ENERGY RESOURCES + ENERGY TRANSFER REVISION NOTES

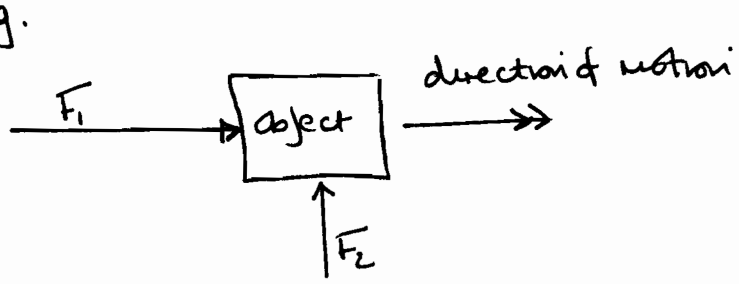
- What is WORK?
  - WORK DONE = F x d = force x distance
  - Measured in Joules (1J = 1N x 1m)
  - ∴ 1 Joule of work is done when a force of 1 newton moves something through a distance of 1m, in the direction of the applied force.

eg. A tin of paint of mass 3kg is lift from ground level to a shelf 2 meters above the ground. How much work is done on the tin of paint?

$$WD = f \times d$$
$$WD = (3kg \times 10N/kg) \times 2m$$
$$WD = \underline{60J}$$

- Remember: Work is only done if the force is in the direction of movement.

eg.



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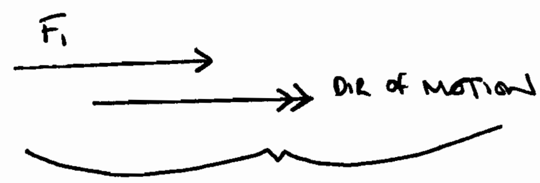
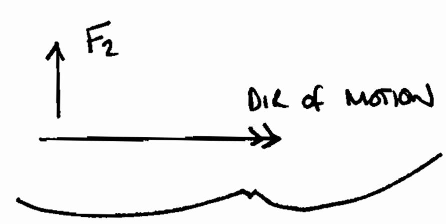
ANALYSIS





IN DOING WORK ON AN OBJECT - ENERGY IS TRANSFERED TO THAT OBJECT

eg. the paint tin has now gained GRAVITATIONAL POTENTIAL ENERGY.
the pushed object has now gained KINETIC ENERGY.

- What is ENERGY?
  - You have to put fuel into a machine to make it work.
  - fuel has ENERGY
  - eg. 1 litre of Petrol has 40MJ of Energy

- ∴ max amount of work that we can get out of 1 litre of petrol is 40MJ.
- Work and Energy both measured in Joules
- ENERGY CAN BE USED TO DO WORK.

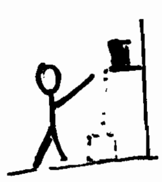
• TYPES OF ENERGY

- Chemical Energy - chemical energy that is stored within a substance eg. food. Released by process of a chemical reaction.
- Gravitational Potential Energy - energy stored due to an object's position within a gravitational field ie. tin of paint on a shelf.
- Kinetic Energy - the energy of motion. eg. a moving car.
- Heat Energy - a hot object possesses heat energy.
- Elastic Strain Energy - energy stored in an object due to strain. eg. work is done in drawing a bow and energy is transferred to the string.

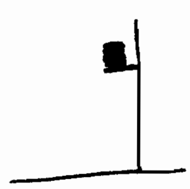
Other types: electrical, sound, light and nuclear.

• ENERGY TRANSFERS - energy changes between the above types

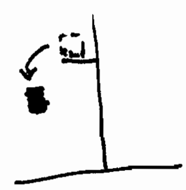
Chemical energy in human muscles allow work to be done to lift paint tin to shelf. Energy is transferred to tin, and due to its position in gravitation field, it has GPE. If it falls off the shelf GPE turns to KE as the tin accelerates to the ground. On impact energy is transferred to heat and sound.



WD by muscles lifting box



Due to position in gravitational field there is GPE



Box falls GPE → KE

Box hit ground producing heat + sound.

• Gravitational Potential Energy (GPE)

GPE = mass × gravitational field strength × height (mgh)

Measured in Joules (J).

