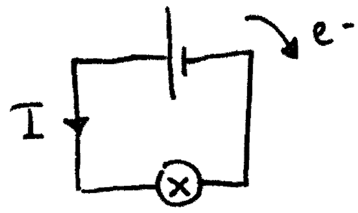
ELECTRICITY REVISION NOTES

CURRENT - AMPS (A) 1 Amp = 1 C/s => the rate of flow of charge

POTENTIAL DIFFERENCE - VOLTS (V) 1 Volt = 1 J/C => the energy per unit charge



Electron flow is negative to positive

CONVENTIONAL CURRENT, I, IS positive to negative

CONVENTIONAL CURRENT USED IN ALL OUR CALCULATIONS.

KEY EQUATIONS:

$V = IR$ Voltage = Current × Resistance (Ω) → $V = IR$, $R = \frac{V}{I}$, $I = \frac{V}{R}$

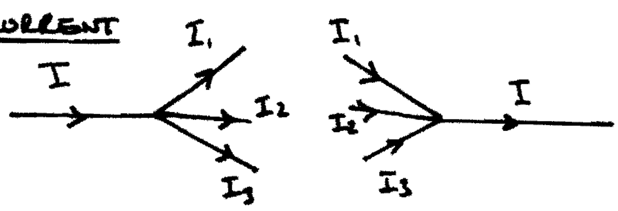
$Q = It$ Charge (C) = Current × time (s) [Q = Electrical charge in Coulombs]

$P = IV$ Power (W) = Current × Voltage

* Electrical Power measured in Watts → 1 Watt = 1 J/s
  in other words => energy transfered per second.

ANALYSIS OF CIRCUITS

① CURRENT



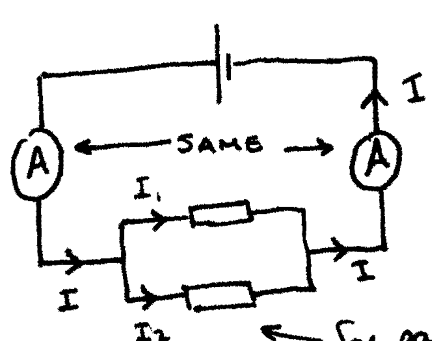
$I = I_1 + I_2 + I_3$

Current flowing into a junction equals current flowing out of a junction

"current cannot be destroyed in a circuit."

SERIES CIRCUIT => CURRENT SAME THROUGHOUT

PARALLEL CIRCUIT => CURRENT SPLITS DEPENDANT ON RESISTANCE



← for parallel component $I = I_1 + I_2$

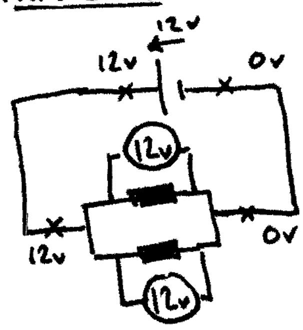
REMEMBER - Ammeters connected in SERIES
Voltmeters connected in parallel.

② VOLTAGE

PARALLEL CIRCUITS => SAME VOLTAGE ACROSS COMPONENTS IN PARALLEL.

SERIES CIRCUITS => COMPONENTS IN SERIES RECEIVE A PROPORTION OF THE TOTAL VOLTAGE.

PARALLEL.

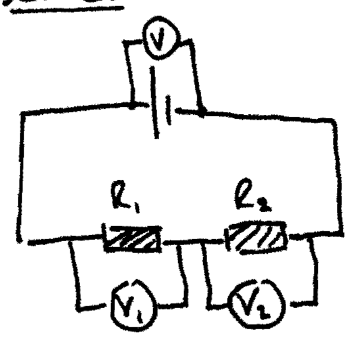


By assigning voltages, we can clearly see that both components have 12v across them

REMEMBER:

A potential difference (voltage) across a component is required to a current to flow. No P.d = No current flow

SERIES



$V = V_1 + V_2$

$V_1 + V_2$ depend on the resistance of the components.

If $R_2 > R_1$ then $V_2 > V_1$

because $V = IR$, and I is constant throughout series circuit.

COMBINATIONS OF RESISTORS

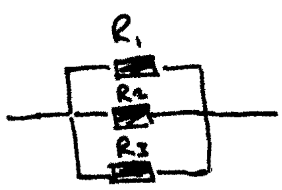
SERIES

$R_T = R_1 + R_2 + R_3 \ldots\ldots$

$R \propto$ length, so like adding length of wire together

All will have the same I through them.

