

Chapter 6

Work and Energy

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Short Questions

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

- **Answer:** No, there is no work done on the car because work is done only when a force is applied and it causes a displacement in the direction of the force. Since the car is moving at a constant speed, there is no change in its kinetic energy, and hence, no net work is done.

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?

- **Answer:**
 - The work done in raising a box does **not depend** on how fast it is raised.
 - It depends on the **path taken** (only if there are frictional forces involved).
 - The work depends directly on the **height** the box is lifted, as work is equal to the product of the weight of the box (force) and the height (displacement).

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

- **Answer:** The work done by a centripetal force on an orbiting satellite is **zero** because the centripetal force acts perpendicular to the direction of the satellite's motion. Since there is no displacement in the direction of the force, no work is done.

4. A car has kinetic energy E_k . By what factor its kinetic energy would change if its velocity is doubled?

- **Answer:** Kinetic energy (E_k) is given by the formula: $E_k = \frac{1}{2}mv^2$. If the velocity is doubled ($2v$), the kinetic energy becomes:

$E_k' = 12m(2v)^2 = 4 \times 12mv^2$
 $E_{k'} = \frac{1}{2} m (2v)^2 = 4 \times \frac{1}{2} m v^2$
 $E_k' = 21m(2v)^2 = 4 \times 21mv^2$ So, the kinetic energy increases by a **factor of 4**.

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

- **Answer:** The kinetic energy of the bullet is converted into:
 - **Heat energy** due to friction between the bullet and the sand.
 - **Sound energy** during the collision.
 - **Energy used to deform** the sand and the bullet.
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6. An LED light bulb has an efficiency of 80%. Does it violate the conservation of energy principle?

- **Answer:** No, it does not violate the conservation of energy principle. The remaining 20% of energy is not lost; it is converted into other forms, such as heat. The total energy remains conserved, but not all of it is converted into useful light energy.
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7. How can using renewable energy sources contribute to reducing environmental impact compared to non-renewable sources?

- **Answer:** Renewable energy sources, such as solar, wind, and hydro, do not emit harmful greenhouse gases or pollutants. They reduce the environmental impact by:
 - Lowering air and water pollution.
 - Reducing dependence on finite fossil fuels.
 - Preventing global warming by minimizing carbon dioxide emissions.
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8. Will we eventually rely entirely on renewable energy sources? Why or why not?

- **Answer:** It is possible but challenging to rely entirely on renewable energy due to:
 - High initial costs of renewable energy technology.
 - Intermittent availability of some resources (like sunlight and wind).
 - The need for technological advancements in energy storage. However, with continuous innovation, renewable energy could become the primary energy source in the future.
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9. How can increasing the power of a machine impact its energy consumption?

- **Answer:** Increasing the power of a machine means it can do more work in less time. This may lead to:
 - Higher energy consumption per unit time.

- Increased efficiency in completing tasks if the machine is well-designed.
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10. A perpetual engine has an efficiency equal to 1. Why will it not work?

- **Answer:** A perpetual engine cannot work because it violates the **laws of thermodynamics**. No machine can be 100% efficient due to unavoidable energy losses (like heat due to friction). Energy is always dissipated in some form, so perfect efficiency is impossible.

Long Questions

1. Define work and its unit. Describe the conditions for maximum and minimum work.

Definition of Work:

Work is done when a force is applied to an object, and it causes the object to move in the direction of the applied force.

The amount of work done depends on the magnitude of the force, the displacement of the object, and the angle between the

force and displacement. Mathematically:

$$W = F \cdot d \cdot \cos(\theta)$$

Where:

- W = Work done (in joules)
- F = Force applied (in newtons)
- d = Displacement of the object (in meters)
- θ = Angle between the force and displacement.

SI Unit of Work:

The SI unit of work is the joule (J).

$$1 \text{ joule} = 1 \text{ newton} \times 1 \text{ meter} \times \cos(0).$$

- This means 1 joule is the work done when a force of 1 newton moves an object 1 meter in the direction of the force.

Conditions for Maximum and Minimum Work:

1. **Maximum Work:** Work is maximum when the angle (θ) between force and displacement is 0° (i.e., force and displacement are in the same direction).

$$W_{\text{max}} = F \cdot d \cdot \cos(0) = F \cdot d$$

Example: Pushing a box forward on a smooth surface.

2. **Zero Work:** Work is zero when:

- Displacement is zero ($d = 0$). For example, holding a book stationary.
- Force is perpendicular to displacement ($\theta = 90^\circ$).

$$W = F \cdot d \cdot \cos(90) = 0$$

Example: Carrying a bag horizontally while walking.