When lifting an object, the work done on the object is equal to the increase in GPE.

$$Wd = F \times d$$
$$= (m \times g) \times h$$

• Kinetic Energy - the energy of motion:

$$KE = \frac{1}{2} \times mass \times (velocity)^2$$
$$KE = \frac{1}{2} m v^2$$

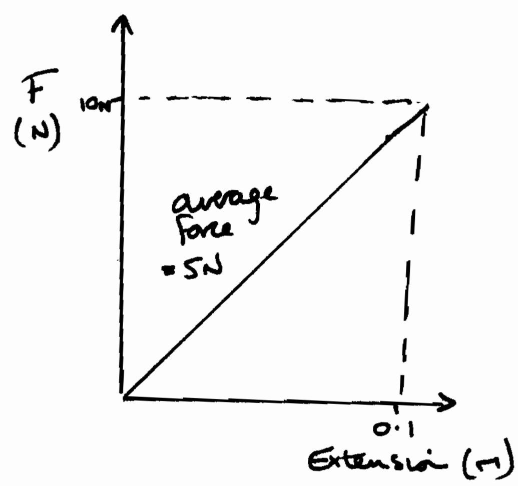
• Strain Energy

Stretched spring stores elastic strain energy - can be obtained when the spring is released if the elastic limit has not been exceeded.

From a force - extension graph:

Energy stored = W.d in stretching spring

$$E_s = \text{average force} \times \text{distance}$$
$$= 5N \times 0.1m$$
$$= 0.5J$$



• Converting K.E to G.P.E

If a ball is thrown vertically into the air - the energy is conserved, and the K.E turns into the GPE. At its highest point:

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

initial KE　　max GPE at highest height

① Max KE
② Max GPE / No KE
③ GPE ↓ / KE ↑

$$\frac{1}{2} \cancel{m} v^2 = \cancel{m} g h$$
$$\frac{v^2}{2g} = h$$ (we can determine the max h, if initial v is known)

<u>Power</u> => the rate of doing work or converting energy

$$\text{Power} = \frac{\text{Work Done or Energy Converted}}{\text{time taken.}}$$

$$\text{Power} = \frac{WD}{t} \text{ or } \frac{E}{t}$$

- Measured in J/s or Watts.
- Will often see kW (1000 W) and MW (1×10^6 W).
- Analysing the Power Eqn :

$$\text{Power} = \frac{Wd}{t} = \frac{F \times d}{t} = F \times \frac{d}{t}$$

We know that velocity, $v = \frac{d}{t}$

$$\therefore \underline{\underline{\text{Power} = F \times v}}$$

eg. A train travelling at 20 m/s experiences resistive drag forces of 8 kN. How much power ~~~~ does the train produce to keep running at 20 ms⁻¹?

$$\begin{aligned} \text{Power} &= F \times v \\ &= 8\text{kN} \times 20 \\ &= 160\,000\,\text{W} \\ &= 160\,\text{kW} \end{aligned}$$

The train must do work to overcome the frictional forces. At $20\,ms^{-1}$ it must do this work at a rate of 160,000 J/s.

<u>Efficiency</u>

- Rarely do we get the same amount of useful energy out of a machine as we put in.
- ENERGY IS ALWAYS CONSERVED, but often in the process, it is not all converted into the type of energy we want. eg. Car engine creates useful energy to turn drive shaft, but always creates HEAT + SOUND which are <u>not</u> useful.

This leads to the idea of efficiency:

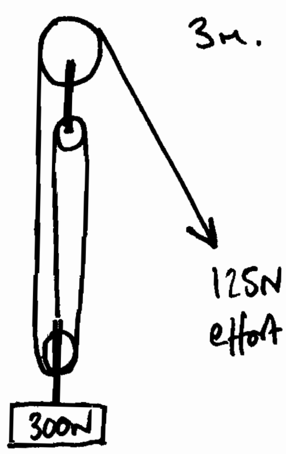
$$\text{Efficiency} = \frac{\text{Useful energy (or work) out of machine}}{\text{Total energy (or work) put into a machine.}} \ (\times 100)$$

$$\text{Efficiency} = \frac{\text{Power Out}}{\text{Power In.}} \ (\times 100)$$

Efficiency can either be expressed as a decimal or a percentage

eg. An engine is 0.45 efficient or 45% efficient.

