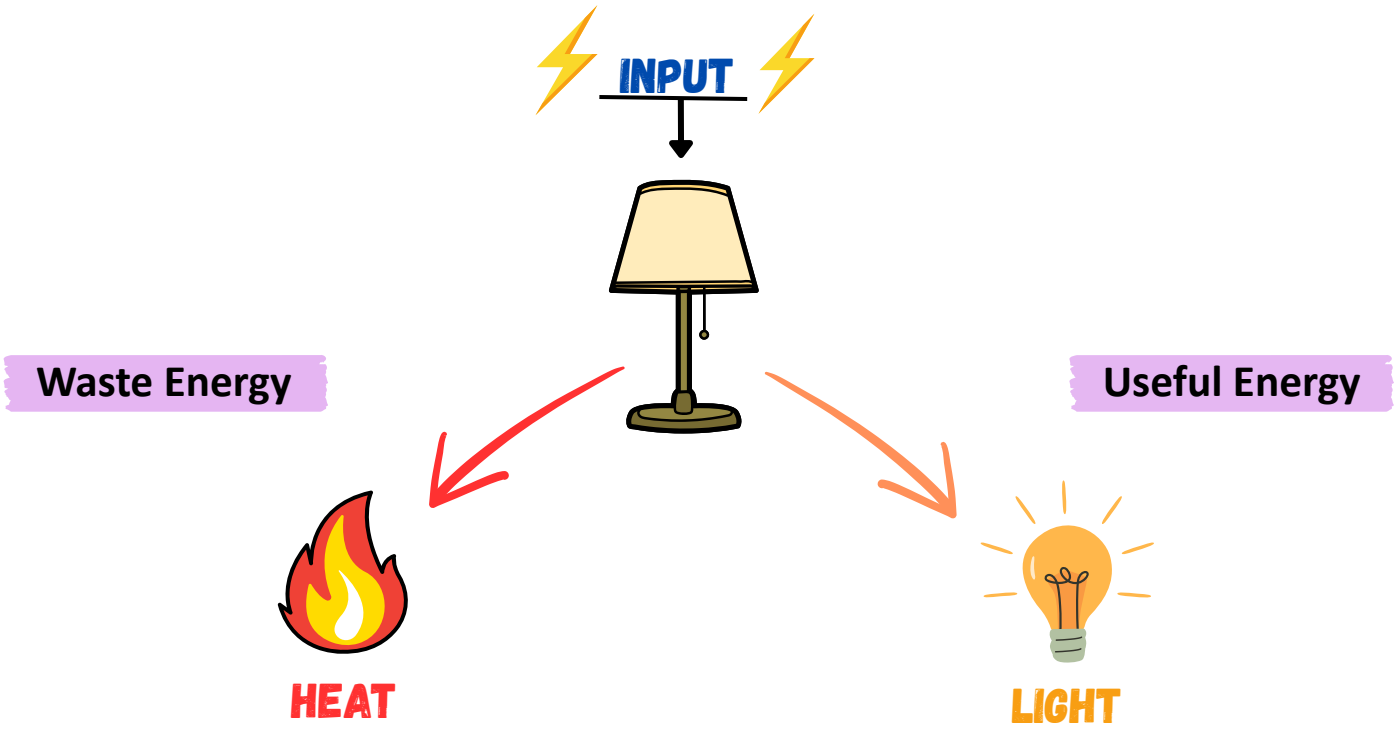
Efficiency – GCSE Physics

CONTENTS:

1. Introduction:

- The concepts of Energy and Power Efficiency are essential for understanding how systems use resources and how to optimize them for better performance and sustainability.
- **Efficiency** is a way of describing how good a machine is at transferring energy into useful forms.



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2. What is Energy Efficiency?

- **Energy Efficiency** measures how effectively a system, device, or process converts input energy into useful output energy to perform a desired task.
- It measures how efficiently Energy is converted into useful work while minimizing waste.
- Formula:

$$\text{Energy Efficiency} = \frac{\text{Useful Output Energy}}{\text{Total Input Energy}}$$

where,

Example:

LED Bulb and Incandescent Bulb:

- An **LED bulb** converts about 80-90% of the electrical energy into light, with very little wasted as heat.
- An **Incandescent bulb**, on the other hand, converts only about 10% of the electrical energy into light — the rest is lost as heat.

The LED bulb is more energy-efficient.

