

EXERCISE 2(B)

Solutions:

Kinetic energy and potential energy are the two forms of mechanical energy.

Solutions:

Wound up watch spring possesses an elastic potential energy.

Solutions:

- (a) Kinetic energy (K)
- (b) Potential energy (U)
- (c) Kinetic energy (K)
- (d) Potential energy (U)
- (e) Kinetic energy (K)
- (f) Potential energy (U)

Solutions:

Potential energy is defined as the energy possessed by a body at rest due to its position or size and shape is called the potential energy.

Different forms of potential energy are as follows:

(i) Gravitational potential energy: The potential energy possessed by a body due to the force of attraction of the earth on it, is called its gravitational potential energy.

Example: Due to its raised height, a stone at a height has gravitational potential energy.

(ii) Elastic potential energy: The potential energy possessed by a body in the deformed

state due to change in its size and shape is called the elastic potential energy.

Example: Due to its compressed state, a compressed spring has elastic potential energy.

Solutions:

The body possesses potential energy even when it is not in motion. For example: due to its raised position, a stone at a height has the gravitational potential energy.

Question: 6

What is meant by gravitational potential energy? Derive an expression for it for a body placed at a height above the ground.

Solutions:

Gravitational potential energy is defined as the potential energy possessed by a body due to the force of attraction of the earth on it, is called its gravitational potential energy.

The gravitational potential energy of a body placed at height above the ground is measured by the work done in lifting it up to that height against the force of gravity.

Let a body of mass m from the ground be lifted to a height h vertically. The force of gravity (mg) on the body acting vertically downwards must be equal to the least upward force F required to lift the body. The work done W on the body in lifting it to a height h is

$W = \text{force of gravity (mg)} \times \text{displacement (h)}$

$$W = mgh$$

This work is stored in the body in the form of its gravitational potential energy when it is at a height h . Hence,

$$\text{Gravitational potential energy } U = mgh$$

Question: 7

Write an expression for the potential energy of a body of mass m placed at a height h above the earth's surface. State the assumptions made, if any.

Solutions:

The work done on the body in lifting it to a height h is

$$W = \text{force of gravity (mg)} \times \text{displacement (h)}$$

$$= mgh$$

Thus, this work is stored in the body in the form of its gravitational potential energy when it is at a height h .

$$\text{Gravitational potential energy } U = mgh$$

Question: 8

What do you understand by the kinetic energy of a body?

Solutions:

Kinetic energy is possessed by a body in motion. So, the energy possessed by a body due to its state of motion is called the kinetic energy.

Question: 9

(a) A body of mass m is moving with a velocity v . Write the expression for its kinetic energy.

(b) Show that the quantity $2K/v^2$ has the unit of mass, where K is the kinetic energy of the body.

Solutions:

(a) The expression for a body of mass m moving with a velocity v is given by

$$\begin{aligned}\text{Kinetic energy} &= 1/2 \times \text{mass} \times (\text{velocity})^2 \\ &= 1/2 mv^2\end{aligned}$$

$$\begin{aligned}\text{(b) } 2K/v^2 &= \text{Joules} / (\text{ms}^{-1})^2 \\ &= (\text{kgms}^{-2} \times \text{m}) / \text{m}^2\text{s}^{-2} \\ &= \text{kg}\end{aligned}$$

Kg is the unit of mass

Question: 10

State the work–energy theorem.

Solutions:

According to the work theorem, the work done by a force in the same direction on a moving body is equal to the increase in its kinetic energy.

Question: 11

A body of mass m is moving with a uniform velocity u . A force is applied on the body due to which its velocity increases from u to v . How much work is being done by the force?

