WORK AND ENERGY

LEARNING OBJECTIVES:

- Work and it's nature.
- Expressions for workdone in different cases.
- Energy and it's forms.
- Relation betwen K.E and linear momentum.

Real life applications :

Φ The main advantage of using Work and Energy methods is that it allows you to easily find the velocity of a body or system of bodies knowing how much "work" went into the system (provided energy is conserved, and there are no frictional losses)

Φ We can apply the work energy methods In our dialy life in order to convert one form of energy into another form.

Φ In the field of space, for a space shuttle heat proof tiles are needed to protect it from the heat resulting from doing work against the drag with a lot of KE so what must be the strength of heat proof tile can be calculated by work energy methods.

Φ To produce the electricity the energy of wind movement performs work when it turns a Wind Turbine.

Φ In the field of mechanics,To run our vehicles the chemical energy in gasoline performs work on a piston, which in turn performs work on a vehicle to create kinetic energy.

Φ Work is performed on air as it enters a Jet Engine to speed up the air, which results in higher kinetic energy of the air particles, which pushes the airoplane

Important Formulae :

1) $W = \overline{F}.\overline{S} = FSCos\theta$

2) $W = mgh\left(1 - \frac{d_2}{d_1}\right)$

3) $W = mgl(1 - Cos\theta)$

4) $\mathrm{W} = \frac{\mathrm{mgl}}{2}(1 - \mathrm{Cos}\theta)$

5) $W = {}^{mgl}\!/_{4}$

6) $W = \frac{mgl}{2n^2}$

7) $\mathrm{W} = (\mathrm{mg\ Sin}\theta)\mathrm{S}$

8) W = m(g+a) h

9) $p = \sqrt{2mE}$

10) P.E.=mgh

11) $W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$

12) $P = \frac{\mathrm{w}}{\mathrm{t}}$

13) $P = \vec{F}.\vec{V}$

14) $P = n\left(\frac{1}{2}mv^2\right)$

15) $p = \frac{mgh}{t}$

§§ Work:

In ordinary language the word ''Work'' means any physical or mental activity but in physics, Work is said to be done by a force if the point of application of force undergoes displacement either in the direction of force or in the direction of component of force.

Amount of work done is equal to the dot product of force and displacement. If $\overline{F}$ is the force acting on a body and $\overline{S}$ is displacement,

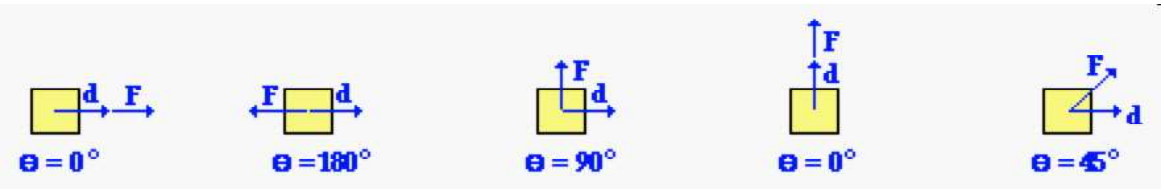
i.e. $W = \overline{F}.\overline{S} = FSCos\theta$

Since work is the dot product between force and displacement it is a scalar quantity.

Units of work : erg in CGS system, joule in S I system

Conversion: one joule = 10^7 erg

§§ NATURE OF WORK:



¶¶ POSITIVE WORK:

Workdone is said to be positive if applied force or one of it's components is in the direction of displacement.

therefore W=FScos0°=positive.

If the force is in the same direction as the displacement, then the angle is 0 degrees

EXAMPLES:

1.Workdone by the gravitational force on a freely falling body is positive.

2.When a spring is stretched ,both the stretching force and displacement act in the same direction so workdone is positive.

3.When a block is lifted from the ground the workdone by lifting force is positive.

4.When a horse pulls a cart the applied force and displacement are in the same direction so work done by horse is positive.

¶¶ NEGATIVE WORK:

Workdone by a force is said to be negative if the applied force has a component in a direction opposite to that of the displacement.

EXAMPLES:

1.When a body is dragged on rough surface,workdone by frictional force is negative.

2.Workdone by the gravitational force on a vertically projected up body is negative.

¶¶ ZERO WORK:

If a body displaces perpendicular to the direction of force then the workdone is zero.

If there is no displacement then workdone is zero.

EXAMPLES:

1.A person carriyng a load and moving horizontally on a platform does no work against gravity.

2.When abody moves in a circle the workdone by the centripetal force is zero.

3.The tension in the string of a simple pendulum is always perpendicular to it's displacement so,workdone by tension is zero.

4.A person carrying a load on his head and standing at a given place is zero.

§§ EXPRESSIONS FOR WORKDONE IN DIFFERENT CASES:

1) The work done in lifting a body of mass m having density d_1 inside a liquid of density d_2 through a height h is (a=0) $W = mgh\left(1-\frac{d_2}{d_1}\right)$

2) A point sized sphere of mass m is suspended vertically using a string of length l . If the bob is pulled to a side till the string makes an angle θ with the vertical, work done against gravity is $W = mgl(1-Cos\theta)$

3) A uniform rod of mass m and length l is suspended vertically. If it is lifted to a side till it makes an angle θ to the vertical , work done against gravity is $W = \frac{mgl}{2}(1-\cos\theta)$

4) A uniform chain of mass m and length l is suspended vertically. If the lower point of the chain is lifted to the point of suspension, work done against gravity is $W = {}^{mgl}/_{4}$

5) A uniform chain of mass m and length 'l' is kept on a table such that ${}^{1}/_{n}th$ of its length is

hanging down vertically from the edge of the table. The work done against gravity to pull the hanging part on to the table is $W = \frac{mgl}{2n^2}$

6) A bucket full of water of total mass M is pulled up using a uniform rope of mass m and length l, work done is $W = Mgl + mg\,{}^{l}\!/_{2} = \left(M + {}^{m}\!/_{2}\right)gl$ (Bucket is treated as point mass)

7) If a body of mass m slides down distance S, work done by gravity is $W = (mg\,\mathrm{Sin}\theta)S$ (θ is inclination to the horizontal)

8) A block of mass m is suspended vertically using a rope of negligible mass. If the rope is used to lift the block vertically up with uniform acceleration a, work done by the tension in the rope is W = m(g+a) h (h is distance through which it is lifted up)
In the above case if the block is lowered with acceleration a W = m (a-g)h

EXAMPLE

√ **Problem 1:**

A force of 10N actson a body of mass 1.0 kg at rest. Find the work done in 4 seconds.

Solution.

F = 10 N; m = 1.0 kg ; u = 0, t = 4s; acceleration

$a = \frac{F}{m} = \frac{10}{1}$ = 10 ms^{-2}.