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3. What is Power Efficiency?

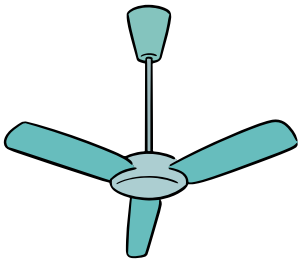
- **Power efficiency** is the ratio of useful output power to the total input power supplied to a system or device.
- It measures how efficiently Power is converted into useful work while minimizing waste.
- Formula:

$$\text{Power Efficiency} = \frac{\text{Useful Output Power}}{\text{Total Input Power}}$$

Where,

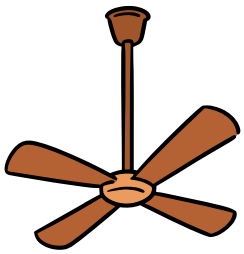
- Output power is the power used to perform the desired task.
- Input power is the total power supplied to the system.
- The rest is usually lost as heat, noise, or vibration.

Example:



FAN A

Power efficiency of 80%.



FAN B

Power efficiency of 50%.

Fan A is more power-efficient because it converts more of the input power into useful mechanical power, while wasting less power as heat, noise, or friction.

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4. How to Calculate Efficiency?

- **Efficiency** tells us how well a device or system converts input energy or power into useful output.
- It's usually expressed as a percentage.

Formula for Energy Efficiency:

$$\text{Energy Efficiency} = \frac{\text{Useful Output Energy}}{\text{Total Input Energy}}$$

Formula for Power Efficiency:

$$\text{Power Efficiency} = \frac{\text{Useful Output Power}}{\text{Total Input Power}}$$

Steps to Calculate Efficiency:

Step#1: Find the input value (energy or power supplied to the system).

Step#2: Find the useful output value (energy or power used for the intended purpose).

Step#3: Apply the formula.

Step#4: Multiply by 100 to convert it into a percentage.

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5. Solved Examples.

Problem1: A light bulb takes 100 joules of electrical energy and produces 60 joules of light energy. The rest is lost as heat. Calculate the energy efficiency of the light bulb.

Solution:

Step#1: Find the input value,

Total Input Energy = **100 J**

Step#2: Find the useful output value,

Useful Output Energy = **60 J**

Step#3: Apply the formula:

$$\text{Energy Efficiency} = \frac{\text{Useful Output Energy}}{\text{Total Input Energy}}$$

$$\text{Energy Efficiency} = \frac{60}{100} = 0.6$$

Step#4: Multiply by 100

$$\text{Energy Efficiency} = 0.6 \times 100\%$$

$$\text{Energy Efficiency} = 60\%$$

The light bulb has an energy efficiency of **60%.**

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Problem2: A water pump uses 500 watts of electrical power and delivers 400 watts of useful mechanical power to pump water. Calculate the power efficiency of the pump.

Solution:

Step#1: Find the input value,

Total Input Power = **500W**

Step#2: Find the useful output value,

Useful Output Power = **400W**

Step#3: Apply the formula:

$$\text{Power Efficiency} = \frac{\text{Useful Output Power}}{\text{Total Input Power}}$$

$$\text{Power Efficiency} = \frac{400}{500} = 0.8$$

Step#4: Multiply by 100

$$\text{Power Efficiency} = 0.8 \times 100\%$$

$$\text{Power Efficiency} = 80\%$$

The water pump has a power efficiency of **80%**.

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6. FAQ

1.What is Efficiency?

Efficiency measures how well something (a machine, device, or system) converts input (like energy) into useful output without wasting resources.

2. How can we reduce unwanted energy transfers in machines?

We can reduce unwanted energy transfers by using lubrication to reduce friction, insulation to prevent heat loss, and streamlining to reduce air resistance.

3. What is Energy Efficiency?

Energy efficiency means using less energy to do the same job. It helps save money and reduces waste.

Example:

- An LED bulb (energy-efficient) gives the same light as an old incandescent bulb but uses much less electricity.

4. What is Power Efficiency?

Power efficiency measures how well a device converts input power (electricity) into useful output (like light, motion, or computation) without wasting it as heat.

Example:

- A 90% efficient power supply wastes only 10% of electricity as heat, while a 60% efficient one wastes 40%.

5.Why Does Efficiency Matter?

- Saves money (lower electricity bills).
- Reduces pollution (less energy waste = fewer power plants needed)