Solutions:

Let a body of mass m moving with an initial velocity u . When force is applied on the body along its direction of motion, an acceleration ‘ a ’ is produced and the velocity of the body changes from u to v in moving a distance S . So,

Work done by the force = force \times displacement

$$W = F \times S \quad (1)$$

$$\text{From relation } v^2 = u^2 + 2aS$$

$$\text{Displacement, } S = (v^2 - u^2) / 2a$$

$$\text{Force, } F = ma$$

Substituting the values of F and S in equation (1), we get

$$W = F \times S$$

$$W = ma \times (v^2 - u^2) / 2a$$

$$= 1 / 2 mv^2 - 1 / 2 mu^2$$

$$W = k_f - k_i$$

Hence, work done on the body is equal to increase in kinetic energy.

$$W = 1 / 2 m (v^2 - u^2)$$

Question: 12

A light mass and a heavy mass have equal momentum. Which will have more kinetic energy?

Solutions:

Kinetic energy and momentum are related as

$$K = p^2 / 2m \quad \text{where } p \text{ is momentum and } k \text{ is kinetic energy}$$

Both masses have same momentum p. The kinetic energy k is inversely proportional to mass of the body

Hence, a body of light mass has more kinetic energy because smaller the mass, larger is the kinetic energy.

Question: 13

Two bodies A and B of masses m and M ($M \gg m$) have same kinetic energy. Which body will have more momentum?

Solutions:

Kinetic energy is related to momentum and mass as

$$p = \sqrt{2mk}$$

Since the kinetic energy of both bodies are same, momentum is directly proportional to square root of mass

Mass of body B is greater than that a body A

Therefore body B will have more momentum than body A.

Question: 14

Name the three forms of kinetic energy and give one example of each.

Solutions:

The three forms of kinetic energy are:

(i) Translational kinetic energy

Example: A car moving in a straight path.

(ii) Rotational kinetic energy

Example: A rotational wheel

(iii) Vibrational kinetic energy

Example: In a solid, the atoms vibrate about their mean positions.

Question: 15

State two differences between the potential energy and the kinetic energy.

Solutions:

Potential energy	Kinetic energy
It can change only in the form of kinetic energy.	It can change into any other form
It does not depend on the speed of the body	It depends on the speed of the body

Question: 16

Complete the following sentences:

(a) The kinetic energy of a body is the energy by virtue of its _____.

(b) The potential energy of a body is the energy by virtue of its _____.

Solutions:

(a) The kinetic energy of a body is the energy by virtue of its motion.

(b) The potential energy of a body is the energy by virtue of its position.

Question: 17

When an arrow is shot from a bow, it has kinetic energy in it. Explain briefly from where does it get its kinetic energy?

Solutions:

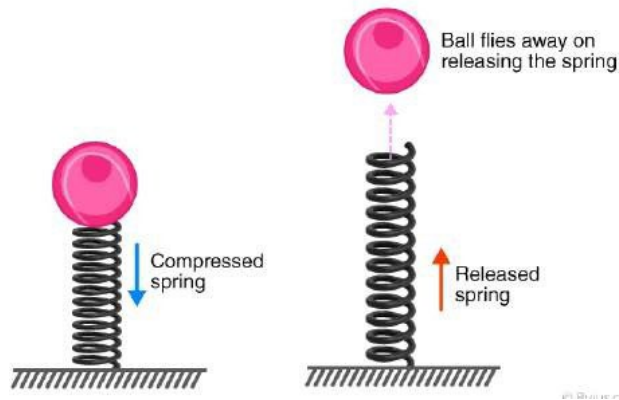
When the string of a bow is pulled, the work done is stored in the deformed state of the bow which is in the form of its elastic potential energy. When the string is released to shoot an arrow, the potential energy of the bow changes into the kinetic energy of the arrow which makes to move.

Question: 18

A ball is placed on a compressed spring. What form of energy does the spring possess? On releasing the spring, the ball flies away. Give a reason.

Solutions:

Due to the compressed state, the compressed spring has elastic potential energy. The potential energy of the spring changes into kinetic energy when it is released, which does work on the ball if placed on it and changes into kinetic energy of the ball due to which it flies away.