EXAMPLE : A pulley system is used to lift a load. What is the efficiency. If the load rope moves 1m, the effort rope will need to be pulled 3m.



$$\text{Efficiency} = \frac{\text{Work Done on load}}{\text{Work Done by effort}}$$

$$= \frac{300N \times 1m}{125N \times 3m}$$

$$= \underline{\underline{0.8 \quad \text{or} \quad 80\%}}$$

MATTER

- Everything we touch, swallow, breathe is made out of SMALL PARTICLES.
  - Smallest particles → ATOMS. (approx 100 different types).
    - ↳ material of only one type of atom → ELEMENT.
    - eg. oxygen, hydrogen, nitrogen, carbon.
  - MOLECULES – atoms combine chemically to make molecules.
    - eg. water is two hydrogen + one oxygen atom.

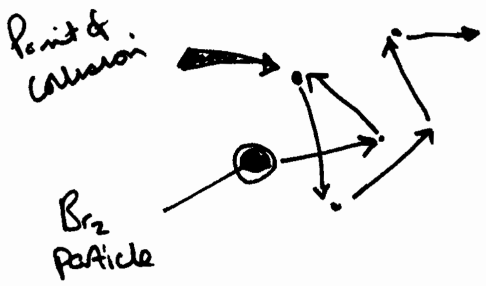
- Concept of atoms and molecules came about 100 years ago.
- Matter is name used to describe all solids, liquids + gases.
- Two ideas that led to theory of particles:
  - Ink diffusing in a beaker of water
  - The Male Emperor Moth detecting female scent (particles) upto distance of 10km.

DIFFUSION – the process of one substance spreading through another.

Bromine experiment:

ENGLAND P.122 → When VACUUM in tube, bromine spreads very rapidly into space due to the kinetic energy of the particles.

→ When AIR in the tube, bromine gas takes up to twenty minutes to DIFFUSE through tube due to collisions with air particles.



Path is random due to constant collisions with air particles ∴ diffusion takes longer

- Humans diffuse digested food into the bloodstream.
- Plants diffuse nutrients into their roots (nitrogen, potassium, phosphorus).

BROWNIAN MOTION

- Robert Brown, a botanist, studied pollen grains suspended in water. He noticed that: the grains of pollen were moving around randomly.
- This BROWNIAN MOTION can be seen if SMOKE PARTICLES are observed through a microscope.

What is happening? The smoke particles are constantly being collided with by the small, <u>invisible air particles</u>. The collision cause the smoke particle to change direction. It subsequently has another collision. The motion ∴ appears random.

The air particles are moving very quickly ∴ have sufficient kinetic energy to deflect the more massive smoke particle.

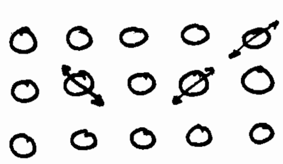
<u>KINETIC THEORY OF MATTER</u>

Key points of kinetic theory:

1. Every material is made up of small particles (atoms + molecules)
2. Size of particles are different for different materials.
3. Particles are very hard - cannot be squashed or stretched, but the distance between them can change.
4. The particles are always moving. The higher the temperature, the faster they move.
5. At the same temperature all particles have the same energy - heavy particles move slowly, fast particles move quickly.

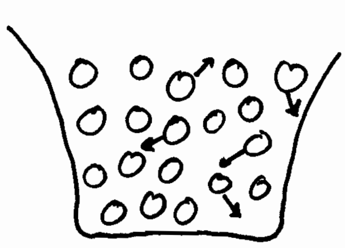
<u>3 STATES OF MATTER</u> - SOLID, LIQUID + GAS.

<u>SOLID</u>



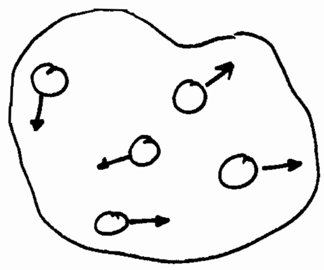
- Particles packed in ordered fashion - like stacked apples.
- Particles cannot move out of position, but can vibrate about that fixed position
- Greater temp → more vibration → material expands. (dist between particles increases).
- Particles packed very close together and held in place by very strong forces. ⇒ difficult to deform material.

