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Energy

GCSE overview

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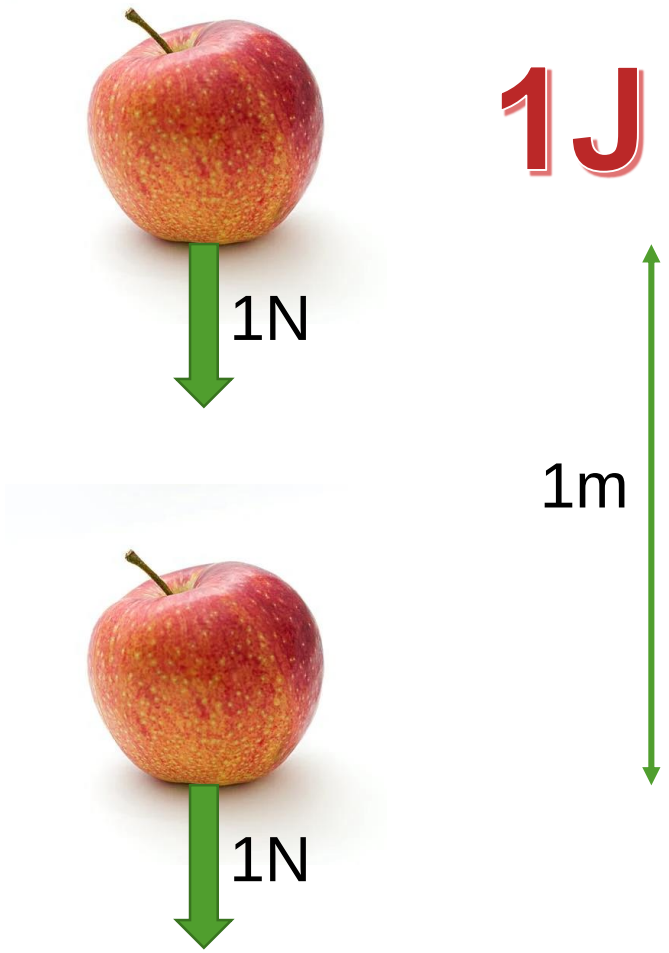
Work and the joule



Not all forces require fuel. Those that do involve motion. The energy transfer caused by the force is called the work done.

Work done = Force x distance moved

in the force's direction

As the same energy is gained by one object and lost by the other, the total amount of energy does not change.

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Work and the joule

9N

9N

4m

36J

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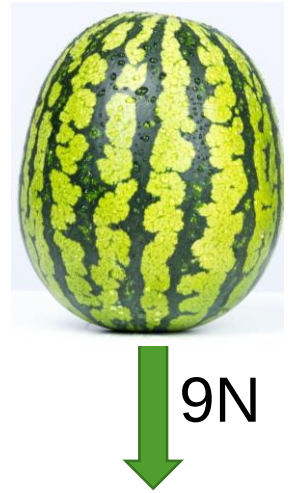

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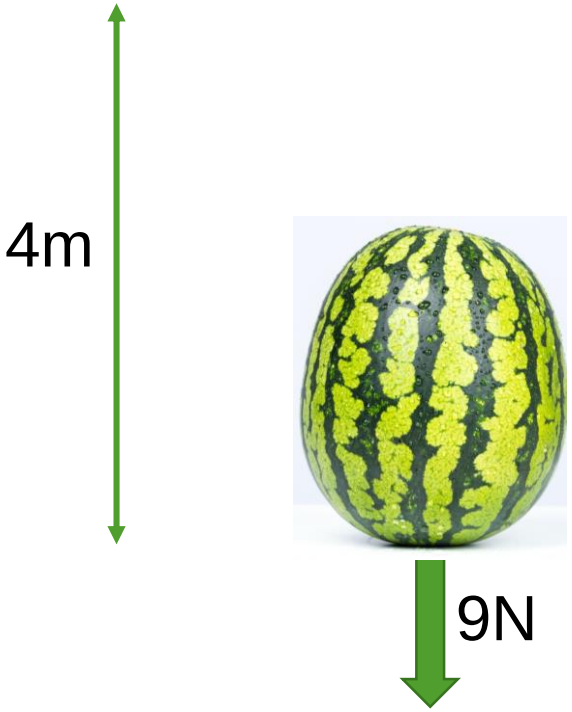

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Energy conservation and systems

A system is a set of objects which can exchange energy.