Question: 19

A pebble is thrown up. It goes to a height and then comes back on the ground. State the different changes in form of energy during its motion.

Solutions:

When the pebble is thrown upwards, the kinetic energy in it is converted to potential energy. Its kinetic energy is completely converted into potential energy at the top point in its motion. The potential energy is converted into kinetic energy while coming down and at the bottom the potential energy is completely converted to kinetic energy.

Question: 20

In what way does the temperature of water at bottom of a waterfall differ from the temperature at the top? Explain the reason.

Solutions:

During the fall of water from the height, the potential energy stored in water at a height changes into the kinetic energy. On striking the ground, a part of kinetic energy of water changes into the heat energy which increase the temperature of water.

Question: 21

Name the form of energy in which potential energy can change.

Solutions:

The potential energy can change only in the form of kinetic energy.

Question: 22

Name the form of mechanical energy, which is put to use.

Solutions:

Kinetic energy

Question: 23

Name six different forms of energy?

Solutions:

The six different forms of energy are

- (i) Solar energy
- (ii) Heat energy
- (iii) Light energy
- (iv) Hydro energy
- (v) Nuclear energy
- (vi) Mechanical energy

Question: 24

Energy can exist in several forms and may change from one form to another. For each of the following, state the energy changes that occur in:

- (a) the unwinding of a watch spring
- (b) a loaded truck when started and set in motion,
- (c) a car going uphill,
- (d) photosynthesis in green leaves,
- (e) charging of a battery,
- (f) respiration,
- (g) burning of a match stick,
- (h) explosion of crackers.

Solutions:

- (a) Potential energy of a watch spring converts into kinetic energy
- (b) Chemical energy of diesel or petrol converts into mechanical energy
- (c) Kinetic energy converts into potential energy
- (d) Light energy converts into chemical energy
- (e) Electrical energy converts into chemical energy
- (f) Chemical energy converts into heat energy
- (g) Chemical energy converts into heat and light energy
- (h) Chemical energy converts into heat, light and sound energy

Question: 25

State the energy changes in the following cases while in use:

- (a) Loudspeaker
- (b) A steam engine
- (c) Microphone
- (d) Washing machine
- (e) A glowing electric bulb
- (f) Burning coal
- (g) A solar cell

- (h) Bio-gas burner
- (i) An electric cell in a circuit
- (j) A petrol engine of a running car
- (k) An electric iron
- (l) A ceiling fan
- (m) An electromagnet.

Solutions:

- (a) Electrical energy changes into sound energy
- (b) Heat energy changes into mechanical energy
- (c) Sound energy changes into electrical energy
- (d) Electrical energy changes into mechanical energy
- (e) Electrical energy changes into light energy
- (f) Chemical energy changes into heat energy
- (g) Light energy changes into electrical energy
- (h) Chemical energy changes into heat energy
- (i) Chemical energy changes into electrical energy
- (j) Chemical energy changes into mechanical energy
- (k) Electrical energy changes into heat energy
- (l) Electrical energy changes into mechanical energy
- (m) Electrical energy changes into magnetic energy

Question: 26

Name the process used for producing electricity from the nuclear energy.

Solutions:

The process used for producing electricity from the nuclear energy is nuclear fission

Question: 27

Is it practically possible to convert a form of energy completely into the other useful form? Explain your answer.

Solutions:

No. Because, whenever there is a conversion of energy completely into other useful form, a part of energy is dissipated in the form of heat which is lost to the surroundings.

Question: 28

What is degraded energy?

Solutions:

During the transformation of energy from one form to another, a part of energy gets convert to some undesirable form or a part of it is lost to the surroundings due to the friction or radiations which cannot be used for productive purpose. This is known as

dissipation of energy or degradation of energy.

Question: 29

What do you mean by degradation of energy? Explain it by taking one example of your daily life.

