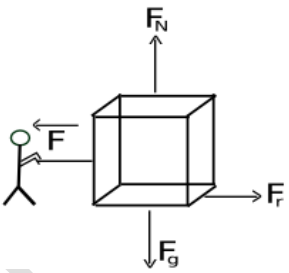
5.WORK – ENERGY - POWER

Work: Work is said to be done when a body undergoes displacement in the direction of the applied force. Measure of work depends on applied force(F) and the displacement of the object along the direction of force (s)
Work, W = F x s
Work done to raise a body of mass 'm' to a height 'h' against gravity, **W = mgh**
Unit of work is 'Nm' and it is called **joule** (J).
1 joule is the amount of work done to raise a body of mass 100 g through a height of 1 m.
Work may be positive or negative. It is considered as positive if the displacement is along the direction of force and it is considered as negative if the object is displaced opposite to the direction of force.
In the figure , an object is dragged by a force F as shown in the figure. There are three other forces experienced on the object other than the mechanical force F. They are frictional force F_r opposite to F, Gravity F_g acts vertically downward, Normal reaction from the ground vertically upwards. Here the work done by the force F is positive and that done by the force F_r is negative. But the work done by gravitational force F_g and normal reaction F_N are zero as there is no displacement along the direction of these two forces.



Energy: Energy is the capacity to do work. Unit of energy is same as that of work and is joule. We make use of different forms of energy in our day to day life.
Examples:Mechanical energy, Electric energy, heat energy and chemical energy.
There are two types of mechanical energy. They are kinetic energy and potential Energy.
Kinetic Energy:Energy possessed by a body by virtue of its motion is kinetic energy. Flowing water, moving vehicle, wind etc are examples for objects having kinetic energy.
The kinetic Energy of an object depends on its mass (m) and speed (v).
Kinetic Energy, $\mathbf{K = \frac{1}{2} mv^2}$
Potential Energy: The Energy possessed by a body by virtue of its position or strain is the potential Energy (U). Stone placed at height, water reserved in dam, compressed spring, stretched rubber band etc are examples for the objects possessing potential energy.
Potential energy of a body of mass 'm' placed at height 'h' is, U = mgh

Work – Energy principle.

Work - Energy theorem states that work done is equal to change in kinetic Energy.
When certain force is applied on a body of mass 'm' moving with velocity u, its velocity is changed to v.
According to Work – Energy theorem, Work done, $W = \frac{1}{2} mv^2 - \frac{1}{2} mu^2$
Energy transformation: Energy in one form can be transformed to other form with the help of suitable equipments. A few examples are given in the table.

Equipment	Energy transformation
Generator	Mechanical energy to Electrical Energy
Fan	Electrical Energy to mechanical Energy
Iron Box	Electrical Energy to heat energy
Electric Lamp	Electrical Energy to light Energy

Law of Conservation of Energy: *Energy can neither be created or destroyed. Energy can only be transformed from one form to another*. This is the Law of conservation of Energy.
Let us explain with an example.
Consider a stone at a height 'h' at rest. Now it is possessed only potential Energy. If it is allowed to fall down, its kinetic energy will gradually increase and potential energy decrease. But at any instant while its fall the sum of potential energy and kinetic energThat is, total energy will be a constant.
Power: Work done per second is power.
Power, P = work/time = W/t
Unit of power is J/s and is called watt (W)
Horse power (HP) is another unit of power.
1HP = 746 W

PRACTICE QUESTIONS & ANSWERS

1."All manual labours are not considered as work." Justify this statement.

Ans. Work is said to be done, only when an object is displaced under the action of force. For example, A person standing still on a floor carrying a load on his head. He has applied force on the load against the gravitational force, but there is no displacement to the object. So work done by the force is zero.

2.Explain the factors influencing the measure of work.

Ans. We have work done, W = Fxd. Hence work done depends on the magnitude of applied force and displacement along the direction of force.

3. Give the unit of work.

Ans. 'Nm' is the unit of work. It is called 'joule'.

4. What are the forces experienced on a stone lying on a table?

Ans. i. Gravitational force (weight) acting vertically downward direction.

ii. Reactive force from the surface of the table in the vertically upward direction.

5. Write down an expression for work done to raise a body of mass 'm' to the height 'h' against the gravitational force.

Ans. Work, W = mgh. Where 'g' is the acceleration due to gravity.

6. When a force of 50 N is applied continuously on a body, it is displaced 2 m along the direction of force. Calculate the work done.

Ans. Force F = 50 N, displacement,d = 2 m. Work, W = Fxs = 50x2=100 J.

7.a. When a force of 200 N is applied continuously on a body of mass 50 kg, it is displaced 0.5 m along the direction of force.

b. If the same body is raised to the height of 2 m, calculate the work done against gravitational force.