3. **Negative Work:** Work is negative when force and displacement are in opposite directions ($\theta = 180^\circ$).

$$W_{\text{negative}} = F \cdot d \cdot \cos(180) = -F \cdot d$$

Example: Friction acting against the motion of a sliding object.

2. What is kinetic energy? Derive its expression by using graphical analysis.

Definition of Kinetic Energy:

Kinetic energy (E_k) is the energy possessed by an object due to its motion. It depends on the mass of the object (m) and its velocity (v).

Expression for Kinetic Energy:

The formula for kinetic energy is:

$$E_k = \frac{1}{2} \cdot m \cdot v^2$$

Derivation Using Work-Energy Theorem:

1. **Force and Displacement Relationship:**

Consider an object of mass m initially at rest ($u = 0$) that accelerates under a constant force F to achieve a velocity v over a distance d .

2. Work Done:

Work done on the object is:

$$W = F \cdot d$$

From Newton's second law, force $F = m \cdot a$, where a is acceleration. Substituting F :

$$W = m \cdot a \cdot d$$

3. Using Kinematic Equation for d :

From the kinematic equation:

$$v^2 = u^2 + 2ad \text{ (Since } u = 0\text{),}$$

Rearrange for d :

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

4. Substitute d in Work Formula:

$$W = m \cdot a \cdot (v^2 / 2a) = 1/2 \cdot m \cdot v^2$$

Thus, the work done on the object equals its kinetic energy:

$$E_k = 1/2 \cdot m \cdot v^2$$

Example of Kinetic Energy:

A car of mass 1000 kg moving at 20 m/s has kinetic energy:

$$E_k = 1/2 \cdot 1000 \cdot (20)^2 = 200,000 \text{ J}$$

3. What is potential energy? What are its different types? Show that gravitational potential energy is equal to the product of mass (m), gravitational field strength (g), and height (h).

Definition of Potential Energy:

Potential energy (E_p) is the energy possessed by an object due to its position or configuration. It is stored energy that can be converted into other forms, such as kinetic energy.

Types of Potential Energy:

1. Gravitational Potential Energy:

Energy stored in an object due to its height above the ground.

$$E_p = m \cdot g \cdot h$$

2. Elastic Potential Energy:

Energy stored in stretched or compressed objects, such as springs or rubber bands.

$$E_p = 1/2 \cdot k \cdot x^2$$

Where k is the spring constant and x is the displacement.

3. Chemical Potential Energy:

Energy stored in chemical bonds, such as in fuels, batteries, or food.

Derivation of Gravitational Potential Energy:

1. Force Required to Lift an Object:

To lift an object of mass m to a height h , a force equal to the object's weight is applied:

$$F = m \cdot g$$

2. Work Done to Lift the Object:

Work done in lifting the object is:

$$W = F \cdot h$$

3. Gravitational Potential Energy:

The work done is stored as gravitational potential energy:

$$E_p = m \cdot g \cdot h$$

Example of Gravitational Potential Energy:

A rock of mass 5 kg lifted to a height of 10 m has potential energy:

$$E_p = 5 \cdot 9.8 \cdot 10 = 490 \text{ J.}$$

4. What is meant by energy conversion and energy conservation?

Energy Conversion:

Energy conversion is the process of transforming energy from one form to another. The total energy before and after the conversion remains the same, as per the law of conservation of energy.

Examples of Energy Conversion:

1. Electric Bulb:

Electrical energy $\rightarrow$ Light energy + Heat energy.

2. Car Engine:

Chemical energy in fuel $\rightarrow$ Kinetic energy (motion) + Heat energy.

3. Hydroelectric Power Plant:

Gravitational potential energy of water $\rightarrow$ Kinetic energy $\rightarrow$ Electrical energy.

Energy Conservation:

The law of conservation of energy states that energy cannot be created or destroyed; it can only change from one form to another. The total energy in a closed system remains constant.

Examples of Energy Conservation:

1. Pendulum:

Potential energy at the highest point converts into kinetic energy at the lowest point and vice versa.

2. Roller Coaster:

At the top of the track, the car has maximum potential energy. As it moves down, potential energy is converted into kinetic energy.

Importance of Energy Conservation:

1. Reduces wastage of resources.
2. Protects the environment by minimizing pollution.
3. Ensures sustainable energy use for future generations.

4. What is meant by energy conversion and energy conservation?

Energy Conversion:

- **Definition:**

Energy conversion is the process of transforming energy from one form to another. During energy conversion, the total amount of energy remains constant (as per the law of conservation of energy), but its form changes.

