Unit# 6

Work and energy

Q# 1 Write a detail note on work?

Ans: Definition:

In physics, Work is said to be done if force acts on a body and body moves some displacement in the direction of force.

Mathemically:

Work is the dot product of force (F) and displacement (d).

$$W = F.d$$

In-Component:

When force and displacement are not parallel then only x-component of force is parallel to displacement so:

$$W = F_x . d$$

$$W = Fd\cos\theta$$

Factors:

Work depends upon three factors:

1) Force
2) Displacement
3) Angle b/w Force and displacement.

Unit:

SI unit work is joule (Nm).

Maximum:

Work is maximum if angle b/w force and displacement is 0°.

$$W = Fd \cos 0$$

$$W = Fd\,(1)$$

$$W = Fd$$

Minimum:

Work is minimum if angle b/w force and displacement is 90°.

$W = Fd \cos 90$

$W = Fd (0)$

$W = 0$

Positive:

Work is positive if angle b/w force and displacement is less than 90°.

Negative:

Work is negative if angle b/w force and displacement is greater than 90°.

Q#2 Define joule.

Ans: The amount of work is one joule when a force of one newton displaces a body through one metre in the direction of force. Thus

$1\ J = 1N \times 1\ m$

Q# 3 Define the term Energy also write formula and SI unit?

Ans: A body possesses energy if it is capable to do work.

Example:

Energy is what is needed to apply a force to move something, whether it's lifting a book off the floor, pulling a wagon up a hill, or even causing electrons to flow through a wire.

Si unit: its unit is joule.

Q# 4 Why do we need energy?

Ans: The energy is an important and fundamental concept in science. It links almost all the natural phenomena. When we say that a body has energy, we mean that it has the ability to do work. Also work energy principle energy:

$\Delta E = W$

So no work is done without energy.

Q# 5 Define the term Mechanical energy?

Ans: The energy possessed by a body both due to its motion or position is called mechanical energy. For example:

Water running down a stream, wind, a moving car, a lifted hammer etc

Mechanical energy possessed by a body is of two types: kinetic energy and potential energy.

Q# 6 What is Kinetic energy? Derive its expression by using graphical analysis?

Ans: The energy possessed by a body due to its motion is called Kinetic energy.

Example: A football is kicked by a boy it moves because it possess Kinetic energy.

Formula:

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

Factors: It depend upon two factors

1) Mass
2) Velocity

Si unit: Unit of energy is same as that of work i.e joule

Work energy principle:

kinetic energy theorem, which states that the work done on an object is equal to change in energy i.e $W = \Delta E$.

Where W is the work done and $\Delta E'$ is the change in energy.

Derivation:

Consider a constant force 'F' is acting on an object of mass 'm' and as a result the object moves On a frictionless surface.

The kinetic energy of an object will be equal to work done. The work done on force - displacement graph can be calculated by finding area of figure under force -displacement graph as shown in:

Change in kinetic energy (k.E) = Work done =F,d

Work done = area under force displacement graph

Here the area under force displacement graph is the area of rectangle, thus:

Change in kinetic energy (k.E) = Area of rectangle = width x length = (F)(d)

$$K.E=(ma)(v_{av}t)$$

Here $v=\frac{vi+vf}{2}$

As speed is increasing its velocity from $v_i= 0$ to $v_f=v$ therefore the average seed is therefore

$$V_{av}=\frac{0+v}{2}=\frac{v}{2}$$

And acceleration can also be written as:

$$a=\frac{v}{t}$$

so

$$k.E = m\frac{v}{t}\times\frac{1}{2}v\,t$$

$$k.E=\frac{1}{2}mv^2$$

Q# 7 What is potential energy? Show that gravitational potential energy is equal to the product of mass 'm', gravitational field strength 'g' and height 'h'?

Ans: The energy possessed by a body by virtue of its position (in a force field or in configuration) is called potential energy'.

Example: For example, an apple on a tree is capable to do work as it falls. Thus, it possesses energy due to its position.