PARALLEL

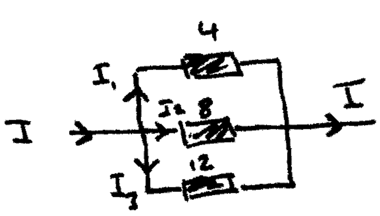


$R \propto \dfrac{1}{\text{X-Sectional Area}}$

- Area has increased
- ∴ overall resistance
- decreases.

$\dfrac{1}{R_T} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3} \ldots\ldots$

Remember: it is $\frac{1}{R_T}$, therefore once the fractions on the RIGHT HAND SIDE OF THE EQUATION have been added, the answer MUST be inverted to give R_T.



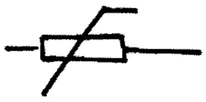
Note: More current will flow through the path of lower resistance, BUT current will still flow through the paths of higher resistance

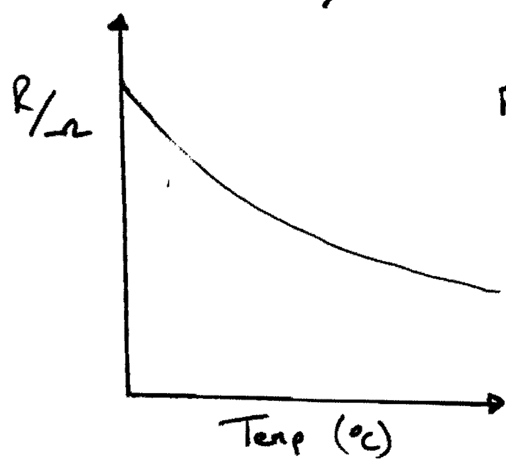
ie. $I_1 > I_2 > I_3$

VARIABLE RESISTOR - used to change the circuit resistance 

CHARACTERISTICS CURVES

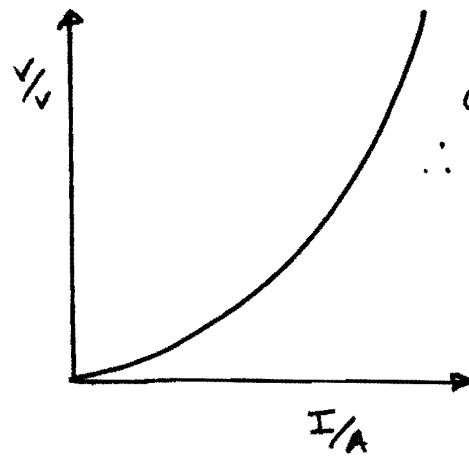
THERMISTOR





R↓ as T↑

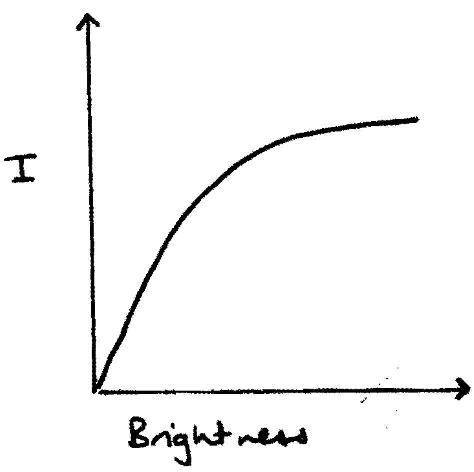
FILAMENT BULB

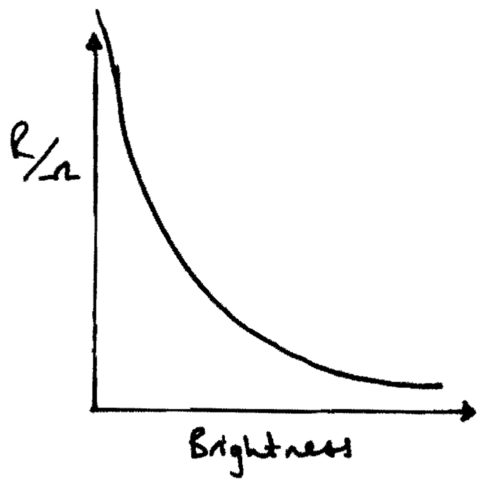


Gradient = R
∴ R↑ as I↑

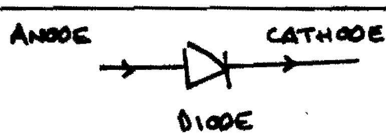
LIGHT DEPENDANT RESISTOR

LDR

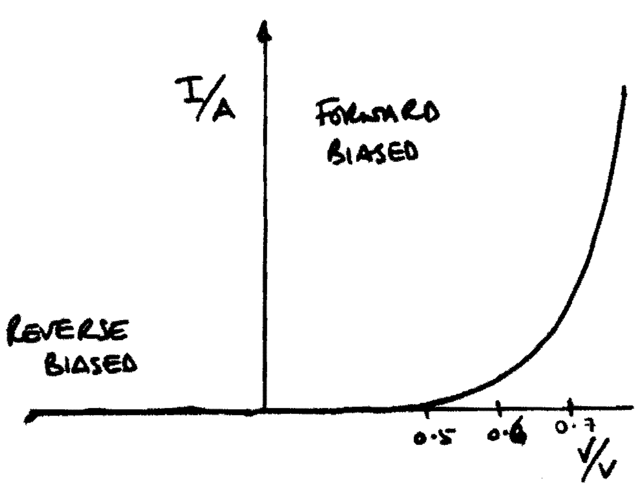


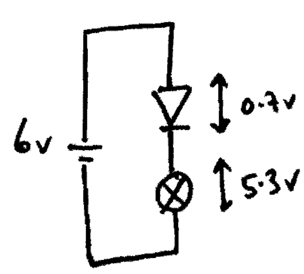


DIODE

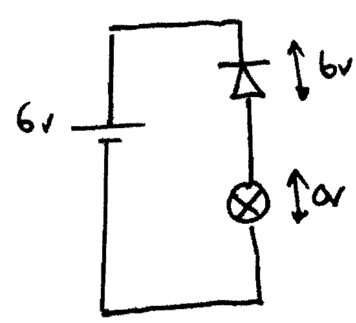


NO CURRENT FLOW UNTIL V ACROSS DIODE IS GREATER THAN 0·5 - 0·7 V, WHEN FORWARD BIASED





