P1.1.1 Energy Stores and Systems

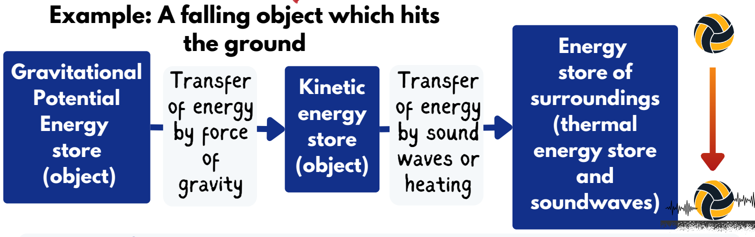
Store	Description	Examples
Magnetic	Energy when repelling poles are pushed together or attracting poles are separated.	Two magnets, fridge magnets, Maglev trains
Thermal (internal)	Total kinetic & potential energy of particles (energy stored due to the temperature of an object.)	Human bodies, hot objects
Chemical	Energy stored in chemical bonds.	Food, fuel, battery
Kinetic	Energy an object has when it is a moving object.	Moving objects, runners, buses
Electrostatic	Energy when repelling charges are pushed together or attracting charges separated.	Thunderclouds, two charges
Elastic potential	Energy when objects are stretched or compressed.	Catapults, springs, balloons
Gravitational potential	Energy of an object raised above ground level	Raised mass, kites, mugs on a table
Nuclear	Energy stored in the nucleus of atoms.	Nuclear fuel

Representing Energy Transfers

Transfer diagrams

- Illustrate the transition from initial to final states of a system
- Boxes: Energy stores (e.g. Gravitational Potential Energy)
- Arrows: Energy transfer

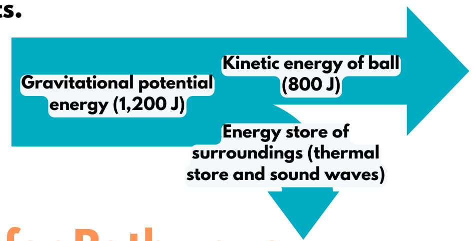
Example: A falling object which hits the ground



As a ball falls, its gravitational potential energy store decreases while kinetic energy store increases. Upon hitting the ground, the kinetic energy store decreases, transferring energy to the surroundings, raising their thermal energy store and creating sound waves.

Sankey Diagrams

- A diagram used to show how energy flows through a system.
- A large arrow represents total energy input, splitting into smaller arrows for useful and wasted outputs.
- Arrows are drawn to scale for easy comparison of energy distribution.



Conservation of Energy

Energy can be usefully transferred to other stores or wasted/dissipated into the surroundings. However, it cannot be created or destroyed.

Systems

- An object or group of objects
- Changes within systems result in energy being transferred.
- Closed system = no net energy transfer in or out
  - Total energy in a closed system never changes

Energy Transfer Pathways

Pathway	Description	Example
Mechanical	Force moves an object through a distance (work done by forces)	Boat accelerating due to engine
Electrical	Charges moving due to a potential difference when a current flows	Electric kettle heating water
Heating	Energy is transferred from an object with a higher temperature to one with a lower temperature.	Stove heating a pan
Radiation	Energy transferred by waves (e.g., infrared radiation)	Sun heating the Earth

Examples

Mechanical – Object projected upwards

Throwing a ball into the air

Chemical store decreases (human) → Kinetic store increases (ball) → Gravitational potential store increases (ball)

Mechanical & heating – Moving object hitting an obstacle

A ball colliding with an stationary ball

Kinetic store decreases (ball) → Kinetic store increases (obstacle) → Thermal or sound store (dissipated) (ball & obstacle)

Electrical & heating – Bringing water to a boil in an electric kettle

Electrical store (mains supply) → Thermal store (heating element) → Thermal store (water)

Mechanical – Object accelerated by constant force

A car accelerating

Chemical store decreases (fuel) → Kinetic store increases (vehicle)