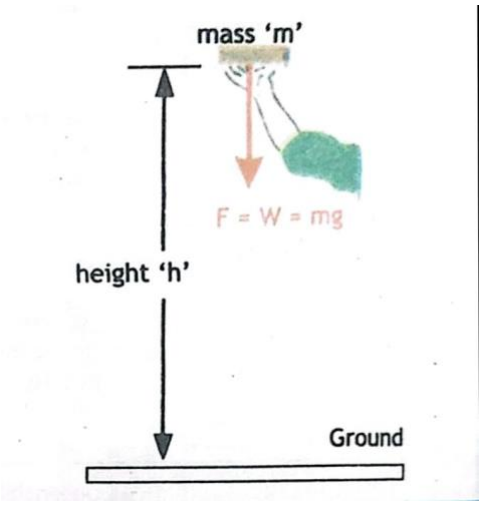
Formula: P.E = mgh

Unit: Its SI unit is joule.

Derivation:

Consider an object of mass 'm' being lifted vertically by a force 'F' to 'h' as shown. The work done by the force F is given by equation.

$$W= FS$$



Since the force in this case is equal to its weight F=W=mg

Here the distance moved is the height 'h'

Putting equation 2 and 3 in equation 1, we get

P.E = mgxh= mgh

Q# Give an example of Energy Conversion?

Ans: Potential energy of water which is stored at a certain height is converted into kinetic energy by making it fall on turbine to produce electricity.

Q# What is the law of Conservation of energy?

Ans: Energy can neither be created nor destroyed in any process. It can be converted from one form to another, but the total amount of energy remains constant".

This means that if the workdone 'W' is zero then, the change in energy 'ΔE' is also zero.

$$\Delta E = 0$$

If the total energy at the final stage is E_{Tf} and the total energy at initial stage is E_{Ti} then by conservation of energy principle

$$E_{Tf} = E_{Ti}$$

for example: when electrical energy is provided to a fan some of the electrical energy is used in rotating the fan, the remaining energy is not lost or destroyed but converted into other forms of energy (such as thermal energy) such that the total amount of energy is constant,

Q# Difference between renewable and non-Renewable energy resources?

Renewable Resources:

1) Renewable resources cannot be depleted over time.
2) Renewable resources include sunlight,water,wind etc
3) Most renewable resources have low carbon emissions and low carbon footprint.
4) The upfront cost of renewable energy is high.

Non- Renewable resources:

1) Non-Renewable resources deplete over time.
2) Non-Renewable energy includes fossil fuels ,coal,oil etc
3) Non-Renewable energy has a comparatively higher carbon footprint.
4) Non-Renewable energy has a comparatively lower upfront cost.

Q# Describe the advantages and disadvantages of energy from Renewable energy resources?

Ans: Advantages:

- Free of greenhouse gasses.
- Free of Air pollution.
- Zero carbon emissions.
- A cheaper from of electricity.
- Energy independence. Etc

Disadvantages:

- Geographical limitations.
- High initial investment.
- Challenge in energy store
- Unreliable supply. Etc

Q# What is perpetual motion?

Ans: Perpetual motion is the motion of bodies that continues forever in an unperturbed system.

Perpetual motion machine is a hypothetical machine that can do work infinitely without an external energy source.

This kind of machine is impossible, as it would violate either the first or second law of thermodynamics, or both.

Q# What are fossil fuels?

Ans: Fossil fuels, which include coal, oil, and natural gas, are rich in hydrocarbons-molecules made up of hydrogen and carbon atoms. When these hydrocarbons burn, they combine with oxygen from the air to create carbon dioxide, water and energy.

The general chemical equation for the combustion of a hydrocarbon, such as methane (CH_4 found in natural gas, is as follows:

$$CH_4 + 2O_2 \text{ -------> } CO_2 + 2H_2O + \text{Energy}$$

Q# Why oil is preferred over coal?

Ans: Despite the limited global reserves of oil, it is favored over coal due to its higher energy output for the same quantity.

Q# Why fossil fuels are called Non-Renewable energy resources?

Ans: The fossil fuels took millions of years for their formation. They are known as non-renewable resources. We are using fossil fuels at a very fast rate.

Q # What are the negative effects of using fossil fuels?

Ans: Fossil fuels release harmful waste products. These wastes include carbon mono-oxide and other harmful gases, which pollute the environment. This causes serious health problems such as headache, tension, nausea, allergic reactions, irritation of eyes, nose and throat.

Q# What are nuclear Fuels?