Its displacement

$S = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2}(10)4^2 = 80$ m

The work done

W = FS = maS = 1.0 ´ 10 ´ 80 = 800 J

√ **Problem 2** :

Find the work done in lifting a stone of mass 10 kg and specific gravity 3 from the bed of a lake to a height of 6 m in water.

Solution.

Weight in air = 10 kg.wt

Specific gravity = $\frac{d_s}{d_w}$ = 3

$$W = mgh\left(1 - \frac{d_w}{d_s}\right)$$

$$W = 10 \times 9.8 \times 6 \times \left(1 - \frac{1}{3}\right)$$

$$W = 98 \times 6 \times \frac{2}{3} = 392J$$

√ **Problem: 3**

A massive box is dragged along a horizontal floor by a rope. The rope makes an angle of 60^0 with the horizontal. Find the work done if the tension in the rope is 200 N and the box is moved through a distance of 20 m.

Solution.

Tension T = 200 N; distance S = 20 m , $\theta = 60^0$

Work done W = $\vec{F}.\vec{S} = FS\cos\theta = (F\cos\theta)\,s$

$= 200 \times \cos 60^0 \times 20 =$ 2000 J

√ **Problem :4**

A rod of length 2 m and mass 0.5 kg is fixed at one end and allowed to hang vertically from a rigid support. Find the work done in raising the other end of the rod until it makes an angle of 60^0 with the vertical . (g = 10ms^{-2})

Solution.

m = 0.5 kg, *l* = 2 m, $\theta = 60^0$

Work done $W = mg\frac{l}{2}(1-\cos\theta)$

$= 0.5 \times 10 \times \frac{2}{2}(1-\cos 60^0) = 5 \times \left(1-\frac{1}{2}\right) = 5 \times \frac{1}{2} = 2{\bullet}5J$

√ **Problem :5**

A man of mass 70 kg ascends a flight of 36 steps each 20 cm high. What is the work he does against gravity ?

Solution.

m = 70 kg; S = 36 ´ 0.20=7.2 m; g=9.8ms^{-2}

W=Fs=mg s = 70 x9.8 x 7.2 = 4932J

TEACHING TASK

Single correct option questions:

1. A staircase has 40 steps each of width 35 cm and height 25 cm. A boy of mass 20 kg ascends the staircase. The work done by him is (g =10 m s^{-2})
A) 2 × 10^5 J B) 4.8 × 10^3 J C) 2 × 10^3 J D) 4.8 × 10^5 J

2. A rain drop of mass (1/10) gram falls vertically at constant speed under the influence of the forces of gravity and viscous drag. In falling through 100 m, the work done by gravity
A) 0.98 J B)0.098J C) 9.8 D) 98 J

3. A bucket of mass 'm' tied to a light rope is lowered at a constant acceleration of 'g/4'. If the bucket is lowered by a distance 'd', the work done by the rope will be (neglect the mass of the rope)
A) $\frac{1}{4}mgd$ B) $\frac{3}{4}mgd$ C) $-\frac{3}{4}mgd$ D) $-\frac{5}{4}mgd$

4. A body of mass 5kg initially at rest, is moved by a horizontal force of 2N on a smooth horizontal surface. The work done by the force in 10s is
A) 4J B) 16J C) 32J D) 40J

5. Two bodies have masses in the ratio 1 : 2 are displaced by through distances in the ratio 2 : 1 when forces in the ratio 1 : 2 act on the bodies at angles 30^0 and 60^0 respectively with their displacements. Then the ratio of workdone by the forces is
A) 1 : 2 B) 2 : 1 C) $\sqrt{3}:1$ D) $1:\sqrt{3}$

6. A uniform chain of mass M and length L is held on a smooth table with 1/5th of it's length is hanging down from the edge of the table. Work done against the gravity to pull the hanging part back on to the table is
A) MgL/5 B) MgL/10 C) MgL/6 D)MgL/50

More than one correct option questions

- *This section contains multiple choice questions. Each question has 4 choices (A), (B), (C),(D), out of which **ONE or MORE** is correct. Choose the correct options*

7. Which of the following are correct
a) When a body is dragged on rough surface,workdone by frictional force is negative.
b) Workdone by the gravitational force on a vertically projected up body is positive.
c) When a body is dragged on rough surface,workdone by frictional force is positive.
d) Workdone by the gravitational force on a vertically projected up body is negative.
A) a,b are corect B) a,d are correct C) b,c are correct D)c,d are correct

8. When a body of mass m is lifted to a height h above the ground without any acceleration,
a) work done by the applied force = mgh
b) work done by the gravitational force = -mgh
c) work done by the resultant force = 0
d) work done by the resultant force = 2mgh
A) a,b,c are corect B) a,b,d are correct C) b,c,d are correct D)a,c,d are correct

9. In which of the following work is said to be not done
a) the workdone by the centripetal force on a body moving in a circle.
b) workdone by tension in the string of a simple pendulum.
c) A person carrying a load on his head and standing at a given place is zero.
A) a,b are corect B) a,c are correct C) b,c are correct D) all are correct

10. a) Workdone by the frictional force is always negative
b) If a body of mass m slides down distance S, work done by gravity is $W = (mg\cos\theta)S$
c) If a body of mass m slides down distance S, work done by gravity is $W = (mg\,\mathrm{Sin}\theta)S$
d) Workdone by the frictional force is always zero.
A) a,b are corect B) a,c are correct C) b,d are correct D)c,d are correct

Assertion - A and Reason - R:

- *This section contains certain number of questions. Each question contains Statement – 1 (Assertion) and Statement – 2 (Reason). Each question has 4 choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct Choose the correct option.*

A) Both A and R are true and R is the correct explanation for A.
B) Both A and R are true and R is not correct explanation of A.
C) A is true but R is false.
D) A is false but R is true

11. **A:** Workdone by a force is a vector
R: Workdone by a force is the dot product of force and displacment.

12. **A:**The work done during a round trip is always zero.
R: No force is required to move a body in its round trip.

13. A: A man pushes a wall and fails to displace it then the work done by him is negative
R: Work is said to be done when a force doesn't displace a body.