FORWARD BIASED



REVERSE BIASED

↙ No current can flow

BINARY CODES

568 to us means $(5 \times 100) + (6 \times 10) + (8 \times 1)$

we use powers of ten $\rightarrow$ $(5 \times 10^2) + (6 \times 10^1) + (8 \times 10^0)$ $[10^0 = 1]$

In digital electronics, there are only 2 possible values:

HIGH VOLTAGE LEVEL = 1

LOW VOLTAGE LEVEL = 0

∴ we create codes using powers of 2

If we take a 4-bit code, the maximum number of output we can have is $2 \times 2 \times 2 \times 2 = 16$ outputs.

∴ Analysis a 4-bit code would be 0111

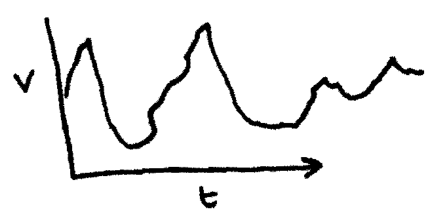
$= (0 \times 2^3) + (1 \times 2^2) + (1 \times 2^1) + (1 \times 2^0)$

$= 0 + 4 + 2 + 1$

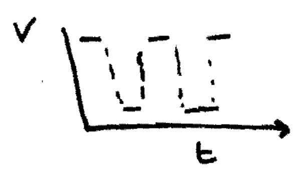
$= 7$

SIGNALS

ANALOGUE - a continuously varying signal between a maximum and minimum value



DIGATAL - is all about gaps or jumps. The signal can only have discrete values. Often represented in binary numbers

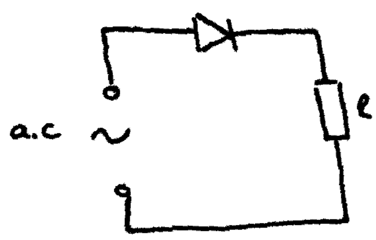


either 1 - HIGH
0 - LOW

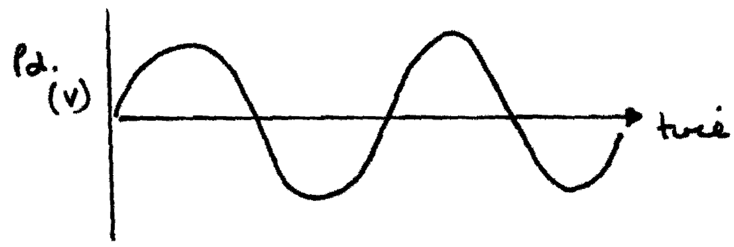
ADVANTAGES OF DIGITAL

1. More easily stored (only 1 or 0)
2. More easily transmitted - easier to decode 1 and 0 if the signal has suffered interference.