- **Examples of Energy Conversion:**

1. **Electric Bulb:** Electrical energy is converted into light energy and heat energy.

2. **Car Engine:** Chemical energy in fuel is converted into kinetic energy to move the vehicle, and some energy is lost as heat.

3. **Hydroelectric Power Plant:** Gravitational potential energy of water is converted into kinetic energy, which is then converted into electrical energy.
 4. **Photosynthesis:** Solar energy is converted into chemical energy stored in plants.
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Energy Conservation:

- **Definition:**

The law of conservation of energy states that energy cannot be created or destroyed; it can only change from one form to another. The total energy in a closed system remains constant.

- **Key Points:**

- Energy may appear to be lost, but it is only transformed or transferred to different forms.
 - Efficiency of energy systems can affect how much usable energy is obtained.
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Example to Illustrate Conservation of Energy:

- A pendulum:
 - At its highest point, it has maximum potential energy and zero kinetic energy.
 - As it swings downward, potential energy converts into kinetic energy.
 - At its lowest point, it has maximum kinetic energy and minimal potential energy.
 - This energy transformation repeats, with no energy being lost in an ideal system.
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Importance of Energy Conservation:

1. **Practical Benefits:**

- Helps reduce energy waste.
- Makes energy use more efficient in daily life.

2. **Environmental Benefits:**

- Reduces the need for excessive extraction of non-renewable resources.
 - Helps mitigate climate change by minimizing unnecessary energy usage.
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5. Describe how useful energy may be obtained from natural resources.

Sources of Energy from Natural Resources:

1. **Solar Energy:**

- **How it Works:** Solar panels convert sunlight into electrical energy using photovoltaic cells.
 - **Use:** Powering homes, industries, and small electronic devices.
 - **Example:** Rooftop solar panels that provide electricity to homes.
2. **Wind Energy:**
- **How it Works:** Wind turbines use the kinetic energy of wind to generate electricity.
 - **Use:** Large-scale electricity production in wind farms.
 - **Example:** Offshore wind farms like those in the Netherlands.
3. **Hydropower:**
- **How it Works:** The potential energy of water stored in dams is converted into kinetic energy when released, driving turbines to generate electricity.
 - **Use:** Supplying electricity to cities and rural areas.
 - **Example:** Hoover Dam in the USA.
4. **Geothermal Energy:**
- **How it Works:** Heat energy from inside the Earth is used to generate electricity or for direct heating purposes.
 - **Use:** Heating homes and generating power in geothermally active areas.
 - **Example:** Iceland's geothermal power plants.
5. **Biomass Energy:**
- **How it Works:** Organic matter like wood, crop waste, or animal dung is burned to release energy or converted into biofuels like ethanol.
 - **Use:** Heating, cooking, and as a fuel source for vehicles.
 - **Example:** Burning wood in stoves or biogas from waste decomposition.
6. **Fossil Fuels (Non-Renewable):**
- **How it Works:** Coal, oil, and natural gas are burned to produce energy.
 - **Use:** Generating electricity, powering vehicles, and heating homes.
 - **Example:** Coal-fired power plants or gas-powered vehicles.
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Advantages of Using Natural Resources:

1. **Renewable Sources:**
- Environmentally friendly (e.g., solar, wind, hydropower).
 - Sustainable and inexhaustible.

- Reduces dependence on non-renewable sources.

2. Non-Renewable Sources:

- Provide high energy output.
- Useful for large-scale, reliable power generation.

Disadvantages of Using Natural Resources:

1. Renewable Energy:

- Dependent on weather conditions (e.g., no sunlight at night for solar).
- Expensive initial installation costs.

2. Non-Renewable Energy:

- Leads to pollution and greenhouse gas emissions.
- Finite in supply, which causes energy shortages in the long term.

6. Differentiate between renewable and non-renewable energy sources with advantages and disadvantages.

Definition:

- **Renewable Energy Sources:**

These are energy sources that naturally replenish and can be used repeatedly without depleting the Earth's resources. Examples include solar energy, wind energy, hydroelectric energy, geothermal energy, and biomass.

- **Non-Renewable Energy Sources:**

These are energy sources that exist in finite amounts and take millions of years to form. Once consumed, they cannot be easily replenished. Examples include coal, oil, natural gas, and nuclear energy.

Detailed Comparison

Feature	Renewable Energy	Non-Renewable Energy
Availability	Unlimited and replenished naturally.	Limited and will eventually run out.
Environmental Impact	Minimal pollution; produces little or no greenhouse gases.	High pollution; major contributor to global warming and climate change.
Examples	Solar, wind, hydropower, geothermal, biomass.	Coal, oil, natural gas, nuclear energy.
Cost	High initial investment but low operational costs.	Lower initial cost, but high long-term environmental and health costs.