Match the following

- *This section contains Matrix-Match Type questions. Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in **Column–I** have to be matched with statements (p, q, r, s) in **Column–II**. The answers to these questions have to be appropriately bubbled as illustrated in the following example.*

  *If the correct matches are A-p,A-s,B-r,B-r,C-p,C-q and D-s,then the correct bubbled 4*4 matrix should be as follows:*

14. Nature of work **Angle b/w $\vec{F}$ & $\vec{S}$**

a) Positive work 1) 90^0
b) Negative work 2) 0^0
c) Zero work 3) 180^0
d) Finite work 4) otherthan 0^0

A) a-1,b-4,c-3,d-2 B) a-3,b-1,c-2,d-4 C) a-2,b-3,c-1,d-4 D) a-4,b-2,c-1,d-3

Comprehension type questions

- *This section contains paragraph. Based upon each paragraph multiple choice questions have to be answered. Each question has 4 choices (A) , (B) ,(C) and (D) out of which **ONLY ONE i**s correct. Choose the correct option.*

15. A 300kg motorcycle is accelerated from rest to a speed of 90kmph in 5s.If the motorcycle travels 1.5km

ci) Find the acceleration of motorcycle
A) $2ms^{-2}$ B)$3ms^{-2}$ C)$4ms^{-2}$ D)$5ms^{-2}$

ii) Find the force exerted by the engine on the motorcycle
A) 1200N B) 1125N C) 1500N D) 2400N

iii) Find the workdone in moving the motorcycle
A) $225X10^5J$ B) $225X10^4J$ C) $18X10^3J$ D) $18X10^2J$

KEY

ΦΦ TEACHING TASK : 1)C, 2)B, 3)C, 4)D, 5)C, 6)D, 7)B, 8)A, 9)D, 10)B, 11)D, 12)C, 13)C, 14)C, 15) i)D, ii)C , iii)A.

LEARNER'S TASK

BEGINNERS (Level - I)

Single correct option questions:

1. A body moves 5 m in a straight line by applying 50 N of force. Then what is the work done by the body
A) 50J B) 100J C) 250J D) 200J

2. A man pushes a block by 30 m long with a force of 3 N. the work done is
A) 90J B) 30J C) 3J D) 300J

3. A man is waiting at a bus stop by holding a box on his head work done by him
A) positive B) zero C) negative D) none

4. The work done in lifting 4 cement bags each of mass 50 kg to the top of a building of eight 20m is
A) 39.2KJ B) 3.92 KJ C) 0.392 KJ D) 392 KJ

5. A man pushes a 60kg block by 30m along a smooth level floor with a force 3N directed 60º above the horizontal. The work done is
A) 150 joule B) 50 joule C) 40 joule D) 45 joule

6. A body is kept on the floor of a lift and it moves through a distance 's' vertically up. The workdone by the friction is
A) mgs B) -mgs C) 0 D) 2 mgs

7. A force $\bar{F} = 5\hat{i} - 3\hat{j} + 2\hat{k}$ moves a particle from $\bar{r}_1 = 2\hat{i} + 7\hat{j} + 4\hat{k}$ to $\bar{r}_2 = 5\hat{i} + 2\hat{j} + 8\hat{k}$. Then work done by that force is
A) 18 unitsB) 28 units C) 38 units D) 48 units

8. A body constrained to move along z-axis of a co-ordinate system is subjected to constant force F given by $(2i + 4j + 3k)$ N. Work done by the force in moving the body by a distance of 6m along the z-axis
A) 18 ergs B) 6 joule C) 18 joule D) 30 joule

9. A body of mass 20 kg is at rest. A force of 5N is applied on it. The work done in first second will be
A) 5/8 J B) 8/5 J C) 5/4 J D) 4/5 J

10. A body moves a distance of 10m along a straight line under the action of a force of 5N. The work done is 25J. The angle which the force makes with the direction of motion of the body is
A) 0º B) 30º C) 60º D) 90º

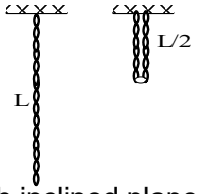
11. A body of mass 5 kg is moved up over 10 m along the line of greatest slope of a smooth inclined plane of inclination of 30° with the horizontal. If g = 10 m/s^2, the work done will be (in J)
A) 500 B) 25 C) 250 D) 250

12. A force F is applied on a lawn mover at an angle of 60° with the horizontal. If it moves through a distance x, the work done by the force is
A) Fx/2 B) F/2x C) 2Fx D) 2x/F

13. A force $\bar{F} = 6i - 8j$ N, acts on a particle and displaces it over 4 m along the X-axis and then displaces it over 6 m along the Y-axis. The total work done during the two displacements is
A) 72 J B) 24 J C) - 24 J D) zero

14. A bicycle has the uniform chain of mass1kg and length 1.6m is suspended vertically. If the lower point of the chain is lifted to the point of suspension,against gravity is(take g= 10ms$^{-2)}$
A) 4J B) 3.2 J C) 8 J D) 16 J

15. A uniform chain of length 'L' and mass 'm' is hanging down vertically from a hook fixed to the roof. The work done in hooking the other end of the chain as shown is
A) mgL B) mgL/2 C) mgL/4 D) mgL/8



16. When a body of mass m slides down from the top of a smooth inclined plane of length L and inclination θ, the work done by the gravitational force on the body is
A) mgL cosθ B) mgL sinθ C) mgL tanθ D) 2mgL sinθ

17. The work done in lifting a stone of mass10kg from the bottom of a lake to a height of 6 m in water is (given that the ratio between densies of stone and water as 1/3)
A) 0.392 J B) 3.92 J C) 39.2 J D) 392 J

ACHIEVERS (Level - II)

Solve the following

1. A body of mass 5 kg is placed at the origin, and can move only on the x-axis. A force of 10 N is acting on it in a direction making an angle of 60^o with the x-axis and displaces it along the x-axis by 4 metres. Calculate the amount of work done by the force.

2. A force $F = (5\hat{i} + 3\hat{j})$ N is applied over a particle which displaces it from its origin to the point

$r = (2\hat{i} - 1\hat{j})$ m.Find the work done on the particle.

3. A horizontal force of 5 N is required to maintain a velocity of 2 m/s for a block of 10 kg mass sliding over a rough surface. Calculate the work done by this force in one minute.

4. A 10 kg satellite completes one revolution around the earth at a height of 100 km in 108 min. Calculate the work done by the gravitational force of earth.

When the distance covered by the body is $5m$,
Find its kinetic energy.

5. A chain is placed on a frictionless table with one fourth of it hanging over the edge. If the length of the chain is 2m and its mass is 4kg, Calculate the energy need to be spent to pull it back to the table.

6. A uniform chain of length 2m is held on a smooth horizontal table so that half of it hangs over the edge. If it is released from rest.Find the velocity with which it leaves the table.

7. The lenght of a smooth inclined plane of inclination 30 is 20 m. What is The work done in moving 50 kg mass from the bottom of the inclined plane to top.