Solutions:

During the transformation of energy from one form to another, a part of energy gets convert to some undesirable form or a part of it is lost to the surroundings due to the friction or radiations which cannot be used for productive purpose. This is known as dissipation of energy or degradation of energy.

Example: During the glow of light bulb, a major part of electrical energy utilised is converted to heat energy while some part is converted to useful light energy.

Question: 30

Complete the following sentence:

The conversion of part of energy into an undesirable form is called..... .

Solutions:

The conversion of part of energy into an undesirable form is called degradation of energy.

MULTIPLE CHOICE TYPE

Question: 1

A body at a height possesses:

- a. Kinetic energy**
- b. Potential energy**
- c. Solar energy**
- d. Heat energy**

Solutions:

A body at a height possesses potential energy.

Question: 2

In an electric cell while in use, the change in energy is from:

- a. Electrical to mechanical**
- b. Electrical to chemical**
- c. Chemical to mechanical**
- d. Chemical to electrical**

Solutions:

In an electric cell while in use, the change in energy is from chemical to electrical

NUMERICALS

Question: 1

Two bodies of equal masses are placed at heights h and $2h$. Find the ratio of their gravitational potential energies.

Solutions:

$$\text{Height } H_1 = h$$

$$\text{Height } H_2 = 2h$$

$$\text{Mass of body 1} = m$$

$$\text{Mass of body 2} = m$$

$$\text{Gravitational potential energy of body 1} = mgH_1$$

$$= mgh$$

$$\text{Gravitational potential energy of body 2} = mgH_2$$

$$= mg(2h)$$

$$\text{Ratio of gravitational potential energies} = mgh / mg(2h)$$

$$= mgh / 2mgh$$

$$= 1 / 2$$

$$= 1 : 2$$

Question: 2

Find the gravitational potential energy of 1kg mass kept at a height of 5m above the ground if $g = 10\text{ms}^{-2}$.

Solutions:

Given

$$\text{Mass, } m = 1 \text{ kg}$$

$$\text{Height, } h = 5 \text{ m}$$

$$\text{Gravitational potential energy} = mgh$$

$$= 1 \times 10 \times 5$$

$$= 50 \text{ J}$$

Question: 3

A box of weight 150 kgf has gravitational potential energy stored in it equal to 14700 J. Find the height of the box above the ground.

Solutions:

$$\text{Gravitational potential energy} = 14700 \text{ J}$$

$$\text{Force of gravity} = mg$$

$$= 150 \times 9.8 \text{ N/kg}$$

$$= 1470 \text{ N}$$

$$\text{Gravitational potential energy} = mgh$$

$$14700 = 1470 \times h$$
$$h = 10 \text{ m}$$

Question: 4

A body of mass 5 kg falls from a height of 10 m to 4 m. Calculate:

- (i) the loss in potential energy of the body,
(ii) the total energy possessed by the body at any instant? (Take $g = 10 \text{ ms}^{-2}$).

Solutions:

- (i) Mass of the body, $M = 5 \text{ kg}$

$$\text{Potential energy at height } 10 \text{ m} = mgh$$
$$= 5 \times 10 \times 10$$
$$= 500 \text{ J}$$

$$\text{Potential energy at height } 4 \text{ m} = mgh$$
$$= 5 \times 10 \times 4$$
$$= 200 \text{ J}$$

$$\text{Loss in potential energy} = (500 - 200) \text{ J}$$
$$= 300 \text{ J}$$

- (ii) The total energy possessed by the body at any instant remains constant for free fall

It is equal to the sum of P.E and K.E

Thus, at height 10 m, K.E = 0

Therefore total energy = P.E + K.E

$$\text{Total energy} = 500 + 0$$
$$= 500 \text{ J}$$

Question: 5

Calculate the height through which a body of mass 0.5 kg is lifted if the energy spent in doing so is 1.0 J. Take $g = 10\text{m/s}^{-2}$.

