Physics – P1

Conservation and disipation of energy

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Equations:

[Work Done = Force x Distance](#Work_Done_EQ)

[GPE Change = mass x gravitational field strength x height change](#Gravitational_Potential_Energy_EQ)

[Kinetic Energy = 0.5 x mass x speed2](#Kinetic_Energy_EQ)

[Elastic Potential = 0.5 x spring constant x extension2](#Elastic_Potential_EQ)

[Efficiency = Useful Power x Total Power](#Efficiency_EQ)

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Changes in Energy Stores

Energy can be stored in different ways and can be transferred through heating, waves, an electric current, or when force moves an object. Here are some examples of energy stores:

* Chemical Energy – fuels, foods, or the chemicals found in batteries. Energy is transferred during chemical reactions.
* Kinetic Energy – the energy an object has when it is moving.
* Gravity Potential Energy – the energy an object has because of its position, for example an object above the ground.
* Elastic Potential Energy – the energy stored in a springy object when it is stretched or compressed
* Thermal Energy – energy a substance has because of its temperature.

Energy can be transferred from one store to another. For example, in a torch, the chemical energy in the battery is transferred to electrical energy, which flows through the bulb, where it becomes light and heat energy.

Energy Transfers

When an object starts to fall, it speeds up. This is because of gravity acting on the object causing energy to be transferred from its **gravitational** **potential** energy store into its **kinetic** energy store. When that object impacts the ground, the energy is transferred by heating into the **thermal** energy store of the object and the floor, and by sound waves moving away from the point of impact.

Increase in thermal energy store of surroundings

Energy transferred to the surroundings

Kinetic Energy Store

Gravitational Potential Energy Store

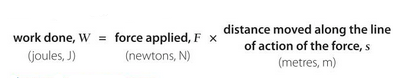
Sound waves from the point of impact

Conservation of Energy

The principle of conservation of energy says that **“Energy cannot be created or destroyed; it simply changes form”**. This is easily demonstrated in a closed system. A closed system is a group of objects in which the total energy is always the same before and after. A good example of this is a swinging pendulum in a vacuum. The energy would go between kinetic and gravitational potential without any being lost.

Work Done

When an object is moved by a force, work is done on the object by the force. The amount of energy transferred to the object is equal to the work done on it. Therefore, **Energy Transferred = Work Done**. The work done by a force depends on the size of the force and the distance moved. Work done can be calculated using:



Gravitational Potential Energy

When you lift an object up, you do some work. Your muscles transfer energy from the **chemical** energy store in the muscle to the **gravitational potential** energy (GPE) store of the object. The force you need to lift an object at a constant velocity is equal and opposite to the gravitational force on the object. In other words, the force you need to apply is equal to the object’s weight. For example, the force you need to lift an object weighing 80N is 80N.

Calculating Gravitational Potential Energy

Objects on the moon can be lifted easier than objects on the Earth. This is because the gravitational field strength on the moon is much less than that of the Earth (by about 83%). To find the change in GPE store, use:

Text, letter

Description automatically generated

Kinetic and Elastic Potential Energy Stores

The speed an object has because of its motion depends on its mass (kg) and speed (m/s). This energy is called kinetic energy. It can be calculated using:

Text

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When you stretch an elastic band or compress a spring, the work you do is stored as elastic potential energy. The force needed to compress a spring varies with the spring’s extension. It is calculated using:

Text

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Energy Dissipation

A machine (such as a washing machine) transfers energy for a purpose. Friction between the moving parts causes them to warm up. Because of this, not all of the energy is usefully transferred. Some of the energy is wasted.

* Useful Energy – Energy that is transferred to where it is wanted in a way it is wanted.
* Wasted Energy – Energy that is not usefully transferred.

Friction in machines always causes energy to be wasted. This wasted energy is dissipated (spread out). For example, in the gearbox of a car heats up because of friction and is eventually transferred to the thermal store of the air. However, useful energy is also eventually transferred to other places.

Efficiency

The efficiency of something is the useful energy vs the total energy. If something is more efficient, more of the total energy is useful.



Improving Efficiency

Whilst energy will always be lost in some way, we can reduce the amount of energy lost:

* Lubricate moving parts to reduce friction
* In circuits, use wires with the least resistance possible
* Streamline the shape of moving objects to reduce air resistance (drag)
* Cut out noise (eg tighten loose parts) to reduce energy lost through vibration

Wasted Energy

|  |  |  |
| --- | --- | --- |
| Appliance | Useful Energy | Wasted Energy |
| Light Bulb | Light from the glowing filament | Filament heating the surroundings |
| Electric Heater | Energy heating the surroundings | Light emitted from the glowing element |
| Electric Toaster | Energy heating bread | Energy heating the toaster case and air around it |
| Electric Kettle | Energy heating water | Energy heating the kettle itself |
| Hairdryer | Kinetic energy of air caused by fan heating of air caused by heater filament | Sound of fan motor, Energy heating hairdryer itself |
| Electric Motor | Kinetic energy of objects driven by motor, GPE of objects lifted by motor. | Energy heating motor, vibrations caused by motor. |

Power

The power of an appliance is measured in Watts (W) or Kilowatts (kW). One watt is equal to 1 joule per second of energy transfer (1 W = 1 J/s)

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Power Ratings

Here are some typical values of power ratings for different energy transfers:

|  |  |
| --- | --- |
| Torch | 1 W |
| Electric light bulb | 100 W |
| Electric Cooker | 10 kW |
| Railway engine | 1 MW |
| Saturn V rocket (Apollo program) | 100 MW |
| Very large power station | 10,000 MW |