Reliability	Can depend on weather conditions (e.g., solar panels need sunlight).	Highly reliable; not dependent on weather.
Energy Density	Lower energy output per unit compared to fossil fuels.	High energy output; very efficient for industrial applications.
Sustainability	Sustainable and will not deplete over time.	Unsustainable; reserves are depleting with continuous use.

Advantages and Disadvantages

Renewable Energy:

- **Advantages:**

1. **Eco-Friendly:** Produces little to no greenhouse gas emissions, helping mitigate climate change.
2. **Inexhaustible:** These resources, such as sunlight, wind, and water, are naturally replenished.
3. **Low Operational Costs:** Once installed, systems like solar panels and wind turbines have minimal maintenance costs.
4. **Supports Decentralized Power Production:** Small-scale renewable setups can power homes, reducing dependency on central grids.
5. **Reduces Air and Water Pollution:** No harmful byproducts like those from fossil fuel burning.

- **Disadvantages:**

1. **Weather Dependence:** Solar and wind energy depend on weather conditions, which can limit reliability.
2. **High Initial Costs:** Installation of solar panels, wind farms, or hydropower systems can be expensive.
3. **Land and Space Requirements:** Large renewable energy plants like solar farms or wind farms require significant space.
4. **Energy Storage Challenges:** Efficient storage systems (e.g., batteries) are needed for excess energy, increasing costs.

Non-Renewable Energy:

- **Advantages:**

1. **High Energy Density:** Fossil fuels like coal and oil provide large amounts of energy in a small volume.
2. **Established Technology:** Power plants using non-renewable sources are well-established and widely used.

3. **Cost-Effective in Short Term:** Extraction and transportation costs are relatively low due to existing infrastructure.
 4. **Reliable Supply:** These sources are not dependent on weather and can provide continuous energy.
- **Disadvantages:**
 1. **Pollution:** Burning fossil fuels releases carbon dioxide and other pollutants, contributing to climate change.
 2. **Health Hazards:** Air and water pollution from fossil fuels cause respiratory and other health problems.
 3. **Finite Reserves:** Resources like coal, oil, and natural gas will eventually run out, creating long-term energy challenges.
 4. **Environmental Damage:** Mining and drilling destroy ecosystems and cause land degradation.
 5. **Waste Management:** Nuclear energy, although efficient, produces radioactive waste that is difficult to manage safely.
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Impact on the Environment

- **Renewable Energy:**
 - Reduces carbon emissions significantly, which helps combat climate change.
 - Minimal harm to ecosystems, except for land use issues in some cases (e.g., large solar farms or dams).
- **Non-Renewable Energy:**
 - Responsible for over 75% of greenhouse gas emissions globally.
 - Mining and drilling for fossil fuels lead to habitat destruction, water contamination, and soil erosion.

7. Describe the processes by which energy is converted from one form to another with reference to fossil fuel energy, hydroelectric generation, solar energy, nuclear energy, geothermal energy, wind energy, and biomass energy.

Energy Conversion Processes:

1. **Fossil Fuel Energy:**
 - **Process:**

Chemical energy in coal, oil, or natural gas is released through combustion (burning). This energy is converted into heat energy, which is used to produce steam. The steam drives turbines that generate electrical energy.
 - Example: Coal-fired power plants.

- **Conversion:**

Chemical energy → Heat energy → Kinetic energy → Electrical energy.

2. Hydroelectric Generation:

- **Process:**

The potential energy of water stored in a dam is converted into kinetic energy as water flows down through turbines. The turbines then convert this kinetic energy into electrical energy.

- Example: Hoover Dam.

- **Conversion:**

Gravitational potential energy → Kinetic energy → Electrical energy.

3. Solar Energy:

- **Process:**

Solar panels (photovoltaic cells) convert sunlight directly into electrical energy.

- Example: Solar farms or rooftop solar panels.

- **Conversion:**

Solar energy → Electrical energy.

4. Nuclear Energy:

- **Process:**

Nuclear fission (splitting of uranium or other atoms) releases heat energy. This heat is used to generate steam that drives turbines to produce electricity.

- Example: Nuclear power plants like Chernobyl or Fukushima.

- **Conversion:**

Nuclear energy → Heat energy → Kinetic energy → Electrical energy.

5. Geothermal Energy:

- **Process:**

Heat energy from the Earth's interior is used to heat water, producing steam that drives turbines to generate electricity.

- Example: Geothermal power plants in Iceland.