Solutions:

Given

Mass = 0.5 kg

Energy = 1 J

Gravitational potential energy = mgh

$$1 = 0.5 \times 10 \times h$$

$$1 = 5h$$

$$h = 1 / 5$$

$$h = 0.2 \text{ m}$$

Question: 6

A boy weighing 25 kgf climbs up from the first floor at height of 3 m above the

ground to the third floor at height of 9 m above the ground. What will be the increase in his gravitational potential energy?

(Take $g=10 \text{ N kg}^{-1}$).

Solutions:

$$\begin{aligned}\text{Force of gravity on boy} &= mg \\ &= 25 \times 10 \\ &= 250 \text{ N}\end{aligned}$$

$$\begin{aligned}\text{Increase in gravitational potential energy} &= Mg (h_2 - h_1) \\ &= 250 \times (9 - 3) \\ &= 250 \times 6 \\ &= 1500 \text{ J}\end{aligned}$$

Question: 7

A vessel containing 50 kg of water is placed at a height 15m above the ground.

Assuming the gravitational potential energy at ground to be zero, what will be the gravitational potential energy of water in the vessel? ($g = 10\text{ms}^{-2}$).

Solutions:

Given

$$\text{Mass of water, } m = 50 \text{ kg}$$

$$\text{Height, } h = 15 \text{ m}$$

$$\text{Gravitational potential energy} = mgh$$

$$= 50 \times 10 \times 15$$

$$= 7500 \text{ J}$$

Question: 8

A man of mass 50 kg climbs up a ladder of height 10m. Calculate: (i) the work done by the man, (ii) the increase in his potential energy.

($g= 9.8\text{m s}^{-2}$).

Solutions:

Given

$$\text{Mass of man} = 50 \text{ kg}$$

$$\text{Height of ladder, } h_2 = 10 \text{ m}$$

$$\text{(i) Work done by man} = mgh_2$$

$$= 50 \times 9.8 \times 10$$

$$= 4900 \text{ J}$$

$$\text{(ii) Increase in his potential energy}$$

$$\text{Height, } h_2 = 10 \text{ m}$$

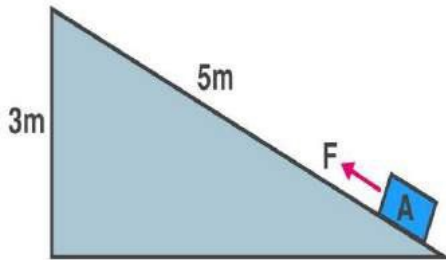
$$\text{Reference point is ground, } h_1 = 0 \text{ m}$$

$$\text{Gravitational potential energy} = Mg (h_2 - h_1)$$

$$\begin{aligned}
 &= 50 \times 9.8 \times (10 - 0) \\
 &= 50 \times 9.8 \times 10 \\
 &= 4900 \text{ J}
 \end{aligned}$$

Question: 9

A block A, whose weight is 100N, is pulled up a slope of length 5m by means of a constant force F (=100N) as illustrated.



- What is the work done by the force F in moving the block A, 5m along the slope?
- What is the increase in potential energy of the block A?
- Account for the difference in the work done by the force and the increase in potential energy of the block.

Solutions:

$$F = 100 \text{ N}$$

Work done by the force in moving the block 5m along the slope = Force \times displacement in the direction of force

$$\begin{aligned}
 &= 100 \times 5 \\
 &= 500 \text{ J}
 \end{aligned}$$

The potential energy gained by the block $U = mgh$ (where $h = 3\text{m}$)

$$\begin{aligned}
 &= 100 \times 3 \\
 &= 300 \text{ J}
 \end{aligned}$$

- is the potential energy gained by the block

The difference i.e 200 J energy is used in doing work against the force of friction between the block and the slope, which will appear as heat energy.

Question: 10

Find the kinetic energy of a body of mass 1kg moving with a uniform velocity of 10m s^{-1} .