8. A body moves a distance of 20 m along a straight line under the action of force of 10 N if the work done is 200J. The angle between force and displacement vector is

9. A force 5 N is applied on a 20 kg mass at rest. the work done in the third second is

10. The work done in lifting a body of mass 20 kg and specific gravity 3.2 to a height of 8 m in water.

EXPLORERS (Level - III)

More than one correct option questions

- *This section contains multiple choice questions. Each question has 4 choices (A), (B), (C),(D), out of which **ONE or MORE** is correct. Choose the correct options*

1. You lift a suitcase from the floor and keep it on a table the work done by you on the suit case does not depend on

a)The path taken by the suit case b) The time taken by you in lifting bag

c)The weight of the suit case

d) your weight

A) a,b,d are corect B) a,b,c are correct C) b,c,d are correct D)a,b,c,d are correct

2. A bucket full of water is drawn up by a person. In this case

a) the work done by the gravitational force is negative because the force and displacement are in opposite directions

b) the work done by the gravitational force is positive because the force and displacement are in the same direction

c) the work done by the applied force is negative because the force and displacement are in the same direction

d) the work done by the applied force is positive because the force and displacement are in opposite direction.

A) a,c are corect B) a,d are correct C) b,c are correct D) b,d are correct

3. The work done by gravity in lifting a body to a certain height depend upon

a) time of its rise b) path followed by the body c) mass of the body

d)Height of the body

A) a,b are corect B) c,d are correct C) b,c are correct D) all are correct

Assertion - A and Reason - R:

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*which **ONLY ONE** is correct Choose the correct option.*

A) Both A and R are true and R is the correct explanation for A.
B) Both A and R are true and R is not correct explanation of A.
C) A is true but R is false. D) A is false but R is true

4. **A:** The graph drawn between force and displacement is useful in calculating workdone a force.
B:The area under a 'force - displacement' curve gives work.

5. **A:** A man is waiting at a bus stop by holding a box on his head. Work done by him is negative.
R:Work is said to be done when a force displaces a body.

6. **A:** Two identical bodies of same mass are raised to same heights by two persons X and Y in 10s and 20s respectively. The work done by X is same as by Y.
R:The workdone by the force doesn't depend on time of application of it.

Match the following

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  *If the correct matches are A-p,A-s,B-r,B-r,C-p,C-q and D-s,then the correct bubbled 4*4 matrix should be as follows:*

7. Expression for work **Angle b/w** $\vec{F}$ & $\vec{S}$

a) W=FS 1) 90^0
b) W=-FS 2) 0^0
c) W=0 3) 180^0
d) $W=FS\cos\theta$ 4) anywhere between 0^0 and 180^0

A) a-1,b-4,c-3,d-2 B) a-3,b-1,c-2,d-4 C) a-2,b-3,c-1,d-4 D) a-4,b-2,c-1,d-3

Comprehension type questions

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8. A box of mass 1 kg is pulled on a horizontal plane of length 1 m by a force of 8 N then it is raised vertically to a height of 2m, (g=10 ms-2)

i) Find the workdone in while moving horizentally
A) 8J B)20J C)28J D)12J

ii) Find the workdone in while moving vertically
A) 8J B)20J C)28J D)12J

iii) Find the net workdone on the box
A) 8J B)20J C)28J D)12J

KEY

ΦΦ LEARNER'STASK :

- **BEGINNERS :**1) C, 2) A, 3) B, 4) B, 5) D, 6) C, 7) C, 8) C, 9) A, 10) C, 11) C, 12) A, 13) C, 14) A, 15) C, 16) B, 17) D,
- **ACHIEVERS:**1) 20J, 2) +7J, 3) 600J, 4) 0J, 5) 2.5J, 6) 4 m/s. 7)4900J, 8)0, 9)25/8J, 10)1100J
- **EXPLORERS :** 1) A, 2) B, 3) A, 4) D, 5) A, 6) C, 7) A, 8) i) A, ii) B, iii) C.

§§ ENERGY-SOURCES-FORMS OF ENERGY:

¶¶ Introduction to Energy

It is often said that a person A is more energetic than a person B. The meaning of this statement is that a person A can do more work than the person B. Similarly, a person after doing a lot of work gets tired and after that he is not able to do much work. It is clear that a person doing work expends something. This 'something' is known as the energy of the person. The energy spent by a person is equal to the work done by him. Human beings and animals get energy by eating food.

It may be noted that anything which is capable of doing work has energy. For example, the steam pushes up the lid placed on the boiling water container. It means, the steam has the ability or capacity to do work. The work done by the steam on the lid is equal to the energy of the steam.

¶¶ Definition of energy

If a person can do a lot of work we say that he has a lot of energy or he is very energetic. In physics also, anything which is able to do work is said to possess energy.

Thus, energy is the ability to do work or the capacity to do work.

¶¶ Units of energy

Unit of energy is same as that of the unit of work as work is a form of energy.

So, S.I. unit of energy is **Joule (J).**

When we say that energy of a body is 1 joule, it means, this body has the capacity to do 1 J work.

¶¶ Commercial unit of Energy

The commercial unit (or trade unit) of energy is kilowatt-hour which is written in short form as kWh. Kilowatt-hour is usually used as a commercial unit of electrical energy.

One kilowatt-hour is the amount of electrical energy consumed when an electrical appliance having a power rating of 1 kilowatt is used for 1 hour. Since a kilowatt means 1000 watts, so we can also say that one kilowatt-hour is the amount of electrical energy consumed when an electrical appliance of 1000 watts is used for 1 hour.

1 kilowatt-hour is the amount of energy consumed at the rate of 1 kilowatt for 1 hour. That is, 1 kilowatt-hour = 1 kilowatt for 1 hour

or 1 kilowatt-hour =1000 watts for 1 hour

Note:

Watt or kilowatt is the unit of electrical power but kilowatt-hour is the unit of electrical energy.

Energy is a scalar quantity.

Dimensional formula of energy = ML^2T^{-2}

§§ Kinds of Energy

In actual practice there are many kinds of energy, such as mechanical energy; heat energy; light energy; sound energy, electrical energy; nuclear energy; chemical energy, etc. Let us discuss about mechanical energy.

¶¶ Mechanical energy (M.E)

The sum of kinetic energy (K.E) and potential energy (P.E) of a body is known as mechanical energy. $\therefore$ M.E = K.E + P.E

¶¶ Kinetic energy:-

The kinetic energy of an object is a measure of the work an object can do by the virtue of its motion. Therefore kinetic energy is defined as "the energy possessed by a body by virtue of its motion".

Kinetic energy of a body of mass m moving with velocity v is expressed as K.E=$\frac{1}{2}mv^2$ Since mass and square of velocity are always positive K.E. never be negative.

Examples:

1.A vehicle in motion.
2.Water flowing along a river.
3.A bullet fired from a gun.
4.A running athlet have kinetic energy.

¶¶ **Potential Energy**:-

The energy possessed by a body by virtue of its state or position is known as potential energy.

Expression: P.E.=mgh

Examples:

1.Water on hill top and stretched or compressed spring possess potential energy.
2.stone at a certain height.
3.The spring wound in a watch possesses potential energy
4.An arrow in a bowl possesses potential energy.

¶¶ **Gravitational potential energy :-**

The Potential energy due to height above the earth's surface is called gravitational potential energy.