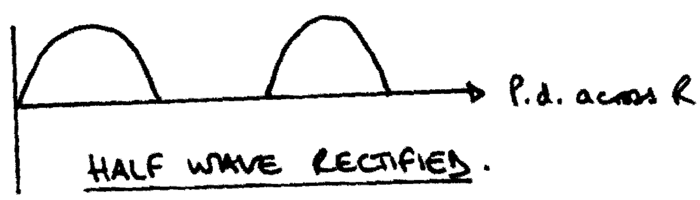
HALF WAVE RECTIFICATION (USE OF DIODES)



a.c supply → current constantly changing direction.

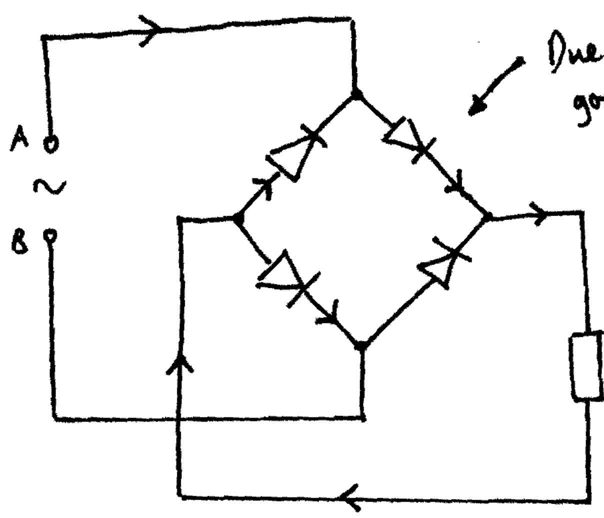


With Diode ⇒ pd. across R is:



HALF WAVE RECTIFIED.

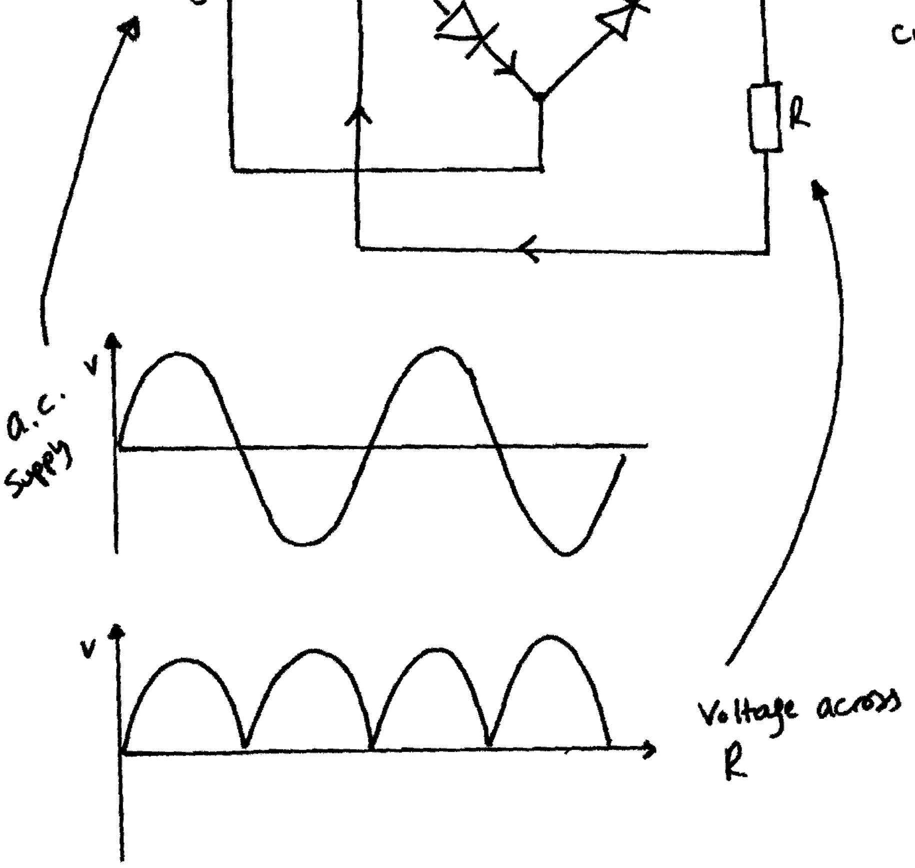
FULL WAVE RECTIFICATION



Due to diode set-up, current always goes through R in the same direction.

Follow the arrows. >

Now re-do but with the conv current flowing out of B.



Voltage across R

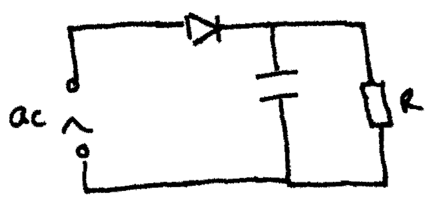
FULL WAVE RECTIFIED.