- **Conversion:**

Geothermal heat energy → Kinetic energy → Electrical energy.

6. Wind Energy:

- **Process:**

Wind turns large turbines, and the mechanical energy from this rotation is converted into electrical energy using a generator.

- Example: Offshore wind farms.

- **Conversion:**

Kinetic energy of wind → Mechanical energy → Electrical energy.

7. Biomass Energy:

- **Process:**

Organic materials like wood, agricultural waste, or animal manure are burned to produce heat energy, which is then used to generate electricity.

- Example: Biomass power plants.

- **Conversion:**

Chemical energy → Heat energy → Kinetic energy → Electrical energy.

8. Describe the process of electricity generation by drawing a block diagram of the process from fossil fuel input to electricity output.

Steps in Electricity Generation from Fossil Fuels:

1. **Fuel Combustion:**

- Fossil fuels (coal, oil, or gas) are burned to release heat energy.

2. **Steam Production:**

- The heat from combustion boils water to produce steam at high pressure.

3. **Turbine Operation:**

- The high-pressure steam drives the blades of a turbine, converting heat energy into mechanical energy.

4. **Generator:**

- The turbine's mechanical energy rotates a generator to produce electrical energy.

5. **Transmission:**

- The electrical energy is transmitted through power lines to homes and industries.

Block Diagram:

- **Fossil Fuel → Combustion (Heat) → Steam → Turbine (Mechanical Energy) → Generator (Electrical Energy).**
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9. Define power. What is the relation of its SI unit with horsepower?

Definition of Power:

- Power is the rate at which work is done or energy is transferred. It is given by the formula:

$$P = \frac{W}{t} \quad \text{Where:}$$

- P = Power
- W = Work done or energy transferred
- t = Time taken

SI Unit of Power:

- The SI unit of power is the **watt (W)**.
1 watt = 1 joule of work done in 1 second.

Horsepower and Relation with Watt:

- Horsepower (hp):**
Horsepower is a unit of power commonly used in the automobile and machinery industries.
1 horsepower (hp) = 746 watts (W).

Example:

If an engine produces 10 horsepower, its power output in watts is:

$$P = 10 \cdot 746 = 7460 \text{ W} \quad P = 10 \cdot 746 = 7460 \text{ W}$$

10. What is efficiency? Why is it important for cars or electronic devices to be designed with high efficiency? Why can machines never be 100% efficient?

Definition of Efficiency:

- Efficiency is the ratio of useful energy output to total energy input, expressed as a percentage: $\text{Efficiency}(\eta) = \left(\frac{\text{Useful Energy Output}}{\text{Total Energy Input}} \right) \cdot 100$
 $\eta = \left(\frac{\text{Useful Energy Output}}{\text{Total Energy Input}} \right) \cdot 100$

Importance of High Efficiency:

- Energy Conservation:**
High efficiency ensures that less energy is wasted, conserving resources like fuel or electricity.
- Cost Savings:**
Efficient machines consume less energy, reducing operational costs for users.
- Environmental Benefits:**
High-efficiency systems emit less pollution, helping to mitigate climate change.

Why Machines Cannot Be 100% Efficient:

- Machines cannot be perfectly efficient because some energy is always lost as heat, sound, or friction. According to the **Second Law of Thermodynamics**, no energy conversion process is completely free of energy losses.

Example:

An electric motor that uses 100 J of energy to perform 80 J of useful work has an efficiency of:

$$\eta = \left(\frac{80}{100} \right) \cdot 100 = 80\% \quad \eta = \left(\frac{80}{100} \right) \cdot 100 = 80\%$$

11. Explain by drawing energy flow diagrams through steady-state systems such as a filament lamp, a power station, and a vehicle traveling at a constant speed on a level road.

Energy Flow in a Filament Lamp:

1. Electrical energy → Heat energy → Light energy (useful output).

- A filament lamp wastes a significant portion of energy as heat.

Energy Flow in a Power Station:

1. Chemical energy in fuel → Heat energy → Kinetic energy (steam) → Mechanical energy (turbines) → Electrical energy.

- Example: Coal-fired power plants.

Energy Flow in a Vehicle Traveling at Constant Speed:

1. Chemical energy in fuel → Heat energy → Kinetic energy (motion of the car) → Sound energy (minor loss).

- At constant speed, the input energy balances the resistive forces like friction and air resistance.

Extera Short Questons (Topic Wise)

Here's a more **detailed version** of the questions and answers with added explanations:

6.1 Work

1. **What is the definition of work in physics?**

Work is done when a force is applied to an object, causing it to move in the direction of the applied force. The magnitude of work depends on the force, the displacement of the object, and the angle between them.