In a closed system no energy can be transferred to or from one of its objects by an object outside the system. In a closed system, the total energy stored will not change. This is the conservation of energy.

Another way of putting this is that energy can not be created (out of nothing) or destroyed.

Know your energy formulae

Name of store	Formula	Depends on	Chapter
All	Energy E = F d	F = force (N) d = distance moved (m)	33
All	Power P = E / t	t = time taken (s)	33
Gravitational potential energy (g.p.e.)	E = mgh	m = mass (kg) g = grav. field str. (N/kg) h = height (m)	33
Kinetic energy (k.e.)	$E = mv^2/2$	v = speed or velocity (m/s)	34
Thermal	$E = mc \Delta T$	c = specific heat capacity (J/kg°C) ΔT = temperature change (°C)	30
Elastic potential energy (e.p.e.)	$E = ke^2 / 2$	k = spring constant (N/m) e = extension (m)	37

Extra fact about thermal energy – kinetic energy of particles is often proportional to the ‘kelvin’ temperature (temp above absolute zero at -273°C)

g = 10N/kg

Work and GPE practice

1. Calculate the work done when...
    1. A sack of sand is dragged 4m across the floor with a 15N friction force
    2. A 75kg person climbs 3m of stairs
    3. A 12 000kg bus drives up a hill which is 15m tall
2. Calculate the height a 60kg student ought to be able to climb after consuming a 500kJ chocolate bar

g = 10N/kg

Power Practice

1. Calculate the electrical energy consumed by a 15W lamp if it left on continually for 6 hours.

2. Calculate the power of a 90kg person who can climb 3m up a ladder in 4s.

3. How much time will it take a 2kW motor to lift a 1kN weight 12m?

Kinetic energy practice

1. Calculate the kinetic energy of
    1. An 8.2kg briefcase thrown at 3.5m/s.
    2. A 100g apple travelling at 12m/s.
    3. A 1200kg car travelling at 40mph (equivalent to 18m/s)
2. What is the speed of a 10kg mass if it has 10kJ of kinetic energy?

Thermal energy practice

The specific heat capacity of water is 4200 J/kg°C.

1. How much thermal energy does 1.5kg of water lose in cooling from 80°C to 55°C?

2. How much time does it take a 2kW heater to raise the temperature of 2kg of water from 15°C to 95°C?

Elastic potential energy practice

1. How much energy is taken to stretch a 400N/m spring to an extension of 3cm?

2. How much energy is taken to stretch the spring in q1 from 3cm to 6cm?

3. How far will 25J enable you to stretch a 20kN/m spring?

Dissipation, Efficiency and Payback times

Machines and processes transfer energy from one store to another (e.g. a car engine from chemical to kinetic). Not all of the energy transfers are useful, as when the car's exhaust heats the surroundings. This is wasted energy.

The force of friction, when two objects slide over each other, heats the surroundings uselessly. This is called the dissipation of energy.

The fraction of energy (or power) used usefully is called efficiency.

A solar panel which costs £2000 to buy and install, and subsequently saves £200 on fuel bills each year has a payback time of £2000 / £200 = 10 years.

Practice with Wastage, Efficiency & Payback

1. List the ways in which energy is used usefully and wasted in a television and in a washing machine.

2. An old-fashioned light bulb had a 60W electrical power input, yet made 15W of light. Calculate its efficiency.

3. The payback time of good insulation on a hot water tank in a house is 8 months. The insulation costs £30. How much money will be saved in five years as a result of installing it.

Heat transfer – always from hotter to cooler objects

Conduction	Convection	Radiation
Two objects in contact Thermal conductivity (high for metals) (low for insulators) Air is good insulator, but must be kept still.	Hot fluid (gas or liquid) moves from a warm place to a cooler place. As fluid temperature rises, it expands, its density reduces, and floats on the cooler surrounding fluid	Nearly all objects give out infra red radiation. The power radiated depends on • temperature • surface area • surface colour/texture Wavelength of radiation depends on temperature

Extra fact about conduction: power proportional to temperature gradient (°C/m), surface area and thermal conductivity.