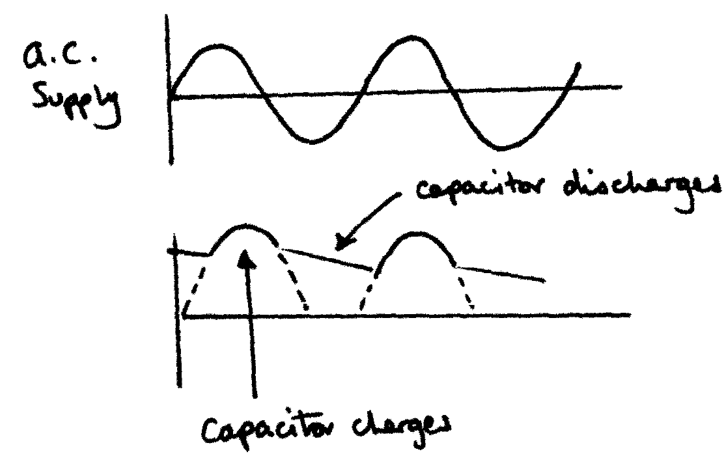
CAPACITORS

- Two metals plates seperated by an insulator.
- Charge stored on the plates enabling it to behave like a basic cell.
- Can be discharged over a short period of time to make a circuit component work.

Size of capacitor measured in Farads (F)
Normally μF.

- Can be used to smooth the voltage from an a.c. supply:



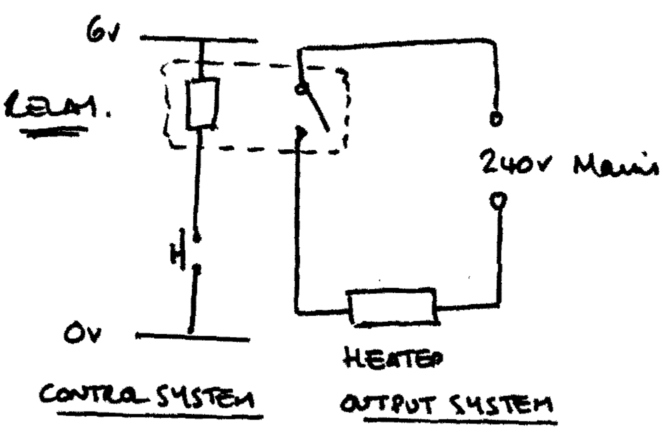


For a slow discharge R x C must be large.

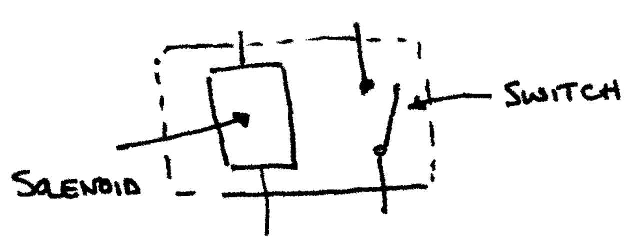
Why? ↑R slows the rate of flow of charge off the capacitor plates
↑C means more charge stored on the plates.

RELAYS

- Ideal for control systems. Low voltage control system can be used to trigger a high voltage system.



- Basic relays use a solenoid coil and a switch.
- When current flows through solenoid, magnetic field is induced, making solenoid behave like bar magnet.
- Switch is pulled closed.



LOGIC GATES – widely used in computers and electronic systems.

AND

A	B	Q
1	1	1
0	1	0
1	0	0
0	0	0

"When both A AND B are high, Q is high."

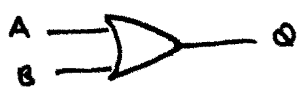
NAND

A	B	Q
1	1	0
1	0	1
0	1	1
0	0	1

Effectively an AND + A NOT.

"When both A and B are NOT 1, Q is 1."

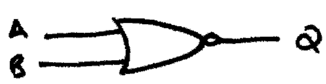
OR



A	B	Q
1	1	1
1	0	1
0	1	1
0	0	0

"When A or B or both are 1, the Q is 1."

NOR



A	B	Q
1	1	0
1	0	0
0	1	0
0	0	1

Effectively an OR plus NOT

"When neither A NOR B is 1, Q is 1"

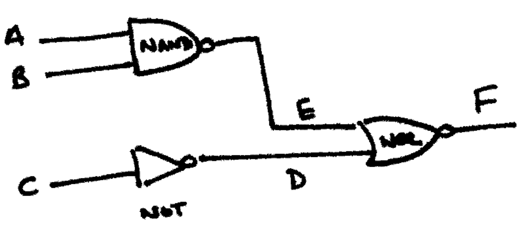
NOT

A	B
0	1
1	0

A simple inverter

COMBINING GATES

INPUT IS 3 BIT ∴ 2×2×2 = 8 possible codes.