In general, if the potential energy at the ground is taken as zero, the potential energy of an object at a height h above the ground is given by

U = mgh

The energy results from the force of attraction mg between the earth and the object.From newton's third law, both earth and the object attract each other. Hence, strictly speaking energy 'mgh' is not the potential energy of the object alone it is the potential energy of object-earth system.

¶¶ **Heat Energy:-**

Heat is the energy that is transferred between a system and its environment because of a temperature difference that exists between them.

Heat is an Internal energy that consists of the kinetic and potential energies associated with the random motion of the atoms, molecules and other micro scopic bodies within object.

¶¶ **Sound Energy:-**

Sound is a form of energy, that is produced by a body when it is in the state of vibration. It propagates in the form of Longitudinal waves through Elastic media and causes sensation of hearing.

¶¶ **Light Energy:-**

→ Light is a form of energy, which causes sensation of vision.

→ Light travels from one place to another place in the form of Electromagnetic waves.

→ E.M wave can transport energy and deliver it to a body on which it falls.

¶¶ **Elastic potential energy :-**

When a spring is streched or compressed from its natural length, its get extra energy. It can return to its natural length by performing some work.

The extra energy stored in a streched or compressed spring is called elastic potential energy.

A streched rubber band also has potential energy, where as rubber band at its natural length lying on a table has no elastic potential energy.

§§ **Other forms of energy :-**

Besides mechanical energy, energy can exist in several other forms.

Charged particles and electric currents can produce electrical energy and magnetic energy.Electric batteries,cooking gas,petrol etc., have chemical energy stored in them.Even matter itself is a concentrated form of energy and can be converted into other forms of energy such as kinetic energy and heat energy.

¶¶ **Electrical energy :**Energy is associated with electric current is called electrical energy

The flow of electrical current causes bulbs to glow, fans to rotate and bells to ring.

Φ **Relation between kinetic energy and momentum :**

Let us consider a body of mass 'm' having a velocity 'v' , then

momentum of the body P = mass × velocity $\Rightarrow$ P = m × v

$$\Rightarrow \quad v = \frac{P}{m} \qquad \text{--------- (1)}$$

From definition, kinetic energy (K.E) of the body

$$K.E = \frac{1}{2}mv^2 \qquad \text{--------- (2)}$$

Now putting the value of (1) in (2) we have

$$K.E = \frac{1}{2}m\left(\frac{P}{m}\right)^2$$

$$K.E. = \frac{1}{2}m\frac{P^2}{m^2} = \frac{1}{2}\frac{P^2}{m} = \frac{P^2}{2m} \quad \text{----- (3)}$$

Thus we can write $P^2 = 2m \times K.E \Rightarrow P = \sqrt{2m \times K.E}$

Thus momentum = $\sqrt{2 \times \text{mass} \times \text{kinetic energy}}$

Note :

1. For same momentum $K.E \propto \frac{1}{m}$

Kinetic energy varies inversely as the mass.

2. If two bodies have same momentum, ratio of their kinetic energy is

$$\frac{K.E_1}{K.E_2} = \frac{m_2}{m_1} \qquad \left[E \propto \frac{1}{m}\right]$$

3. If two bodies have same kinetic energy, ratio of their momenta is $\frac{P_1}{P_2} = \sqrt{\frac{m_1}{m_2}}$

4. If the momentum of a body is increased to x times, its kinetic energy increases to x^2 times.

5. If the kinetic energy of a body is increased to x times, its momentum increases to $\sqrt{x}$ times.

Φ **IMPORTANT POINTS:**

Ψ If two bodies of different masses have same momentum, lighter body will have greater kinetic energy.

eg: When a bullet is fired from a gun, bullet and gun have same linear momentum but kinetic energy of bullet is more than that of gun.

Ψ If two bodies of different masses have same kinetic energy, heavier body will have greater

Ψ A body can have energy without momentum. But it can not have momentum without energy.

Ψ A bullet of mass m moving with velocity v stops in wooden block after penetrating through a distance x. If F is resistance offered by the block to the bullet,

$$\frac{1}{2}mv^2 = Fx \Rightarrow F = \frac{mv^2}{2x} \text{ or } v^2 \propto x$$

Ψ A sphere of mass m is dropped from a height 'h'above the ground. On reaching the ground, it pierces through a distnace S and then stops finally. Resistance offered by the ground is R. Then mgh = (R-mg)S

EXAMPLE

√ **Problem-1:**

The momentum of a body is doubled. By what percentage does its kinetic energy increase?

Solution:

$$K = \frac{p^2}{2m} \Rightarrow \frac{K_1}{K_2} = \frac{p_1^2}{p_2^2}$$

Let $K_1 = K$, $p_1 = p$ then $p_2 = 2p$, K_2=?

$$\frac{K}{K_2} = \frac{p^2}{(2p)^2} \text{ ; } K_2 = 4K.$$

% increase in kinetic energy = $\frac{\text{Increase in kinetic energy}}{\text{Initial kinetic energy}} \times 100$

$$\frac{K_2 - K_1}{K_1} \times 100 = \frac{4K - K}{K} \times 100 = 300\%$$

√ **Problem-2:**

A car and truck have same momentum. Which will have more kinetic energy?

Solution :

From the expression $K = \frac{p^2}{2m}$

If 'p' is cosntant, 'K' is inversely proportional to the mass of the body. Hence, the kinetic energy of the car is more than that of the truck.

√ **Problem-3:**

If $v = (3i + 4j + 5k)\ ms^{-1}$ is the instantaneous velocity of a body of mass 1.50 kg. calculate its kinetic energy.

Solution:

$V = (3i + 4j + 5k) ms^{-1}$ M = 1.5 kg

Kinetic energy K.E. $= \frac{1}{2} mv^2$

$= \frac{1}{2} 1.5(3i + 4j + 5k) .(3i + 4j + 5k;)$ = 37.5 joules

√ **Problem-4:**

A man standing on the edge of a roof of a 20 m tall building projects a ball of mass 100 g vertically up with a speed of 10 ms^{-1} and simultaneously throws another ball of same mass vertically down with the same speed. Find the kinetic energy of each ball when they reach the ground (g = 10 ms^{-2}).

Solution:

Both the two balls reach the ground with the same velocity

h = 20m, m = 100g $= 10^{-1}$ kg , $u = 10\ ms^{-1}$

$v^2 - u^2 = 2gh$

$v^2 = u^2 + 2gh = 10^2 + 2 \times 10 \times 20 = 500$

K.E. of each ball $= \frac{1}{2}mv^2 = \frac{1}{2} \times 10^{-1} \times 500 = 25$ J

$\therefore$ K.E. of balls $= 25$ J, 25 J.

√ **Problem-5:**

A cart of mass 250 kg is taken along a polished inclined surface to the top of a platform which is at a height of 2 m above the ground level. Find the work done by the external force moving the cart to the top.