Mechanical – Vehicle slowing down

Kinetic store decreases (vehicle) → Friction → Thermal store increases (friction in brakes and to surroundings)

Changes in Gravitational Potential Energy Stores

Lifting an object - some energy from the chemical store in muscles is transfer to the gravitational store of the object, Ep

Work done depends on:
1. Change in height
2. Weight

$$E_p = w\ h$$

Gravitational field strength is different on different planet surfaces and weight is equal to the gravitational field strength and mass, therefore:

$$E_p = m\ g\ h$$

Gravitational potential energy, ***Ep***, in joules, J
Mass, ***m***, in kilograms, kg
Gravitational field strength, ***g***, in newtons per kilogram, N/kg
Height, ***h***, in metres, m

E_p = mass * gravity * height

The force needed to lift an object at a constant velocity = Ep of the object = the object's weight

Upward movement - Ep increases, equal to work done by person lifting to overcome gravitational force

Downward movement - Ep decreases, equal to work done the gravitational force acting on it

Elastic Potential Energy Store

The force needed to stretch depends on the extension

$$E_e = \frac{1}{2} k\ e^2$$

Elastic potential energy, *Ee*, in joules, J
Spring constant, *k*, in newtons per metre, N/m
Extension, *e*, in metres, m

$E_e = \frac{1}{2}$ * spring constant * extension^2

Changes in Kinetic Energy Store

Kinetic Energy - The energy stored in moving objects

The kinetic energy store of the ball increases if speed increases

Height drop relates to speed's square; quadrupling height doubles speed. Kinetic energy store of falling objects is also proportional to the square of their speed.

P1.1.2 Changes in Energy

Exam Tip:
Questions may involve linking multiple energy transfers. For instance, when calculating the gravitational potential energy of a ball on a slope, the law of the conservation of energy indicates that a decrease in gravitational potential energy corresponds to an equal increase in kinetic energy.

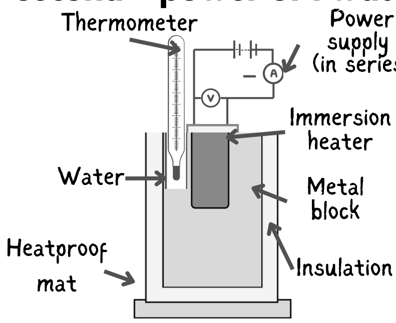
Therefore, kinetic energy depends on mass and speed

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

Kinetic energy, *Ek* , in joules, J
Mass, *m*, in kilograms, kg
Speed, *v*, in metres per second, m/s

$E_k = \frac{1}{2}$ * mass * velocity^2

An energy transfer of 1 joule per second = power of 1 watt.



Measuring specific heat capacity – See Required Practical 1

Thermal Energy Changes in a System

It takes a different amount of energy to heat up different materials. The amount of thermal energy added, thus temperature rise, depends on:

- **The amount of energy supplied to it**
- **The mass of the substance**
- **What the substance is**

Change in thermal energy = mass × SHC × temperature change

$$\Delta E = m\ c\ \Delta\theta$$

Change in thermal energy, **ΔE**, in joules, J
Mass, **m**, in kilograms, kg
Specific heat capacity, ***c***, in joules per kilogram per degree Celsius, J/kg °C
Temperature change, **Δθ**, in degrees Celsius, °C

Rearranged to calculate specific heat capacity

$$c = \frac{\Delta E}{m\ \Delta\theta}$$

Specific Heat Capacity (SHC): **Energy needed to raise the temperature of 1kg of a substance by 1˚C**

Typical SHC values include:
- **Water: 4200 J/kg˚C**
- **Aluminium: 900 J/kg˚C,**
- **Concrete: 880 J/kg˚C**

For example, heating 1.0kg of water by 6˚C involves a transfer of 25,200J because:
1 x 4200 x 6 = 25,200