E, F – from A+B inputs

A	B	C	D	E	F
0	0	0	1	1	0
0	0	1	0	1	0
0	1	0	1	1	0
1	0	0	1	1	0
0	1	1	0	1	0
1	0	1	0	1	0
1	1	0	1	0	0
1	1	1	0	0	1

F: NOR truth table using input data in columns D + E

Assigning 0 and 1 to A, B, C gives 8 different ~~Stat~~ State

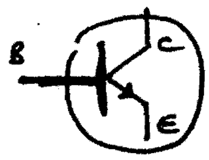
Value into C determines D.

RESULT

F is only high (1) if A, B, C are 1.

TRANSISTORS

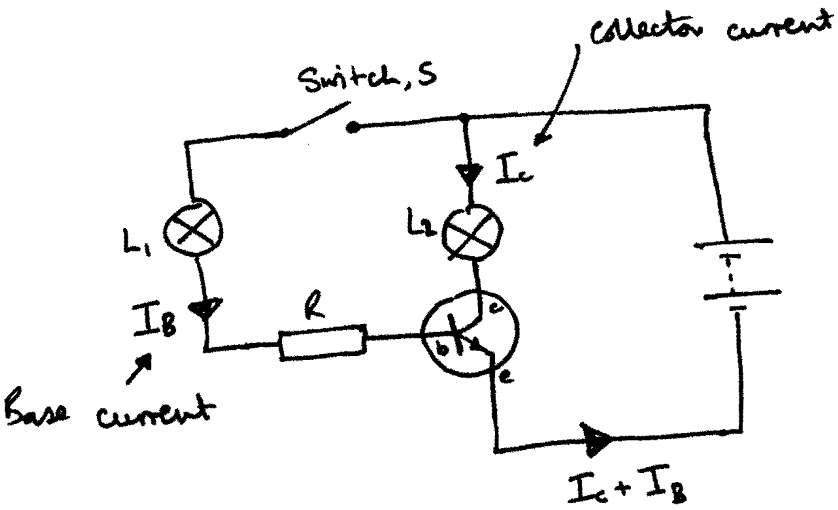
- Can act as a switch within a circuit.
- A small current in one circuit can SWITCH on a higher current in another circuit.
- Similar to a RELAY, but the transistor has no moving parts.



B = base
C = collector
E = emitter.

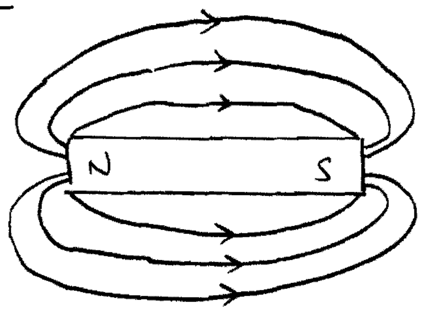
If base current (I_B) is sufficient, current can flow from the collector to the emitter.

Using the transistor as a switch....

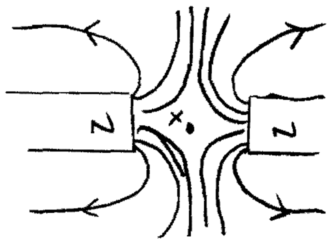


- If S is open, there is NO current flowing into the base of the transistor ⇒ no current flow from collector to emitter. L_1 & L_2 are off.
- If S is closed, current flow into the base, so current flows from the collector to the emitter and both $L_1 + L_2$ come on.

MAGNETS

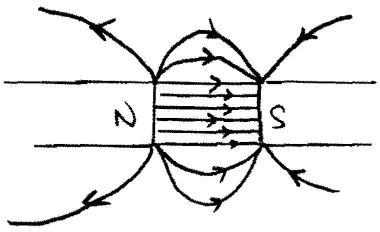


- Field lines do not cross
- Field lines NOT real - graphical illustration to aid understanding.
- Must put direction on field line.



x = Neutral Point

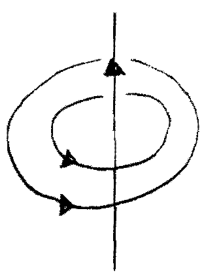
MAGNETS REPEL.