Solution:

m = 250 kg; h = 2 m, Work done W = mgh

$= 250 \times 9.8 \times 2 = 250 \times 196$ = 4900 J = 4.9 KJ

TEACHING TASK

Single correct option questions:

1. A liquid of density 0.8 kg per CC meter is flowing in a pipe line with a speed of 2ms^{-1}.The K.E.per cubic meter of it

A)160J B)1600J C)160.5J D)1.6J

2. Three spheres of different materials are in motion their radii, densities and speeds are as given

Sl.No	Radius	Density	Speed
1	r	d	υ
2	r/2	d	V/2
3	2r	d/2	υ

If K_1, K_2, K_3 are the kinetic energies of those three spheres respectively, those values can be arranged in descending order as given below

A) K_3, K_2, K_1 B) K_3, K_1, K_2 C) K_1, K_2, K_3 D) K_2, K_1, K_3

3. A body is in motion and it is stopped by applying retarding force. Initial speed magnitude of force applied are as given below

Speed	V	2V	V/2
Force	F	F/2	2F

If S_1, S_2, S_3 are the distances travelled before coming to rest, those can be arranged in ascending order as given below

A) S_1, S_2, S_3 B)S_3, S_2, S_1 C) S_2, S_1, S_3 D) S_3, S_1, S_2

4. The mass of a body is halved and velocity is doubled. Percentage increase in the K.E. of the body is

A) 400% B) 300% C) 200% D) 100%

5. Two masses of 1gm and 4gm are moving with equal K.E. The ratio of the magnitudes of their linear momenta is
A) 4 : 1 B) 2 : 1 C) 1 : 2 D) 1 : 16

6. A particle of mass 2kg starting from rest moves with an acceleration $2m/s^2$ for 2s. The gain in K.E. of the body is
A) 16 J B) 8 J C) 4 J D) 2 J

7. A body of mass 0.5 kg is moving with a constant veocity of 2 m/s. In order to bring it to rest in a distance of 2m, the work to be done is
A) 0.5 J B) 1 J C) 2 J D) 4 J

8. A bomb at rest explodes into two pieces of masses 3 Kg and 2 Kg. If the energy of explosion is 600 J and all that energy is converted into kinetic energy, the kinetic energy of the heavier piece is
A) 240 J B) 360 J C) 300 J D) 200 J

9. A simple pendulum of mass 200gm and length 1m is turned through 60º and then released. When the pendulum passes through its mean position, its kinetic energy at that instant will be ($g=10m/s^2$)
A) 4J B) 3J C) 2J D) 1J

10. A gun of mass 'M' fires a bullet of mass 'm' with a velocity 'u'. The kinetic energies of the bullet and the gun are in the ratio
A) m : M B) M : m C) 1 : 4 D) m/M+m

More than one correct option questions

- *This section contains multiple choice questions. Each question has 4 choices (A), (B), (C),(D), out of which **ONE or MORE** is correct. Choose the correct options*

11. Which of the following are the units for energy
a) eV b)joule c)erg d)Btu
A) a,b,c are corect B) a,b,d are correct C) b,c,d are correct D) all are correct

12. Which of the following are conservative forces?
a) Gravitational force b) Electrostatic force c) Magnetic force d)Elastic force
A) a,b,c are corect B) a,b,d are correct C) b,c,d are correct D) all are correct

Assertion - A and Reason - R:

- *This section contains certain number of questions. Each question contains Statement – 1 (Assertion) and Statement – 2 (Reason). Each question has 4 choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct Choose the correct option.*

A) Both A and R are true and R is the correct explanation for A.
B) Both A and R are true and R is not correct explanation of A.
C) A is true but R is false. D) A is false but R is true

13. A : A body can possess mechanical energy without momentum.
R : A bent bow possess potential energy by virtue of deformation.

14. A: A lighter body and heavier body have same momentum.Then they also have same K.E.
R: Kinetic energy does not depend on mass of the body.

15. A: Two bodies of different masses have same momentum.Then the ratio of their K.E is in the inverse ratio of their mass
R: $K.E=1/2(mv^2)$

Match the following

- *This section contains Matrix-Match Type questions. Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in **Column–I** have to be matched with statements (p, q, r, s) in **Column–II**. The answers to these questions have to be appropriately bubbled as illustrated in the following example.*

*If the correct matches are A-p,A-s,B-r,B-r,C-p,C-q and D-s,then the correct bubbled 4*4 matrix should be as follows:*

16.

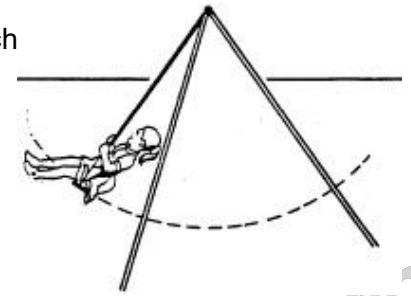
Set-I	Set-II
a) Conservative force	1) Workdone in a closed path is zero
b) Non-Conservative force	2) Workdone in a closed path is not zero
c) Kinetic energy	3) By virtue of position of a body
d) Potential energy	4) By virtue of motion of a body

A) a-1,b-4,c-3,d-2 B) a-1,b-2,c-4,d-3 C) a-2,b-3,c-1,d-4 D) a-4,b-2,c-1,d-3

Comprehension type questions

- *This section contains paragraph. Based upon each paragraph multiple choice questions have to be answered. Each question has 4 choices (A) , (B) ,(C) and (D) out of which **ONLY ONE i**s correct. Choose the correct option.*

17. A 12 kg child swings on a swing which is 0.30 m above the ground. If she reaches a maximum height of 1.5 m



i) What is her potential energy at the highest point in her swing?

A) 140J B)120J

C) 180J D)150J

ii) What is her speed when she reaches this point(above problem) in ms^{-1}?