Ans: In nuclear power plants, we get energy as a result of fission reaction. During fission reaction, heavy atoms, such as Uranium atoms, split up into smaller parts releasing a large amount of energy. Nuclear power plants give out a lot of nuclear radiations and vast amount of heat.

Fission reaction:

$$^{235}U_{92} + {}^{1}n_0 \rightarrow {}^{56}kr_{36} + {}^{92}Ba_{56} + {}^{3}n_0 + \text{energy}$$

Q# What is the significance of using fossil fuels?

Ans: Harnessing nuclear energy is challenging.

- Building and operating nuclear power plants is a complicated process that requires skilled scientists and engineers, which many communities! Lack.

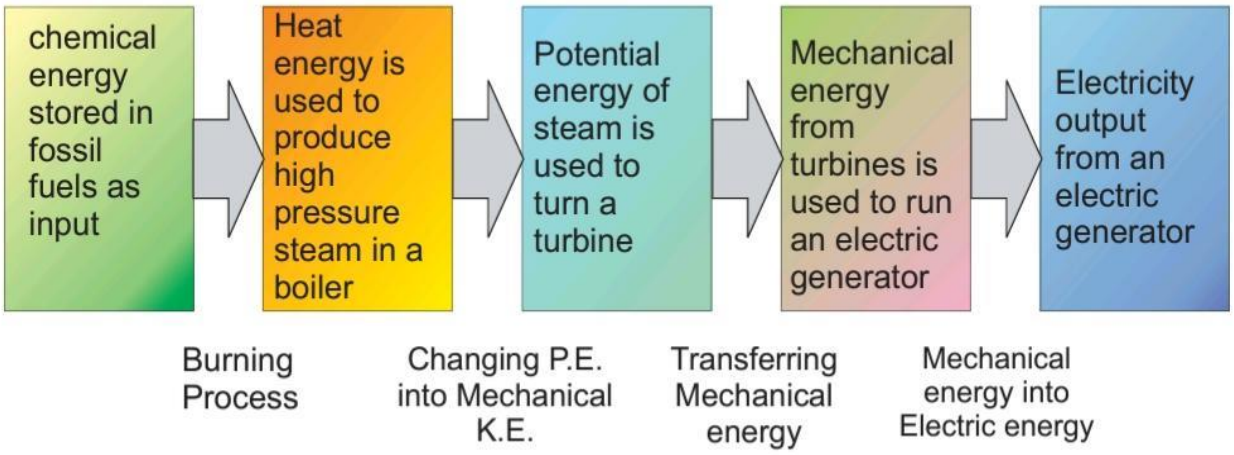
- Nuclear energy produces radioactive waste, which highly toxic and can cause severe health issues like burns, cancers, blood diseases, and bone decay.

Q# How we get electrical energy from Nuclear Fuels?

Ans: The process of nuclear fission involves splitting heavy atoms like uranium or plutonium. Resulting an significant amount of thermal energy. This heat is used to boil water, which then generates electricity.

Q# Draw a ray diagram to show how we get electrical energy from fossil fuels?

Ans: Fossil fuels are burnt in thermal power stations to produce electricity. Various energy conversion processes involved in producing electricity from coal are described in a block diagram as shown:



Q# How we get energy from Bio-mass fuel?

Ans: Bio mass, refers to the material that provides bio-energy. The energy contained in biomass coms from the sun, as plants capture sunlight through photosynthesis and convert into chemical energy, specifically carbohydrates. The most basic way to harness this energy is through consumption, Whenever you eat a fruit, vegetable, or a processed form of either, you are benefiting from the energy stored as a biomass.

Q# How many types of bio-mass are there?

Ans: Bio-mass has many types, this includes logs, branches, wood chips, sawdust, and other by- products from forestry and wood processing. Agricultural residues such as straw, corn stalks, and rice husks can be used as biomass fuel. Certain crops, like switch grass and miscanthus, are grown specifically for energy production. Livestock waste, such as dung, can be used as a biomass fuel.

Q# How we get electrical energy from bio-mass?

Ans: There are many methods currently used around the world to make the best possible use of biomass energy. Biomass can be burned directly to produce heat or used in combustion processes to generate steam, which drives turbines connected to generators for electricity production.

Q# How we get electrical energy from solar Radiation ?