2. **What is the SI unit of work?**

The SI unit of work is the **joule (J)**. One joule is equivalent to the work done when a force of one newton moves an object by one meter in the direction of the force.

3. **How is work calculated when force and displacement are at an angle?**

Work is calculated as:

$$W = F \cdot d \cdot \cos\theta$$

Where:

- F is the applied force,
- d is the displacement,
- θ is the angle between force and displacement.

If the force is perpendicular ($\theta = 90^\circ$), no work is done.

4. **When is work considered positive or negative?**

- **Positive Work:** When force and displacement are in the same direction. For example, pushing a cart forward.
- **Negative Work:** When force opposes the direction of displacement. For example, friction acting against the motion of a sliding object.

5. **Does holding a heavy object stationary involve doing work?**

No, work is not done because there is no displacement. Work requires movement in the direction of the applied force.

6.2 Energy and Its Forms

1. **What is energy?**

Energy is the capacity to do work or cause change. It exists in various forms, such as mechanical, thermal, chemical, nuclear, and electrical energy.

2. **What are the two main forms of mechanical energy?**

- **Kinetic Energy:** Energy of motion, such as a moving car.
- **Potential Energy:** Stored energy due to position, such as a rock on a hill.

3. How is kinetic energy calculated?

Kinetic energy is given by:

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

Where m is the mass and v is the velocity. For example, a 2 kg object moving at 3 m/s has $E_k = 9 \text{ J}$.

4. What is gravitational potential energy?

Gravitational potential energy is energy stored in an object due to its height above the ground. It is calculated as:

$$E_p = m \cdot g \cdot h$$

Where m is mass, g is acceleration due to gravity (9.8 m/s^2), and h is height.

5. Can energy be transformed from one form to another?

Yes, energy transformations occur constantly. For example, in a pendulum, potential energy at the top converts into kinetic energy at the lowest point and vice versa.

6.3 Major Energy Resources

1. What are renewable energy resources?

Renewable energy resources are naturally replenished and never run out. Examples include solar energy, wind energy, hydroelectric energy, geothermal energy, and biomass.

2. What are non-renewable energy resources?

Non-renewable energy resources are finite and take millions of years to form. Examples include coal, oil, natural gas, and nuclear energy.

3. What is the primary source of solar energy?

The Sun is the source of solar energy. Solar panels convert sunlight into electrical energy using photovoltaic cells.

4. How does wind energy generate electricity?

Wind turbines convert the kinetic energy of moving air into mechanical energy, which is then transformed into electrical energy by generators.

5. What is biomass energy?

Biomass energy is derived from organic materials like wood, crop waste, and animal manure. When burned, the chemical energy stored in these materials is released as heat and converted into electricity.

6.4 Power

1. What is power in physics?

Power is the rate at which work is done or energy is transferred over time. It measures how quickly energy is used or work is performed.

2. What is the SI unit of power?

The SI unit of power is the **watt (W)**. One watt equals one joule of energy transferred per second.

3. How is power calculated?

Power is given by the formula:

$$P = \frac{W}{t}$$

Where W is work done or energy transferred, and t is the time taken.

4. What is the relationship between power and energy consumption?

Devices with higher power ratings consume energy faster. For example, a 100 W bulb uses more energy per second than a 60 W bulb.

5. How does power relate to electrical appliances?

The power rating of an appliance indicates its energy usage rate. A 2000 W heater consumes 2000 joules of energy per second.

6.5 Efficiency

1. What is efficiency?

Efficiency is the measure of how much of the input energy is converted into useful output energy. It is expressed as a percentage:

$$\eta = \left(\frac{\text{Useful energy output}}{\text{Total energy input}} \right) \cdot 100$$

2. How is efficiency calculated?

Efficiency is calculated by dividing the useful output energy by the total input energy and multiplying by 100%. For example, a motor that uses 100 J of energy but delivers 80 J of useful work has an efficiency of 80%.

3. Why is efficiency important in machines?

Higher efficiency reduces energy wastage, lowers costs, and minimizes environmental impact. For instance, energy-efficient vehicles consume less fuel.

4. Can any machine be 100% efficient?

No, machines cannot be 100% efficient because some energy is always lost as heat, sound, or friction during the energy transfer process.

5. How can efficiency be improved in systems?

Efficiency can be improved by reducing friction, using better materials, and designing systems to minimize energy loss. For example, LED bulbs are more efficient than traditional incandescent bulbs.