A) 8 B)7 C)20 D)0

KEY

ΦΦ TEACHING TASK :

1) D, 2) B, 3) D, 4) D, 5) C, 6) A, 7) B, 8) B, 9) D, 10) B, 11) D, 12) D, 13) B, 14) B, 15) D, 16) B, 17) i) A, ii) D

LEARNER'S TASK

BEGINNERS (Level - I)

Single correct option questions:

1. A vehicle of mass 1000kg climbs up a hill of 200m height. what is the P.E?

A) 196 x 10^4 J B) 256 x 10^4 J C) 300 x 10^4 J D) 196 J

2. A body of mass 10 kg moves with a velocity of 10 m/s .what is the K.E?

A) 5J B) 500J C) 100 J D) 10J

3. When the momentum of a body is doubled, the kinetic energy is

A) doubled B) halved C) increases four times D) increases three times

4. Two bodies of different masses have same K.E. The one having more momentum is

A) Heavier body B) lighter body C) both D) none

5. Two bodies of masses m_1 and m_2 have equal momenta. Their K.E. are in the ratio

A) $\sqrt{m_2} : \sqrt{m_1}$ B) $m_1 : m_2$ C) $m_2 : m_1$ D) none

6. The momentum of a particle is found to be numerically equal to its kinetic energy, if all units are expressed in SI, the velocity of the particle must be

A) 1 m/s B) 2 m/s C) 0.5 m/s D) 4 m/s

7. Two spheres of different materials are in motion. If their densities are in the ratio 1 : 2 radii are in the ratio 1 : 2 and velocities are in the ratio 2 : 1 their kinetic enegies are in the ratio
A) 1 : 4 B) 4 : 1 C) 1 : 1 D) 8 : 1

8. For the same kinetic energy, the momentum shall be maximum for which of the following particle?
A) electron B) proton C) deuteron D) alpha particle

9. If 'E' represents total mechanical energy of a system while 'U' represents the potential energy, then E-U is
A) always zero B) always less than zero
C) always greater than zero D) either positive or negative

10. Two bodies of different masses have same linear momentum. The one having more K.E. is
A) Lighter body B) heavier body C) bothA&B D) none

11. The product of linear momentum and velocity of a body represents
A) half of the kinetic energy of the body B) kinetic energy of the body
C) twice of the kinetic energy of the body D) mass of the body

12. A cyclist free-wheels from the top of a hill, gathers speed going down the hill, applies his brakes and eventually comes to rest at the bottom of the hill. Which one of the following energy changes take place?
A) Potential to kinetic to heat energy B) Kinetic to potential to heat energy
C) Chemical to heat to potential energy D) Kinetic to heat to chemical energy

ACHIEVERS (Level - II)

1. Calculate the velocity of an alpha particle which has a kinetic energy of 3.50×10^{17}J The mass of an alpha particle is 6.65×10^{-27} kg.

2. Two bodies have their masses $m_1/m_2=3/1$ and their K.E.s $K_1/K_2=1/3$.Find the ratio of their velocities.

3. Two bodies having kinetic energies K_1 and K_2 have equal masses. Their momenta are p_1 and p_2 respectively, then find the value of p_1/p_2.

4. A liquid of specific gravity 0.8 is flowing in a pipe line with a speed of 2 m/s. Find the K.E. per cubic meter of it.

5. A river is flowing at a speed $4ms^{-1}$. Find the K.E. of cubic metre of water.

6. Two masses of 2kg and 8kg are moving with linear momenta in the ratio 1 : 2. Calculate the ratio of their K.E.

7. The momentum of two bodies are in the ratio 2 : 3 and their K.E. are in the ratio 8 : 27. Find the ratio of masses.

8. The KE of the body is K if $1/4^{th}$ of its mass is removed and velocity is doubled its new KE is.....

9. A river of salty water is flowing with a velocity 2 m/s. if the density of water is 1.2g/cc.then the KE of each of cubic metre of water is....

10. If the KE of a body increases by125%.the percentage increases in its momentum is

11. A spring is kept compressed by a toy cart of mass 150 g on realising the cart it moves with a speed of 0.2 m/s. calculate the PE of the spring.

EXPLORERS(Level - III)

More than one correct option questions

- *This section contains multiple choice questions. Each question has 4 choices (A), (B), (C),(D), out of which* ***ONE or MORE*** *is correct. Choose the correct options*

1. Which of the following are correct relations?
a)1KWH=$3.6X10^6$J b) $1eV = 1.6 \times 10^{-19} J$ c) 1J=10^7erg
A) a,b are corect B) a,c are correct C) b,c are correct D) all are correct

2. Which of the following have the same units
a) Work b) P.E c) K.E d) Gravitational force
A) a,b,c are corect B) a,b,d are correct C) b,c,d are correct D) all are correct

3. Which of the following belongs to same category?
a) Gravitational force b) Electrostatic force
c) Magnetic force d) frictional force force
A) a,b,c are corect B) a,b,d are correct C) b,c,d are correct D) all are correct

Assertion - A and Reason - R:

- *This section contains certain number of questions. Each question contains Statement – 1 (Assertion) and Statement – 2 (Reason). Each question has 4 choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct Choose the correct option.*

A) Both A and R are true and R is the correct explanation for A.
B) Both A and R are true and R is not correct explanation of A.
C) A is true but R is false.
D) A is false but R is true.

4. **A:** The rate of change of total momentum of a many particle system is proportional to the sum of internal forces of system.
R: Internal forces can changes the K.E but not the momentum of the system.

5. **A:** Both P.E and K.E have the same units.
R: Both P.E and K.E are scalar quantities.

6. **A:** Energy is a scalar quantity.
R: Both energy and work have the same units

7. **A:** KWH is the unit of electrical energy.
R: 1KWH = 3.6×10^6 joule

Match the following

- *This section contains Matrix-Match Type questions. Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in **Column–I** have to be matched with statements (p, q, r, s) in **Column–II**. The answers to these questions have to be appropriately bubbled as illustrated in the following example.*

  *If the correct matches are A-p,A-s,B-r,B-r,C-p,C-q and D-s,then the correct bubbled 4*4 matrix should be as follows:*

8.

Set-I	**Set-II**
a) PE=KE	1) at height h/2
b) PE=2KE	2) constant at any point
c) KE=2PE	3) at height 2h/3
d) PE+KE	4) at height h/3

A) a-1,b-4,c-3,d-2 B) a-1,b-3,c-4,d-2 C) a-2,b-3,c-1,d-4 D) a-4,b-2,c-1,d-3

Comprehension type questions

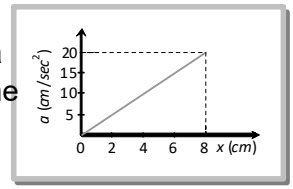
- *This section contains paragraph. Based upon each paragraph multiple choice questions have to be answered. Each question has 4 choices (A) , (B) ,(C) and (D) out of which **ONLY ONE i**s correct. Choose the correct option.*

9. A body of mass 5 kg is moving with a momentum of 10 kg-m/s. A force of 0.2 N acts on it in the direction of motion of the body for 10 seconds.
i)The change in momentum is
A) 12kgms^{-1} B)20kgms^{-1} C) 15kgms^{-1} D)18kgms^{-1}
ii)The increase in its kinetic energy is
A) 6J B)10J C)8J D)4.4J

RESEARCHERS (Level - IV)

Single correct option questions:

1. A 10 kg mass moves along x-axis. Its acceleration as a function of its position is shown in the figure. What is the total work done on the mass by the force as the mass moves from $x = 0$ to $x = 8$ cm [**AMU (Med.) 2000**]



A) $8 \times 10^{-2}\ J$ B) $16 \times 10^{-2}\ J$ C) $4 \times 10^{-4}\ J$ D) $1.6 \times 10^{-3}\ J$