Ans: Solar radiation is harnessed in two main ways for energy.

- The first method involves solar photovoltaic cells, also known as solar cells, which directly convert sunlight into electricity. These cells are made of semiconductor materials like silicon, which generate an electric current when exposed to sunlight.
- The second method is through solar thermal systems, which utilize the heat from sunlight for various applications such as electricity generation, water heating, and space heating. Concentrated Solar Power (CSP) systems concentrate sunlight onto a small area using mirrors or lenses**.** The concentrated sunlight is then used to heat a fluid, like water or a heat transfer fluid, which in turn produces steam. This steam is used to drive a turbine connected to a generator for electricity production.

Q# what are the significance of solar energy?

- Significant land area is required to produce significant amounts of electricity.
- Solar energy is intermittent and variable because it depends on weather conditions and the time of day.
- Cloudy days and night time limit the availability of sunlight, requiring additional energy storage or backup systems to ensure a continuous power supply.

Q# What are the advantages of solar energy?

Ans: Some advantages includes:

- Cells do not emit any greenhouse gases during operation, making them a clean energy option.
- The energy from sun is completely free and renewable energy resource that is also very eco-friendly.
- The use of solar energy helps reduce reliance on fossil fuels, decrease greenhouse gas emissions, and promote sustainable and renewable energy.

Q# Explain how we get energy from Geothermal resources?

Ans: In some parts of the world, the Earth provides us hot water from geysers and hot springs. There is hot molten part, deep in the Earth called magma. Water reaching close to

the magma changes to steam due to the high temperature of magma. This energy is called geothermal energy.

Q# Explain how we get energy from wind?

Ans: Wind power or wind energy is a form of renewable energy that harnesses the power of the wind to generate electricity. It involves using wind turbines to convert the turning motion of blades, pushed by moving air (kinetic energy) into electrical energy (electricity).

Q# How we get energy from the waves in the Sea?

Ans: Wave energy, also called ocean wave energy, is obtained from the movement of surface waves on the ocean. Wave Energy Converters (WECs) are devices created to capture the kinetic energy of these waves. There are different types of WECs, each with its own design and working principle.

- One type is point absorbers which move up and down with the waves. This vertical motion powers a system that converts the mechanical energy into electricity, such as a hydraulic pump or an electrical generator.
- Another type is attenuators, which are long floating structures that move with the waves. The relative motion between the segments of the attenuator is used to generate electrical. Oscillating water columns utilize the rising and falling motion of waves to create air movement in chamber. This moving air is then used to drive a turbine connected to a generator, producing mechanical energy. Than mechanical energy is converted into electrical energy.

Q# How we get energy from tides?