Extera Long Questions (Topic Wise)

1. Discuss the concept of work in detail. Explain its types, conditions, and real-world applications.

Definition of Work:

Work is defined as the measure of energy transfer that occurs when a force is applied to an object, causing it to move. Mathematically:

$$W = F \cdot d \cdot \cos\theta$$

Where:

- W = Work done (in joules)
- F = Force applied (in newtons)
- d = Displacement (in meters)
- θ = Angle between the force and displacement.

Types of Work:

1. Positive Work:

- Occurs when the force and displacement are in the same direction ($\theta < 90^\circ$).
- **Example:** Pushing a box forward.

2. Negative Work:

- Occurs when the force opposes the displacement ($\theta > 90^\circ$).
- **Example:** Friction acting on a sliding object.

3. Zero Work:

- Occurs when there is no displacement or the force is perpendicular to the motion ($\theta = 90^\circ$).
- **Example:** Holding a book stationary or carrying it horizontally.

Conditions for Work:

1. A force must be applied.
2. The object must move (displacement).
3. The force must have a component in the direction of displacement.

Applications of Work:

1. **Construction:** Lifting materials involves work done against gravity.
 2. **Transport:** Vehicles perform work by overcoming friction and air resistance.
 3. **Daily Activities:** Activities like pulling or pushing objects involve work.
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2. Explain the forms of energy in detail. Highlight the transformation of energy with real-world examples.

Definition of Energy:

Energy is the capacity to do work or cause change. It exists in various forms and can be converted from one form to another.

Forms of Energy:

1. **Kinetic Energy:**

- Energy of motion.
- **Formula:** $E_k = \frac{1}{2} m v^2$
- **Example:** A moving car.

2. **Potential Energy:**

- Energy due to position or configuration.
- **Formula:** $E_p = m g h$
- **Example:** A rock held at a height.

3. **Thermal Energy:**

- Energy related to temperature due to particle motion.
- **Example:** Heat from a stove.

4. **Chemical Energy:**

- Energy stored in chemical bonds.
- **Example:** Energy from burning fuel.

5. **Electrical Energy:**

- Energy due to moving charges.
- **Example:** Energy powering electrical appliances.

6. **Nuclear Energy:**

- Energy released during nuclear reactions.
- **Example:** Energy from nuclear power plants.

Energy Transformations:

Energy can change from one form to another:

1. **Example 1:** A hydroelectric dam converts potential energy of water into kinetic energy, which is then converted into electrical energy.
 2. **Example 2:** A car engine converts chemical energy in fuel into kinetic energy and heat energy.
-

Importance of Energy Transformation:

1. Makes energy usable in various applications.
 2. Drives processes in industries, homes, and natural systems.
-

3. Compare renewable and non-renewable energy resources in detail. Highlight their advantages, disadvantages, and environmental impacts.

Energy Resources:

Energy resources are sources used to produce energy. They are classified into renewable and non-renewable.

Renewable Energy Resources:

- Naturally replenished and sustainable.
- **Examples:** Solar, wind, hydropower, geothermal, and biomass.

Advantages:

1. Eco-friendly and emit little to no greenhouse gases.
2. Sustainable and inexhaustible.
3. Reduces dependence on fossil fuels.

Disadvantages:

1. High initial installation costs.
 2. Dependent on weather (e.g., solar panels need sunlight).
 3. Requires significant space (e.g., wind farms).
-

Non-Renewable Energy Resources:

- Finite and take millions of years to form.

- **Examples:** Coal, oil, natural gas, and nuclear energy.

Advantages:

1. High energy density (produces large amounts of energy).
2. Reliable and consistent.
3. Established infrastructure for use.

Disadvantages:

1. Causes pollution and greenhouse gas emissions.
2. Limited supply and will eventually deplete.
3. Environmental destruction (e.g., mining, drilling).

Environmental Impact:

1. **Renewable:** Minimal environmental harm; reduces carbon footprint.
2. **Non-Renewable:** Major contributor to air and water pollution; accelerates climate change.

MCQS

1. Which of the following is the correct formula for calculating work done?

- A. $W = F \times d \times \sin \theta$ $W = F \times d \times \sin \theta$
- B. $W = F \times d \times \cos \theta$ $W = F \times d \times \cos \theta$
- C. $W = F \times d$ $W = F \times d$
- D. $W = F \times d \times \tan \theta$ $W = F \times d \times \tan \theta$

Answer: B

2. If a force is applied perpendicular to the direction of displacement, the work done is:

- A. Positive
- B. Negative
- C. Zero
- D. Maximum

Answer: C

3. The unit of work in the International System of Units (SI) is:

- A. Newton
- B. Joule
- C. Watt
- D. Pascal

Answer: B

4. When lifting an object vertically upwards, the angle between the force and displacement is:

- A. 0 degrees
- B. 45 degrees
- C. 90 degrees
- D. 180 degrees

Answer: A

5. Which of the following scenarios represents negative work?

- A. Pushing a box forward
- B. Lifting a book upward
- C. Friction slowing down a sliding object
- D. Holding a stationary object