<u>LIQUID</u>



- Particles still close together ∴ very difficult to compress a liquid.
- Particles can slide over each other ∴ liquid can change shape to fit ~~into~~ any container, but volume will remain constant at a fixed temperature.
- As liquid warms it expands due to increased vibration.

GAS



- In gas, the particles are seperated by large distance.
- Forces between gas particles are small.
- Easy to compress - lots of empty space
- Gas particles are in constant state of random (rapid) motion.
- Gases expand to fill the available space.

GAS PRESSURE

- Gas in a container exerts pressure on the container's wall → gas particles are constantly colliding with the wall.

Pressure depends on:

- No of collisions that particles have with the container's wall per second.
- How hard particles hit wall (how much energy they have).

Can increase pressure by:

1. Put more molecules in the container
2. Reduce volume of container.
3. Heat the gas → more energy, therefore move faster ⇒ harder collisions.

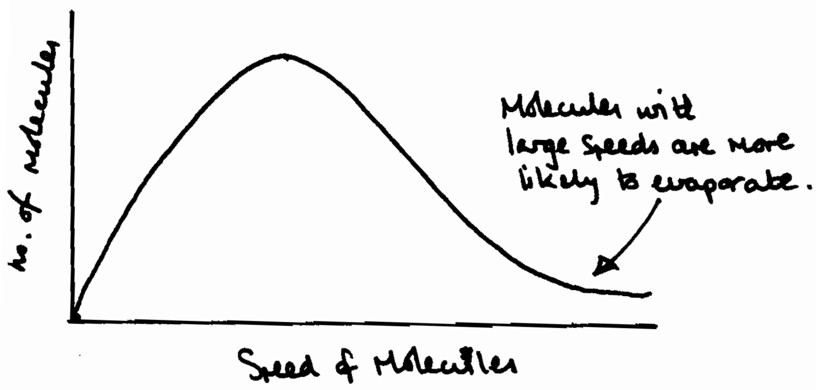
CHANGING SOLID TO LIQUID

- Heat solid ⇒ molecules vibrate more + quicker.
- If sufficient heat supplied, molecules break their bonds and are able to move away from their fixed positions ⇒ SOLID has melted.
- The temperature at which this happens is called MELTING POINT of the material.
- Most materials expand when they melt
- Melting point can be changed slightly:

Antifreeze in car engines ⇒ lowers the melting point of water.
Salt on potentially icy roads → lowers the melting point of water.

EVAPORATION

- As liquid warms up → the AVERAGE SPEED OF THE MOLECULES increases.
- However, not ALL of the molecules will be at the same speed.
- The distribution of speeds look like the graph below.



- Some molecules near the surface of the water will have enough energy to escape to escape.
- They evaporate from the water to form a vapour (water in a gaseous state).

- As the overall temperature increases more molecules have enough energy to escape. ∴ evaporation occurs at a faster rate.
- Eventually temp reaches the BOILING POINT of the liquid. At this ~~Eva~~ temp evaporation occurs in the liquid as well – bubbles of vapour form in the liquid and rise to surface.

- Evaporation causes cooling. Why? The faster, hotter molecules leave the liquid, taking their energy with them.
  - evap of sweat keeps human body cool on a hot day.

The Gas Laws

- When gas in a cylinder is compressed to half its volume, the pressure is doubled.

  ⇒ the pressure of the gas is inversely proportional to its volume

$$P \propto \frac{1}{V}$$

Boyle's Law ⇒ Pressure × Volume = Constant

$N/m^2 \times m^3$

Also, the Law of Pressures ⇒ $P \propto T$

Pressure is proportional to temperature

∴ ↑ T you ↑ the pressure in a container.

T is in Kelvin **

Finally, Charles' Law ⇒ $V \propto T$

Volume ∝ Temperature (K).

The GAS EQN can be derived as:

$$\frac{PV}{T} = \text{constant} \qquad \left[\frac{\text{Pressure} \times \text{Volume}}{\text{Temperature}} = \text{constant}\right]$$

OR

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

Remember:
- Look carefully at numbers 150 kPa = 150,000 Pa
- Temperature is in Kelvin NOT celsius ∴ you may need to convert eg. 20°c = 293 K