Solutions:

$$\text{Mass, } m = 1 \text{ kg}$$

$$\text{Velocity, } v = 10 \text{ m / s}$$

$$\text{Kinetic energy} = \frac{1}{2} \times \text{mass} \times (\text{velocity})^2$$

$$= \frac{1}{2} \times 1 \times (10)^2$$

$$= 1/2 \times 1 \times 100$$
$$= 50 \text{ J}$$

Questions: 11

If the speed of a car is halved, how does its kinetic energy change?

Solutions:

The kinetic energy decreases, if the speed is halved keeping the mass same. Since kinetic energy is proportional to the square of velocity, it becomes one-fourth.

Question: 12

Calculate the decrease in the kinetic energy of a moving body if its velocity reduces to half of the initial velocity.

Solutions:

Kinetic energy is directly proportional to the square of velocity.

Hence, velocity is reduced is half its original value. We get,

$$\Delta K = K - K_{\text{new}} = 1/2 mv^2 - 1/2 m (1/2 v)^2$$

$$\text{Hence, } \Delta K = 1/2 mv^2 - 1/2 mv^2 (1/4)$$

$$= 1/2 mv^2 - 1/8 mv^2$$

$$= 3/8 mv^2$$

$$= 3/4 \times 1/2 mv^2$$

$$= 3/4 K$$



Question: 13

Two bodies of equal masses are moving with uniform velocities v and $2v$. Find the ratio of their kinetic energies.

Solutions:

Given

Velocity of first body $v_1 = v$

Velocity of second body, $v_2 = 2v$

Masses are same, so kinetic energy is directly proportional to the square of the velocity ($K \propto v^2$)

Hence, ratio of their kinetic energies is

$$K_1 / K_2 = (v_1)^2 / (v_2)^2$$

$$= v^2 / (2v)^2$$

$$= v^2 / 4v^2$$

$$= 1 / 4$$

$$= 1 : 4$$

Question: 14

A car is running at a speed of 15 km h^{-1} while another similar car is moving at a speed of 45 km h^{-1} . Find the ratio of their kinetic energies.

Solutions:

$$KE = mv^2$$

$$KE \propto v^2$$

$$KE_1 / KE_2 = v_1^2 / v_2^2$$

$$KE_1 / KE_2 = (15 / 45)^2$$

$$KE_1 / KE_2 = (1 / 3)^2$$

$$KE_1 / KE_2 = 1 / 9$$

$$KE_1 / KE_2 = 1 : 9$$

Question: 15

A ball of mass 0.5 kg slows down from a speed of 5m/s^{-1} to that of 3m/s^{-1} . Calculate the change in kinetic energy of the ball.

Solutions:

Given

Mass of ball = 0.5 kg

Initial velocity = 5 m / s

Initial kinetic energy = $1 / 2 \times \text{mass} \times (\text{velocity})^2$

$$= 1 / 2 \times 0.5 \times (5)^2$$

$$= 1 / 2 \times 0.5 \times 25$$

$$= 6.25 \text{ J}$$

Final velocity of the ball = 3 m / s

Final kinetic energy of the ball = $1 / 2 \times \text{mass} \times (\text{velocity})^2$

$$= 1 / 2 \times \text{mass} \times (\text{velocity})^2$$

$$= 1 / 2 \times 0.5 \times (3)^2$$

$$= 1 / 2 \times 0.5 \times 9$$

$$= 2.25\text{J}$$

So, change in the kinetic energy of the ball = $2.25 \text{ J} - 6.25 \text{ J}$

$$= - 4\text{J}$$

Hence, there is a decrease in the kinetic energy of the ball.

Question: 16

A canon ball of mass 500g is fired with a speed of 15m/s^{-1} . Find:

(i) its kinetic energy and

(ii) its momentum.