2. A uniform chain of length L and mass M is lying on a smooth table and one third of its length is hanging vertically down over the edge of the table. If g is acceleration due to gravity, the work required to pull the hanging part on to the table is **[IIT-JEE 1985; MNR 1990; MP PMT 1994, 97, 2000; JIMPER 2000; AIEEE 2002]**

A) MgL B) $\frac{MgL}{3}$ C) $\frac{MgL}{9}$ D) $\frac{MgL}{18}$

3. A particle of mass 'm' and charge 'q' is accelerated through a potential difference of 'V' volt. Its energy is **[UPSEAT 2001]**

A)qV B)mqV C)qV/m D) q/mV

4. A running man has half the kinetic energy of that of a boy of half of his mass. The man speeds up by 1 m/s so as to have same K.E. as that of boy. The original speed of the man will be

A) $\sqrt{2}\ m/s$ B) $(\sqrt{2}-1) m/s$ C) $\frac{1}{(\sqrt{2}-1)} m/s$ D) $\frac{1}{\sqrt{2}} m/s$ **[Pb. PMT 2001]**

5. A body of mass 10 kg at rest is acted upon simultaneously by two forces 4N and 3N at right angles to each other. The kinetic energy of the body at the end of 10 sec is

A)100 J B) 300 J C) 50 J D) 125 J **[Kerala (Engg.) 2001]**

6. If the momentum of a body increases by 0.01%, its kinetic energy will increase by

A)0.01% B)0.02 % C) 0.04 % D) 0.08 % **[MP PET 2001]**

7. If the momentum of a body is increased by 100 %, then the percentage increase in the kinetic energy is **[NCERT1990; BHU 1999; Pb.PMT 1999; CPMT 1999, 2000]**

A) 150 % B)200 % C)225 % D) 300 %

8. A bread gives a boy of mass 40kg an energy of 21kJ. If the efficiency is 28% then the height can be climbed by him using this energy is **[AFMC 1997]**

A) 22.5 m B) 15 m C)10 m D)5 m

9. A force (3i + 4j) newton acts on a body and displaced it by (3i + 4j) meter. The work done by this force is ... **[AIIMS 2001]**

A)5 J B) 25 J C)10 J D)30 J

10. If a water falls from a dam into a turbine wheel 19.6 m below, then the velocity of water at the turbines is (take g=9.8 m/s2) **[AIIMS 2007]**

A) 9.8 m/s B) 19.6 m/s C)39.2 m/s D)98.0 m/s

11. A ball loses 15.0% of its kinetic energy when it bounces back from a concrete wall. With what speed you must throw it vertically down from a height of 12.4 m to have it bounce back to the same height (ignore resistance)? [**AIIMS 2010]**

A) 6.55 m/s B) 12.0 m/s C)8.6 m /s D)4.55 m/s

12. A car of mass 'm' is driven with acceleration 'a' along a straight level road against a constant external resistive force 'R'. When the velocity of the car is 'v', the rate at which the engine of the car is doing work will be **[MP PMT/PET 1998; JIMPER 2000]**

A)Rv B)mav C) $(R + ma)v$ D) $(ma - R)v$

13. A force applied by an engine of a train of mass $2.05 \times 10^6\ kg$ changes its velocity from 5 m/s to

25 m/s in 5 minutes. The power of the engine is **[EAMCET 2001]**
A)1.025 MW B) 2.05 MW C) 5MW D) 5 MW

14. From a water fall, water is falling at the rate of 100 kg/s on the blades of turbine. If the height of the fall is 100m then the power delivered to the turbine is approximately equal to **[BHU 1997]**
A) 100kW B)10 kW C)1kW D) 1000 kW

II) ADDITIONAL PROBLEMS FOR PRACTICE

1. A stone of mass "m" initially at rest and dropped from a height "h" strikes the surface of the earth with a velocity "v". If the gravitational force acting on the stone is W, then which of the following identities is correct?
A) $mv - mh = 0$ B) $\frac{1}{2}mv^2 - Wh^2 = 0$ C) $\frac{1}{2}mv^2 - Wh = 0$ D) $\frac{1}{2}mv^2 - mh = 0$

2. A body falls from a height of 10m and rebounds from a hard surface to a height of 8m. The percentage loss of energy during the collision is
A) 100% B) 50% C) 40% D) 20%

3. A body of mass 'm' is dropped from a height 'h' on a sand floor. If the body penetrates 'x'cm into the sand, the average resistance offered by the sand to the body is

A) $mg\left[1-\frac{h}{x}\right]$ B) mg(h + x) C) $mg\left[1+\frac{h}{x}\right]$ D) $mg\frac{h}{x}$

4. Two Solid spheres of same material having radii in the ratio 1:2 are moving with same kinetic energy on a horizontal path. They are brought to rest by applying same retarding force. Then
i) their initial momenta are in the ratio $1:2\sqrt{2}$
ii) distance travelled are in the ratio 1:1 before coming to rest
iii) The times taken by them coming to rest is $1:2\sqrt{2}$
1) i) and (ii) are correct 2) ii) and (iii) are correct
3) All the three are correct 4) (i) and (iii) are correct

5. A particle is released from a height 'H'. At certain height its kinetic energy is two times its potential energy. Height and speed of particle at that instant are

6. A ball is thrown downwards from a height 'h' with a velocity $\sqrt{4gh}$. The ball loses 50% of its velocity upon impact with the ground. The height to which the ball would rise after the impact is

7. A body thrown vertically up with a certain velocity reaches a maximum height 'h'. At a point 'p' above the ground, the ratio of PE to KE is 1:2. Now the same body is thrown up with double the initial velocity. Then the ratio of PE to KE at the same point 'p' is

KEY

ΦΦ LEARNER'STASK :

- **BEGINNERS :** 1)A, 2)B, 3)C, 4)B, 5)C, 6)B, 7)A, 8)D, 9)C, 10)A, 11)C, 12)A,
- **ACHIEVERS :** 1)$1.03\times10^5 ms^{-1}$, 2) 1:3, 3) $\sqrt{K_1}:\sqrt{K_2}$, 4) 1600 J, 5) $8000 J/m^3$, 6)1 : 1, 7)3 : 2, 8) 3, 9)2.4kJ, 10)50%, 11)3×10^{-3} J
- **EXPLORERS :** 1) D, 2) A, 3) A, 4) D, 5) B, 6) B, 7) A, 8) B, 9) i) A, ii) D.
- **RESEARCHERS :**

I)1)A, 2)D, 3) A, 4)C, 5)D, 6)D, 7)D, 8)B, 9)B, 10)B, 11)A, 12)C, 13)B, 14)A.

II)1) C, 2) D, 3)C, 4)3, 5) h/3, 6) 3H/4, 7)1:11