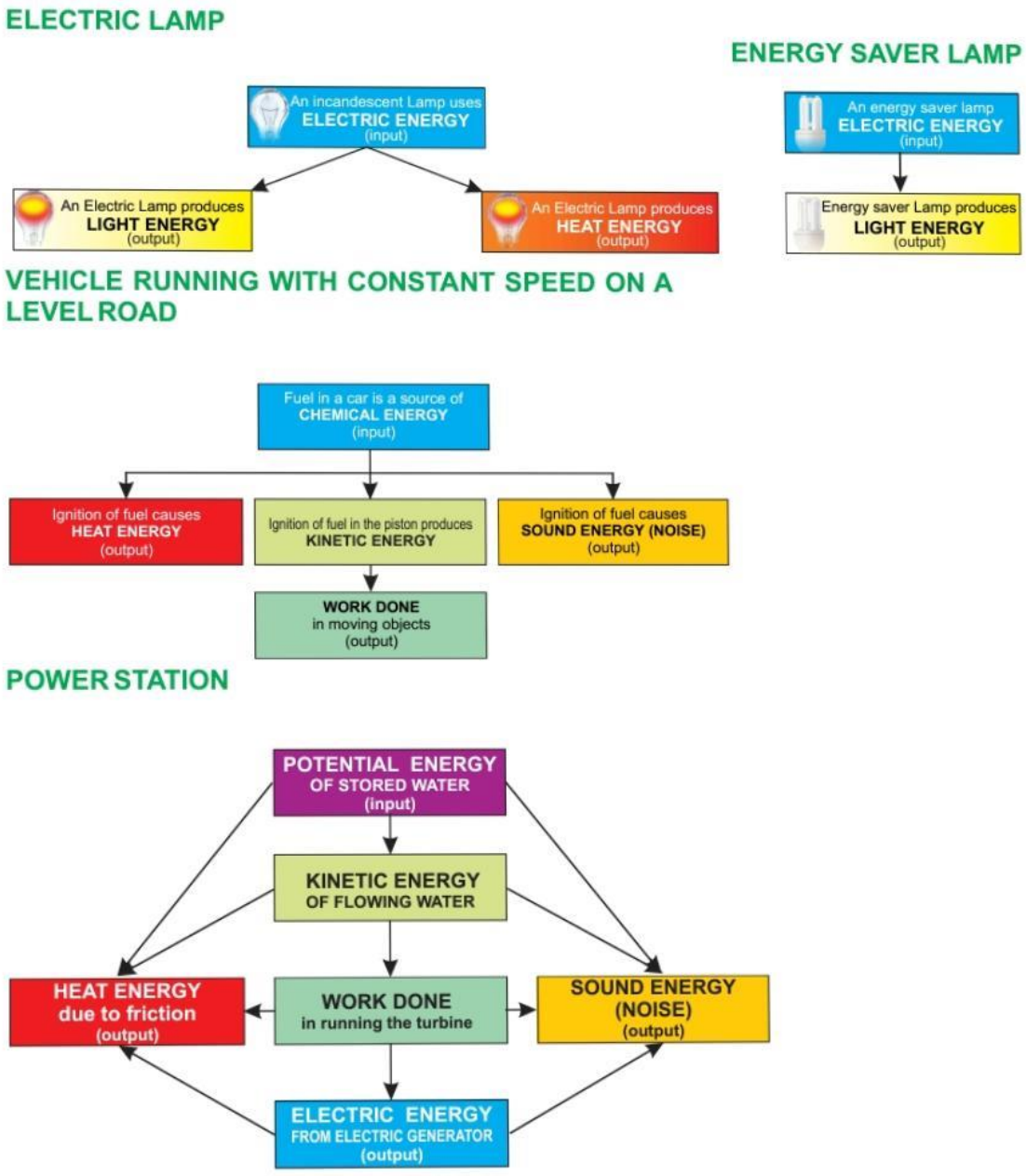
Ans: The gravitational force exerted by the moon as it orbits the Earth leads to the formation of bulges in the oceans, both closest and farthest from the moon. These bulges known as tides, occur twice a day as our planet completes one full rotation on its axis within a 24-hour period. There are primarily two main approaches to harnessing energy from tides.

- The first method involves utilizing tidal stream systems, also referred to as tidal current systems, which harness the kinetic energy generated by the movement of water caused by tidal currents. Specifically designed underwater turbines are strategically placed in areas with strong tidal currents to capture the kinetic energy and convert it into electricity.
- On the other hand, tidal range systems make use of the difference in height between high tide and low tide, known as the tidal range. To generate electricity, a tidal barrage or a dam-like structure is constructed across the entrance of a

tidal basin. Sluice gates within the barrage allow water to flow into the basin during high tide and release it during low tide, thereby producing electricity.

- Another method involves capturing high-tide waters and releasing them through turbines during low tide to generate electrical power from the ocean.

Q# Drwa flow sheet diagrams of following



Q# Define the term Power? Also write formula and unit.

Ans: Power is defined as the rate of doing work.

Mathematically:

$$\text{Power} = \text{Work done/ time}$$

$$P = W/t$$

Since work is a scalar quantity, therefore, power is also a scalar quantity. SI unit of power is watt (W)

$$1\,hp = 746\,W$$

$$1\,hp = 550\ ft.\ Lb^2/s$$

Q# Define the term Watt?

Ans: The power of a body is one watt if it does work at the rate of 1 joule per second (1 J/s).

Q# Define the term efficiency?

Ans: Efficiency of a system is the ratio of required form of energy obtained from a system as output to the total energy given to it as input.

$$E = \text{output/input}$$

$$\%E = \text{output/input} \times 100\%$$

Q# Why efficiency of a system is never 100%?