Answer: C

6. Energy is defined as:

- A. The rate of doing work
- B. The capacity to do work
- C. Force applied over a distance
- D. Mass in motion

Answer: B

7. Which form of energy is associated with an object's motion?

- A. Potential energy
- B. Kinetic energy
- C. Thermal energy
- D. Chemical energy

Answer: B

8. Gravitational potential energy depends on:

- A. Mass and velocity
- B. Mass and height
- C. Force and displacement
- D. Speed and time

Answer: B

9. The law of conservation of energy states that:

- A. Energy can be created and destroyed
- B. Energy cannot be transformed
- C. Total energy remains constant
- D. Energy is always conserved in the form of heat

Answer: C

10. Which of the following is an example of chemical energy?

- A. A moving car
- B. A compressed spring
- C. Food before digestion
- D. A stretched rubber band

Answer: C

11. Which of the following is a non-renewable energy resource?

- A. Solar energy
- B. Wind energy
- C. Coal
- D. Hydropower

Answer: C

12. Which energy resource is considered renewable?

- A. Natural gas
- B. Oil
- C. Biomass
- D. Nuclear energy

Answer: C

13. The primary component of natural gas is:

- A. Ethane
- B. Propane
- C. Methane
- D. Butane

Answer: C

14. Which country has the largest coal reserves?

- A. China
- B. United States
- C. India
- D. Russia

Answer: B

15. Hydropower generates electricity by using:

- A. Wind

- B. Sunlight
- C. Moving water
- D. Fossil fuels

Answer: C

16. Power is defined as:

- A. Work done per unit time
- B. Energy stored in an object
- C. Force applied over a distance
- D. Rate of change of velocity

Answer: A

17. The SI unit of power is:

- A. Joule
- B. Newton
- C. Watt
- D. Pascal

Answer: C

18. If a machine does 1000 joules of work in 5 seconds, its power output is:

- A. 50 watts
- B. 200 watts
- C. 5000 watts
- D. 100 watts

Answer: B

19. Which of the following appliances typically consumes the most power?

- A. LED light bulb
- B. Refrigerator
- C. Electric oven
- D. Ceiling fan

Answer: C

20. The power output of an engine is determined by:

- A. The amount of fuel consumed
- B. The work done and the time taken
- C. The speed of the vehicle
- D. The size of the engine

Answer: B

21. Efficiency is defined as the ratio of:

- A. Input energy to output energy
- B. Useful output energy to total input energy
- C. Total input energy to useful output energy
- D. Work done to time taken

Answer: B

22. A machine with 75% efficiency means that:

- A. 75% of input energy is wasted
- B. 25% of input energy is converted to useful work
- C. 75% of input energy is converted to useful work

D. The machine is 25% efficient

Answer: C

23. Which of the following factors can improve the efficiency of a machine?

- A. Increasing friction
- B. Reducing energy losses
- C. Increasing input energy
- D. Decreasing output work

Answer: B

24. In a light bulb, electrical energy is primarily converted into:

- A. Chemical energy
- B. Thermal energy and light energy
- C. Mechanical energy
- D. Nuclear energy

Answer: B

25. The efficiency of an ideal (perfect) machine is:

- A. 0%
- B. 50%
- C. 75%
- D. 100%

Answer: D

26. Which of the following statements is true about renewable energy resources?

- A. They can be replenished naturally over short periods
- B. They are finite and will eventually deplete
- C. They always produce more energy than non-renewable resources
- D. They are always more efficient than non-renewable resources

Answer: A

27. The primary disadvantage of wind energy is:

- A. High operational costs
- B. Intermittent energy supply
- C. High greenhouse gas emissions
- D. Limited availability of wind

Answer: B

28. Which of the following energy transformations occurs in a hydroelectric power plant?

- A. Chemical to electrical
- B. Thermal to mechanical
- C. Gravitational potential to electrical
- D. Nuclear to thermal

Answer: C

29. The main purpose of a transformer in the transmission of electricity is to:

- A. Convert AC to DC
- B. Increase or decrease voltage
- C. Measure electrical energy
- D. Store electrical energy

Answer: B

30. Which of the following best describes geothermal energy?

- A. Energy from the sun
- B. Energy from wind
- C. Energy from Earth's internal heat
- D. Energy from moving water

Answer: C