Solutions:

Given

A mass of cannon ball = 500 g

$$= 0.5 \text{ kg}$$

$$\text{Speed, } v = 15 \text{ m / s}$$

$$\text{(a) Kinetic energy of ball} = \frac{1}{2} \times \text{mass} \times (\text{velocity})^2$$

$$= \frac{1}{2} \times 0.5 \times (15)^2$$

$$= \frac{1}{2} \times 0.5 \times 225$$

$$= 56.25\text{J}$$

$$\text{(b) Momentum of the ball} = \text{mass} \times \text{velocity}$$

$$= 0.5 \times 15$$

$$= 7.5 \text{ kgm/s}$$

Question: 17

A body of mass 10 kg is moving with a velocity 20m s^{-1} . If the mass of the body is doubled and its velocity is halved, find: (i) the initial kinetic energy, and (ii) the final kinetic energy.

Solutions:

Let initial Mass, $m_1 = 10 \text{ kg}$ and

Velocity, $v_1 = 20 \text{ m / s}$

Final mass, $m_2 = 2 \times 10 \text{ kg}$ and

Velocity, $v_2 = 20 / 2$

$= 10 \text{ m / s}$

Initial kinetic energy, $K_1 = \frac{1}{2} \times \text{mass} \times (\text{velocity})^2$

$$= \frac{1}{2} \times 10 \times (20)^2$$

$$= \frac{1}{2} \times 10 \times 20 \times 20$$

$$= 2000\text{J}$$

Final kinetic energy, $K_2 = \frac{1}{2} \times \text{mass} \times (\text{velocity})^2$

$$= \frac{1}{2} \times 20 \times (10)^2$$

$$= \frac{1}{2} \times 20 \times 10 \times 10$$

$$= 1000\text{J}$$

Therefore $K_1 / K_2 = 2000 / 1000$

$$= 2 / 1$$

$$= 2: 1$$

Question: 18

A truck weighing 1000 kgf changes its speed from 36 km/h^{-1} to 72 km/h^{-1} in 2 minutes. Calculate:

(i) the work done by the engine and

(ii) its power.

(g = 10 m/s^{-2})

Solutions:

$$u = 36 \text{ km / h} = 36 \times 1000\text{m} / 3600\text{s}$$

$$= 10 \text{ m / s and}$$

$$v = 72 \text{ km / h} = 72 \times 1000\text{m} / 3600\text{s}$$

$$= 20 \text{ m / s}$$

Given

$$\text{Mass of truck} = 1000 \text{ kg}$$

(i)

$$W = 1 / 2 \times 1000 \times (20^2 - 10^2)$$

$$W = 500 \times (400 - 100)$$

$$W = 500 \times 300$$

$$W = 150000\text{J}$$

$$W = 1.5 \times 10^5\text{J}$$

(ii)

$$\text{Power} = \text{work done} / \text{time taken}$$

$$= 1.5 \times 10^5 \text{ J} / 120\text{s}$$

$$= 1.25 \times 10^3 \text{ W}$$

Question: 19

A body of mass 60 kg has the momentum 3000 kgm/s⁻¹. Calculate:

(i) the kinetic energy and

(ii) the speed of the body.

Solutions:

Given

$$\text{Mass of body} = 60 \text{ kg}$$

$$\text{Momentum, } p = 3000 \text{ kgm / s}$$

$$(a) \text{ Kinetic energy} = p^2 / 2m$$

$$= (3000)^2 / 2 \times 60$$

$$= (3000 \times 3000) / 120$$

$$= 75000\text{J}$$

$$= 7.5 \times 10^4\text{J}$$

$$(b) \text{ Momentum} = \text{mass} \times \text{velocity}$$

$$3000 = 60 \times \text{velocity}$$

$$\text{Velocity} = 3000 / 60$$

$$\text{Velocity} = 50 \text{ m / s}$$

Question: 20

How much work is needed to be done on a ball of mass 50g to give it a momentum of 5 kg m s⁻¹?