Ans: Every system meets energy losses due to friction that causes heat, noise etc. These are not the useful forms of energy and go waste. This means we cannot utilize all the energy given to a working system.

Q# Why efficiency has no unit?

Ans: Efficiency has no unit because it is simply ratio of two similar Quantities.

Q# What are ideal system?

Ans: An ideal system is that which gives an output equal to the total energy used by it. In other words, its efficiency is 100 %. People have tried to design a working system that would be 100 % efficient. But practically such a system does not exist.

Q# Prove that 1kwh= 3.6 MJ

Ans: As we know

$$1Kwh = (1000)(W)((3600s)$$

= 3600000 Ws

$= 3.6 \times 10^6$ J

= 3.6 MJ

Conceptual Questions

Q#1 A car is moving with a constant speed along a straight road. Is there any work done on the car?

Ans: We know that work done is equal to:

$$W=F.d$$

When a car is moving with constant speed then its mean there is no change in speed that is force will be zero.

$$W = (0)d$$
$$W=0$$

Hence the work done on the car moving with constant velocity will be zero.

Q#2 Does the work done in raising a box up in a building depend upon how fast it is raised up? Through which path? To how much height?

Ans: The work done in raising a box up in a building depends on the height to which it is raised.

In this case work done will be in the form of potential energy :

$W= P.E =mgh$

The work done does not depend on the path through which the box is raised.The work done does not depend on the speed at which the box is raised.

Q# 3 Work done on the body either speeds it up, slows it down. Keeping it mind, explain how much work is done by centripetal force on an orbiting satellite?

Ans: The work done by the centripetal force on an orbiting satellite is zero because the centripetal force is always perpendicular (0 =90) to the satellite's Acceleration direction of motion, resulting in no change in the satellite's speed.

$W= Fdcos(90)$

$W=F\ d\ (0)$

$$W = 0$$

Q# 4 A car has kinetic energy K.E. By what factor its kinetic energy would change, if its velocity is doubled?

Ans: As we know:

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

If v=2v than:

$$K.E = \frac{1}{2}m(2v)^2$$

$$K.E = \frac{1}{2}m(4v^2)$$

$$K.E = 4\left(\frac{1}{2}mv^2\right)$$

$$K.E = 4\ k.E$$

So kinetic energy become four times.

Q# 5 A **bullet is fired from gun, bullet penetrates into sand wall and it stops. Where does its kinetic energy used?**

Ans: A bullet is fired from the gun, bullet penetrates into a sand wall and it stops. Its kinetic energy is used in following ways:

- Sound energy.
- Heat energy.
- Deforming the bullet
- Deforming the target.

Q# 6 An LED light bulb has efficiency of 80%. Does it violate conservation of energy principle?

Ans: As we know that efficiency is the ratio between input and output of a machine.

It means that the machine converts 80% of the power of its input fuel source to actual work. There is 20% waste likely as heat, noise or wear. Hence it does not violate the principle of law of conservation of energy.

Q# 7 How does using renewable energy sources contribute to reducing environmental impact compared to non-renewable sources?

Ans: Using renewable energy sources significantly reduces environmental impact compared to non- renewable sources by emitting fewer greenhouse gases, minimizing air and water pollution, avoiding resource depletion, and requiring less land use for energy production infrastructure. This shift promotes sustainability, improves public health, and enhances resilience against climate change impacts.

Q# 8 Will we eventually rely entirely on renewable energy sources? Why or why not?

Ans: Yes, we may eventually rely entirely on renewable energy sources due to technological advancements ,environmental Concerns, and the finite nature of non-renewable resources like fossil fuels.

However the timeline and feasibility depend on overcoming challenges such as intermittency, storage, and infrastructure development.

Q# 9 How can increasing the power of a machine impact its energy consumption?

Ans: Increasing the power of a machine typically increases its energy consumption because higher power generally requires more energy to operate, leading to greater electricity or fuel consumption depending on the type of machine and its usage pattern.

Q# 10 A perpetual engine has an efficiency equal to 1. Why it will not work?

Ans: Efficiency equal to 1 means 100% efficient which is not possible,. Because 100% means all input energy is used as useful output which is not possible. Some of the energy dissipated as waste heat or in other forms, resulting in efficiency less than 100%.

Hence a perpetual engine having efficiency equal to 1 will not work.