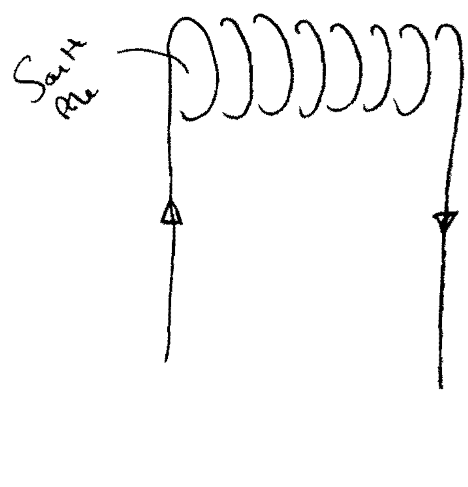
Note: field lines between N and S are evenly spaced.

FIELDS ABOUT A WIRE → RIGHT HAND GRIP RULE

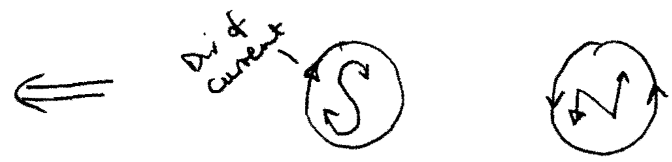
- Thumb is CURRENT DIRECTION (CONV)
- Fingers - point in direction of field.



SOLENOIDS

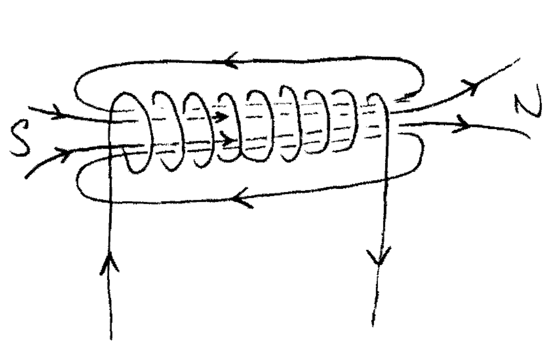


LOOKING AT ENDS



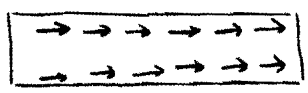
THINK DIRECTION OF CURRENT.

THIS IS ALL ABOUT VISUALISATION.



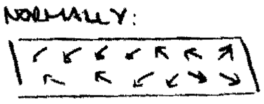
- Magnetic field strongest in solenoid
- Behave like a bar magnet.
- Placing iron core in middle increases strength of field.
- Using a switch or AC supply, the field can be rapidly expanded and collapsed.

↑ strength of solenoid by:
① Increasing the current
② Using more turns of wire
③ Placing some iron in the middle of the solenoid

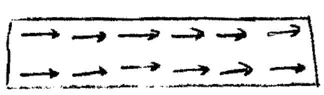


- Magnet are believed to have many domains - all of which behave like mini magnets.
- Aligning the domains gives a metal its magnetism.
- In steel, once domains have been aligned they stay aligned, and the metal is magnetised.

IRON NORMALLY:



IRON IN MAGNETIC FIELD



- In a iron bar, the domains are all jumbled. When under the influence of a magnetic field, they all align making the iron bar behave like a permanent magnet

<u>MAGNETISING METHODS</u>: (FOR MAGNETISING A STEEL BAR)

① Stroke with permanent magnet approx 20 times in the same direction. Domains will then line up.

② Place bar into a solenoid. A short but very strong pulse of current through the solenoid produces a strong magnetic field. Domains align → bar is magnetised.

<u>DEMAGNETISING METHODS</u>

① Hit magnet with hammer.
② Place in solenoid and apply a.c. current - causes domains to become jumbled.
③ Heat bar to approx 700°C. At low temps the atoms in the steel line up to magnetise each domain.
At very high temps the atoms vibrate at random so much that each domain loses its alignment

FLEMINGS LEFT HAND RULE: Thumb = Motion [P.264]
First finger = Magnetic field
Second finger = Current direction.

ELECTROMAGNETIC INDUCTION - When a wire move through an magnetic field an e.m.f is induced and a current flows [P.270].

You can increase the size of the e.m.f and current flow by:

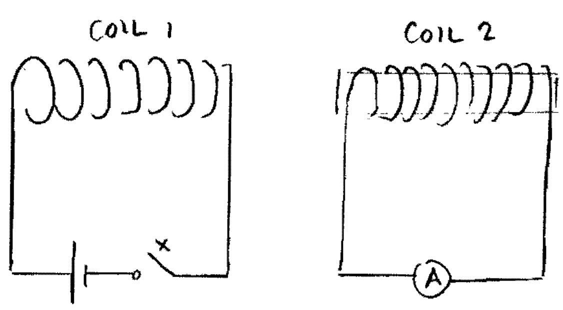
① Moving the wire more quickly - when the wire is stationary between the poles of the magnet, there is no current.

② Using stronger & bigger magnets.