Solutions:

$$\begin{aligned}\text{Momentum, } p &= 500 \text{ gcm / s} \\ &= 0.005 \text{ kgm / s} \\ \text{Mass of ball} &= 50 \text{ g} \\ &= 0.05 \text{ kg} \\ \text{Kinetic energy of the ball} &= p^2 / 2m \\ &= (0.005)^2 / 2 \times 0.05 \\ &= 250\text{J}\end{aligned}$$

Question: 21

How much energy is gained by a box of mass 20 kg when a man

(a) carrying the box waits for 5 minutes for a bus?

(b) runs carrying the box with a speed of 3 m/s^{-1} to catch the bus?

(c) raises the box by 0.5 m in order to place it inside the bus? ($g=10 \text{ m/s}^{-2}$)

Solutions:

Given

$$\text{Mass of box} = 20 \text{ kg}$$

(a) As there is no displacement of the man, so zero work is done

(b) Work done, Kinetic energy of man = $1 / 2 \times \text{mass} \times (\text{velocity})^2$

$$= 1 / 2 \times 20 \times (3)^2$$

$$= 1 / 2 \times 20 \times 9$$

$$= 90\text{J}$$

(c) Work done in raising the box, Potential energy = mgh

$$U = 20 \times 10 \times 0.5$$

$$= 100\text{J}$$

Question: 22

A bullet of mass 50g is moving with a velocity of 500m/s^{-1} . It penetrates 10 cm into a still target and comes to rest. Calculate:

(a) the kinetic energy possessed by the bullet, and

(b) the average retarding force offered by the target.

Solutions:

Given

$$\text{Mass of bullet} = 50 \text{ g}$$

$$= 0.05 \text{ kg}$$

$$\text{Velocity} = 500 \text{ m / s}$$

$$\text{Distance penetrated by the bullet} = 10 \text{ cm}$$

$$= 0.1 \text{ m}$$

(a) Kinetic energy of the bullet = $1 / 2 \times \text{mass} \times (\text{velocity})^2$

$$= 1 / 2 \times 0.05 \times (500)^2$$

$$= 1 / 2 \times 0.05 \times 500 \times 500$$

$$= 6250\text{J}$$

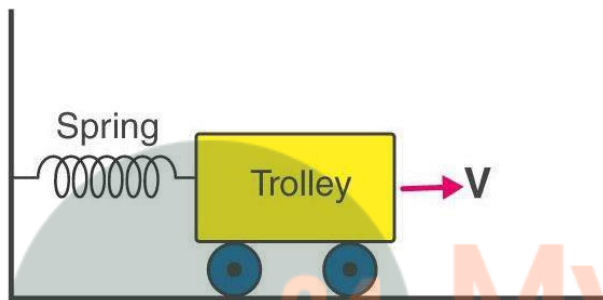
(b) Work done by the bullet against the material of the target = resistance force \times distance

$$6250 = \text{resistance force} \times 0.1 \text{ m}$$

$$\text{Resistance force} = 62500\text{N}$$

Question: 23

A spring is kept compressed by a small trolley of mass 0.5 kg lying on a smooth horizontal surface as shown. When the trolley is released, it is found to move at a speed of $v = 2 \text{ m/s}^{-1}$. What potential energy did the spring possess when compressed?



Solutions:

Given

Mass of trolley = 0.5 kg

Velocity = 2 m / s

When the compressed spring is released, its potential energy is converted into kinetic energy completely.

Potential energy of compressed spring = kinetic energy of moving trolley

$$\text{Kinetic energy of trolley} = 1 / 2 \times \text{mass} \times (\text{velocity})^2$$

$$= 1 / 2 \times 0.5 \times (2)^2$$

$$= 1 / 2 \times 0.5 \times 2 \times 2$$

$$= 1\text{J}$$

So, potential energy of compressed spring = 1.0J