy'. (3)
- 11.2 Explain in which of the above cases, with or without air friction, mechanical energy is **not** conserved. (5)

12 A skateboarder of mass 50 kg rolls along a horizontal surface A at a speed of 2 m·s<sup>-1</sup>. He then rolls down the incline to horizontal surface B, which is 3 m below A. Assume that friction is negligible. Make use of the principle of conservation of mechanical energy to calculate the speed of the skateboarder on reaching surface B (correct to one decimal place). (10)



13 A boy with a mass of 45 kg, jumps with a horizontal speed of 5 m·s<sup>-1</sup> onto a stationary skateboard, with a mass of 5 kg, resting on the horizontal surface of a skateboard ramp. The speed of the boy is 4,5 m·s<sup>-1</sup> immediately after he has jumped onto the skateboard. After jumping onto the skateboard, the boy on the skateboard moves up the plane inclined to the horizontal surface. Through what vertical height will the boy on the skateboard rise before coming to a stop? (Ignore all frictional effects.) (5)