Ans.a.F = 200 N, s = 0.5 m. W = Fxs = 200x0.5 = 100 J.

b.W = mgh= 50x9.8x3 =1470 J

8. Work may be positive or negative. Which is the situation where work is considered as negative? Give an example for negative work.

Ans. If the object is displaced opposite to the direction of force, the work is negative.

Work done by frictional force is always negative.

9.A stone is projected vertically up.

a. Whether the work done by the gravity on the stone is negative or positive while it is going up.

b. What about when it is falling down?

Ans. While it is moving up, displacement is opposite to the direction of gravity. So work done by the gravity is negative.

b. When it is falling down, the displacement is along the direction of gravity and hence the work is positive.

10."Work done by gravity may be positive or negative." Comment to this statement..

Ans. This statement is correct. When a body is projected vertically upward direction, it is displaced opposite to the direction of gravity. So work done by the gravity is negative. But in the case of a freely falling body, work done by the gravity is positive as it is displaced in the direction of gravity.

11. A boy continuously applied 10 N force on a brick of mass 5 kg lying on a flat floor and it displaced to 8 m along the direction of force. If the frictional force experienced on the brick is 4 N,

a. What is the work done by the boy? b. Calculate the work done by the frictional force.

c. What is the work done against the gravity? (Take g = 10 m/s^2)

Ans.a. W = Fxs = 10x8 = 80 J. b. W = Fxs = -4x8 = -32 J

c. Since there is no displacement against the direction of gravity, work done by the boy against the gravity is zero.

12."A person walking along a flat floor carrying a load on his head doesn't do any work" Comment to this statement.

Ans. This statement is wrong. Here only the work done against the gravity is zero. But he has been applying a force in the horizontal direction to move his body forward. So work has been done for this.

13.What is energy? What is its unit? Give examples for various forms of energy.

Ans.i. Energy is the capacity to do work. ii. Its unit is same as that of work and is *joule*.

iii. Mechanical energy, heat energy, chemical energy, electrical energy.

14.What is meant by kinetic energy? Write expression for kinetic energy and specify each variables in it.
Ans. i.Energy possessed by a body by virtue of its motion is called kinetic energy.
ii. Kinetic Energy , $K = \frac{1}{2} mv^2$, m – mass of the object and v – speed.
15. i.What are the factors influencing kinetic energy of an object?
Ans.Mass and speed.
16. What will be the change in kinetic energy of an object in the following situations?
a. Mass is doubled. b. Speed is doubled.
Ans.i.a. As Kinetic energy is directly proportional to the mass, kinetic energy also is doubled when mass is doubled.
b. But kinetic energy is quadrupled when speed is doubled as it is proportional to the square of speed.
17. State work – Energy theorem.
Ans. Work done is equal to change in kinetic energy.
18. A car of mass 1500 kg is running with a speed of 20 m/s. Find its kinetic Energy.
Ans. Kinetic Energy, $K = \frac{1}{2} mv^2 = \frac{1}{2} \times 1500 \times 20 \times 20 = 300000$ J.
19. A boy of mass 50 kg is riding a bicycle of mass 10 kg with a speed of 2 m/s. Calculate the total Kinetic Energy.
Ans. Total mass m = 50+10=60 kg. Speed = 2 m/s
Total Kinetic Energy = $\frac{1}{2} mv^2 = \frac{1}{2} \times 60 \times 2 \times 2 = 120$ J
20. What is potential Energy? Give a few examples for objects that possessed potential energy.
Ans.Energy possessed by a body due to its position or strain is known as potential Energy.
Stone placed at height, stretched rubber band, compressed spring, water stored in a tank etc.. are examples for objects having potential energy.
21. Write down expression for potential energy of an object kept at height.
Ans. Petential Energy U = mgh. m – mass, g – Acceleration due to gravity, h – height.
22. In all our domestic electrical devices, energy in one form is converted to another form. Find out the energy conversion in the following devices.
a. Electric Bulb. b. Electric motor. c. Electric Generator d. Iron box e. Electric fan.
Ans. a. Electric bulb : Electrical energy is transformed to light and heat energy.
b. Electric motor: Electrical energy is transformed to mechanical energy.
c. Electric Generator : Mechanical Energy is transformed to electrical Energy.
d. Iron box : Electrical energy is transformed to heat energy.
e. Electric fan: Electrical energy is transformed to mechanical energy.
23. State law of conservation of energy.
Ans. Energy can neither be created nor destroyed. One form of energy can only be converted to another form.
24.What forms of energies does a freely falling body posses? Identify the transformation of energy during the fall.
Ans. Kinetic Energy & Potential Energy.
Potential energy is being converted to kinetic energy.
25. "The Sun is the major source of energy that we make use of in our daily life." Justify this statement.
Ans.(i). Hydroelectric power station: Rain water is used for producing current there. The vaporisation of sea water by infrared radiation (heat radiation) from sun is caused rain. In this sense, the original source of electrical energy produced in hydroelectric power station is the Sun.
(ii).Windmill: Heat received from the sun is responsible for the formation of wind.
(iii).Food materials: Chemical energy that stored in food grains, fruits, etc. is actually obtained through photo synthesis by receiving sunlight.
(iv).Fossil Fuels: The major fossil fuels like petroleum and coal are formed by the transformation of the remains of living beings. The source of chemical energy stored in the fossils are the sun itself.
26. Define power. What is its unit?
Ans: Power is the rate of doing work.
Power P = Work(W)/time(t). Unit of power is J/s and is called 'watt'.
Another unit for power is horse power (HP).