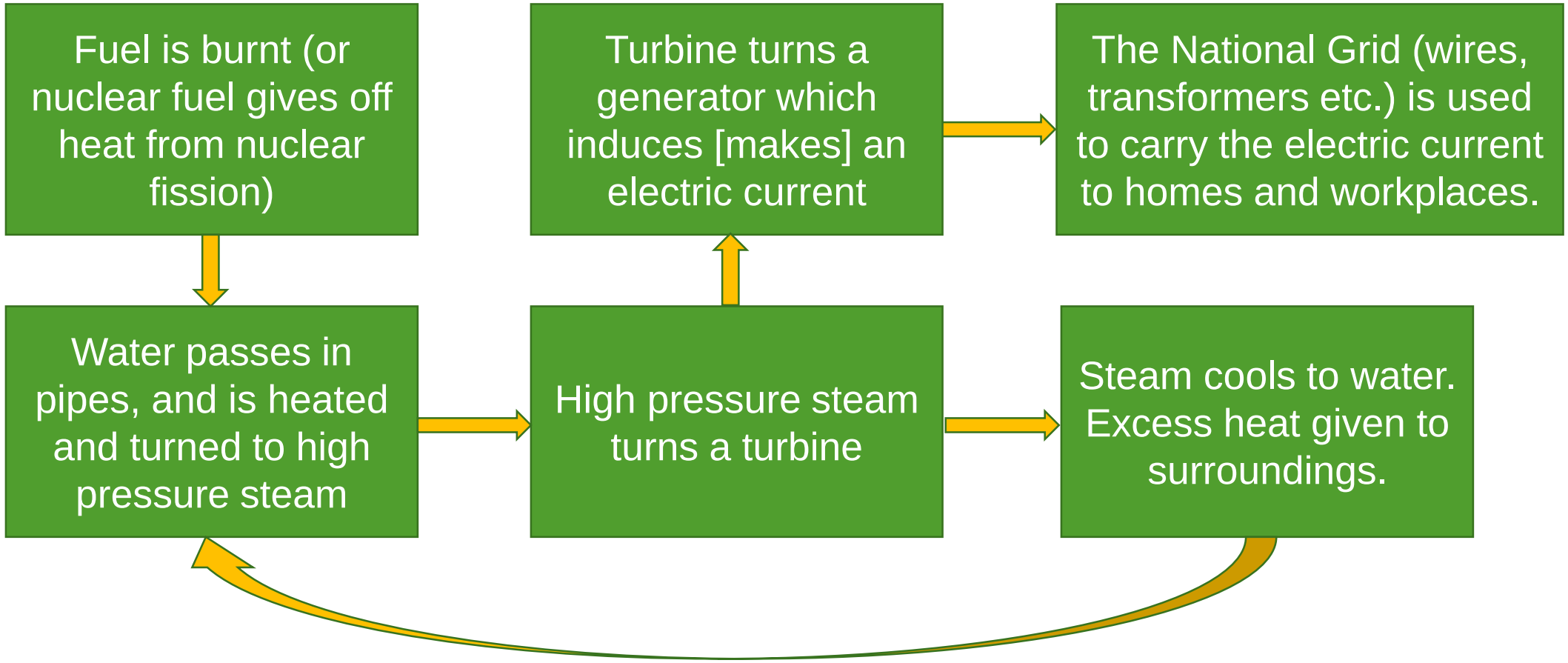
Extra facts about radiation: power proportional to surface area and kelvin temperature^4, while the peak wavelength is proportional to 1/kelvin temperature

Greenhouse effect

short wavelength infra red from Sun passes through atmosphere. It is absorbed by the ground, which warms.

long wavelength infra red from the warm ground is absorbed by clouds and by gases in the atmosphere.

Generating electricity from heat



Energy resources

1. Give three examples of fossil fuels. Are they renewable?

2. Give two advantages and two disadvantages of natural gas compared with nuclear energy for generating electricity.

3. Give two advantages and two disadvantages of offshore wind power compared with biomass for generating electricity.

Links

GCSE Topic Revision

https://isaacphysics.org/pages/gcse_topic_index#gcse_revision

Consolidation Programme

https://isaacphysics.org/pages/summer_programmes_2021