③ Looping the wire so that several turns of wire pass through the poles.

* The wire must be experiencing a changing magnetic flux in order that an emf and current is induced * (there must be motion of either the wire or the magnetic field).

MUTUAL INDUCTANCE



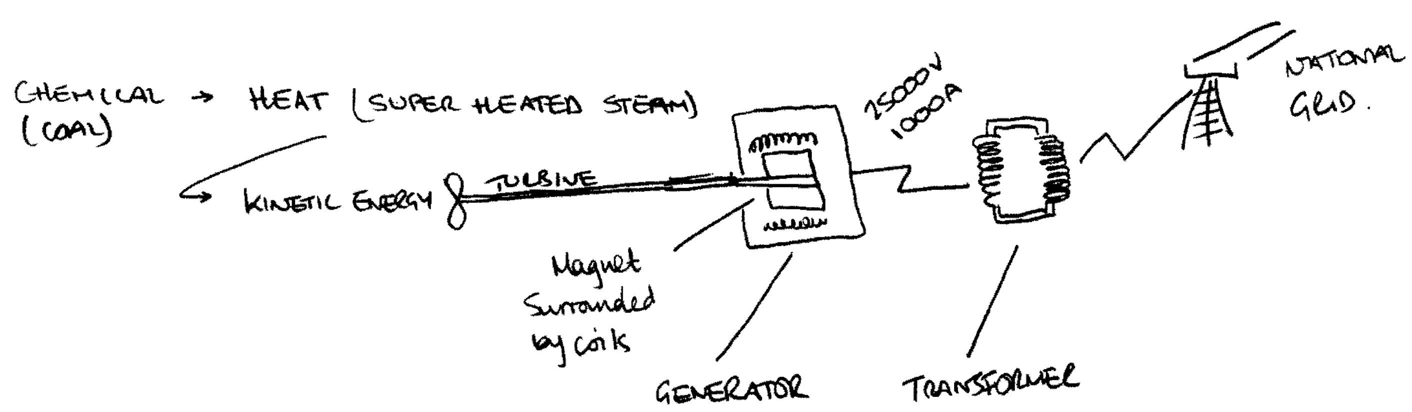
① CLOSE SWITCH X - COIL 1 CREATES RAPIDLY EXPANDING MAGNETIC FIELD WHICH CUTS THROUGHT COILS OF COIL 2. Ⓐ KICKS TO RIGHT.

② ONCE FIELD AROUND COIL 1 IS ESTABLISHED, Ⓐ RETURNS TO ZERO, AS THERE IS NO LONGER A CHANGING MAGNETIC FIELD ACROSS COILS IN 2.

③ WHEN X IS OPENED, FIELD COLLAPSES BACK ACROSS COILS OF COIL 2, ∴ Ⓐ INDICATES CURRENT FLOW. WHILST COIL 2 INFLUENCED BY CHANGING MAGNETIC FIELD THEN RETURNS TO ZERO.

④ BY USING AN AC SUPPLY INSTEAD OF A SWITCH, A BASIC TRANSFORMER IS PRODUCED.

THE COAL POWERED POWER STATION



GENERATOR - Magnets rotate at very high speed creating a changing magnetic field (flux). Rotating magnet surrounded by densely coiled wire ⇒ changing magnetic flux induces an e.m.f and current. ~ 25000V at 1000A.

TRANSFORMER: made up of primary coil, secondary coil and IRON CORE.

Key eqns: $\frac{V_s}{V_p} = \frac{N_s}{N_p}$ and $V_p I_p = V_s I_s$.

Two types of transformer. STEP UP $\Rightarrow V_s > V_p$

STEP DOWN $\Rightarrow V_p > V_s$

Transformer enables the voltage to be stepped up and the current stepped down before transmitting power across the NATIONAL GRID. Why? Cables (Power) in the National Grid have resistance and Power Loss $P_{LOSS} \propto I^2$, therefore to minimise power loss, the current, I, must be small.

Power is transmitted across the National Grid with: VERY HIGH VOLTAGE / LOW CURRENT.

Transformers are very efficient but still experience losses. These are due to 4 reasons.

1. Heat due to resistance of current flow in coils.
2. Eddy currents in the iron core (reduced by using thin laminar of iron seperated by an insulator).
3. Changing the domains in the iron core.
4. If all the coils in the system do not experience a changing magnetic flux - a design consideration!

- TRANSFORMERS require an a.c. supply - the a.c. provides a constantly changing magnetic field. D.C. would not work as it would produce a constant magnetic field - ∴ after initial turning on, NO e.m.f or current would be induced in the secondary coil.

DIAGRAM OF A SIMPLE TRANSFORMER.