27. A man of mass 70 kg climbs up a mountain of 30 m height in 5 minutes. Find the power.
Ans: mass, m = 70 kg height,h = 30 m time, t = 5x60 = 300 s
Power, P = W/t = mgh/t = 70x9.8x30/300 = 68.6 W
28. a. State work – energy theorem.
b. A ball of mass 200g is rolled with a speed of 2m/s and comes to stop after travelling certain distance. Calculate the work done on the ball by frictional force.
Ans.a. Work done = change in kinetic energy.
b. Initial velocity u = 2 m/s Final velocity v = 0 mass of the ball = 200g = 0.2 kg
Initial kinetic energy = ½ mu^2 = ½ x0.2x2x2 = 0.4 J
final kinetic energy = ½ mv^2 = ½ x0 = 0
Work done = change in KE = 0.4 – 0 = 0.4J
29. If a man of mass 50 kg takes 60 s to climb up 20 steps each of height 15 cm, find the power. (take g = 10 m/s^2)
Ans: mass, m = 50 kg Total height,h =0.15x20 = 3 m time, t = 60 s
Power, P = W/t = mgh/t = 50x10x3/60 = 25 W
30. A stone of mass 40 kg is kept on a terrace of 12 m height.
a. What is the potential energy of the stone?
b.If it is allowed to fall down, what will be its kinetic energy when it just reaches the ground?
c. State the law which helps you to find the answer of question (b).
Ans:a. Potential Energy ,U = mgh = 40x10x12 = 4800 J.
b. Kinetic Energy,K = 4800 J. (Because when it just reaches the ground, entire potential energy is converted to kinetic energy)
c. Law of conservation of energy: *Energy can neither be created nor destroyed. One form of energy can only be converted to another form*.
31.According to the law of conservation of energy, energy cannot be created. Then how energy is acquired by a stone kept at a height or a compressed spring?
Ans.(i)The work that had done to raise the stone to the present height is stored in it as potential energy. Similarly the work done to compress the spring is stored in it as potential energy.
32. A stone of mass 40 kg is kept on the terrace of a building 12 m height.
a. What is the potential energy of the stone?
b. If it is allowed to fall free, what will be its kinetic energy when it just reaches the ground?
c. Which is the law that help you to answer the question?
Ans:a. Potential Energy,U = mgh = 40x10x12 = 4800 J.
b. K = 4800 J. c. Law of conservation of energy.
33. According to the law of conservation of energy, Energy can neither be created nor destroyed. If so how do a stone keeping at height and compressed spring possess acquire potential energy?
Ans.(i) The work had been done to lift the stone from the ground is stored in the stone as potential energy.
(ii). The energy consumed to deform the spring is the source of potential energy in compressed spring.
34. A bird of mass 0.5 kg is flying with certain speed keeping the height as 5m. If its potential energy and kinetic energy are equal, find
a. Potential Energy of the bird. b. Speed of the bird. (Given g = 10 m/s^2)
Ans. a.Potential Energy U = mgh = 0.5x10x5 = 25 J
b. Since kinetic energy and potential energy are equal, ½ mv^2 = 25
½ x0.5xv^2 = 25 Or v^2 = 25x2/0.5 = 100 Then v= 10 m/s
35. A stone kept at height of 100 m possessed 200 J of potential energy. And it is allowed to fall freely. Find out the location at which
a. Kinetic energy and potential energy becomes equal.
b. Kinetic energy becomes maximum.
c. Total energy becomes maximum.
Ans.a.At halfway between the path. ie, when it reaches at the height 50 m from the ground.
b. When it just reaches the ground.
c. Total energy remains the same throughout the fall.

36. Fill in the blanks.
a. 1HP = ... watt
b. The energy stored in a compressed spring is .....
c. Kinetic energy and potential energy are ..... energies.
d. Quantities having direction are vectors and that do not have direction is scalars. Work is a ..... quantity.
e. kilowatthour (Kwh) is the unit of .....
Ans. a. 746 b. Potential energy. c. mechanical d. Scalar
37. Complete the pairs according to the first.
a. Nm:joule; J/s: ..... b. force x displacement: work; ..... : power
c. Energy: joule; Work : .....
Ans. a. watt. b. work/time c. joule.