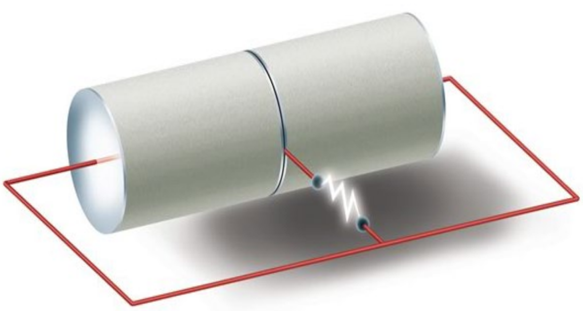
WelTec
Te Whare Wānanga o te Awakairangi

EE3103 EMF
Production assignment



Student name

EE3103 EMF Production notes

Version 2   27/02/17   Chris Meehan

An electromotive force (EMF) is the force or pressure on electrons to make them move. This causes a current to flow.
We will look at 6 methods of producing an EMF.
An EMF is measured in volts.

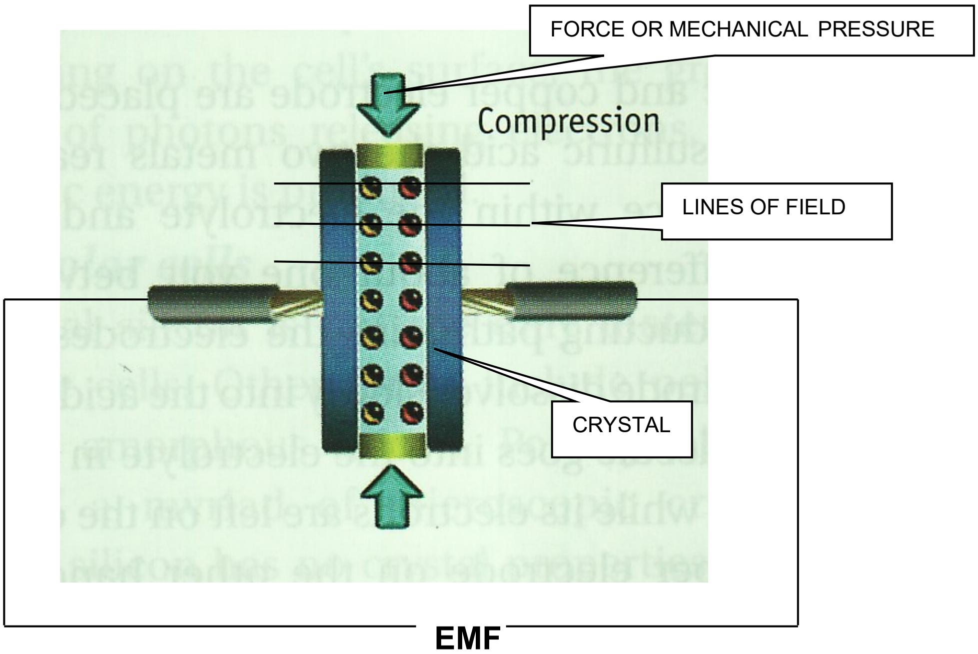
Piezoelectric

Certain crystals when compressed produce an EMF. The voltage is only present while the crystal is being placed under this stress.

Piezoelectric igniters in gas heaters and cigarette lighters employ a *lead zirconate titanate* crystal.
One plane of the crystal is set up with strong polarized fields (parallel lines).
Mechanical pressure applied to this crystal causes stress at right angles to the field.

This produces an EMF across the crystal of around 6000v, high enough to produce a spark to ignite a flame.

At lower voltage levels, stress applied to a crystal needle on a record player produces a corresponding level of EMF, amplified to audible music



Photoelectric

Light energy falling on the surface of a photovoltaic cell is converted to electrical energy, producing an EMF.

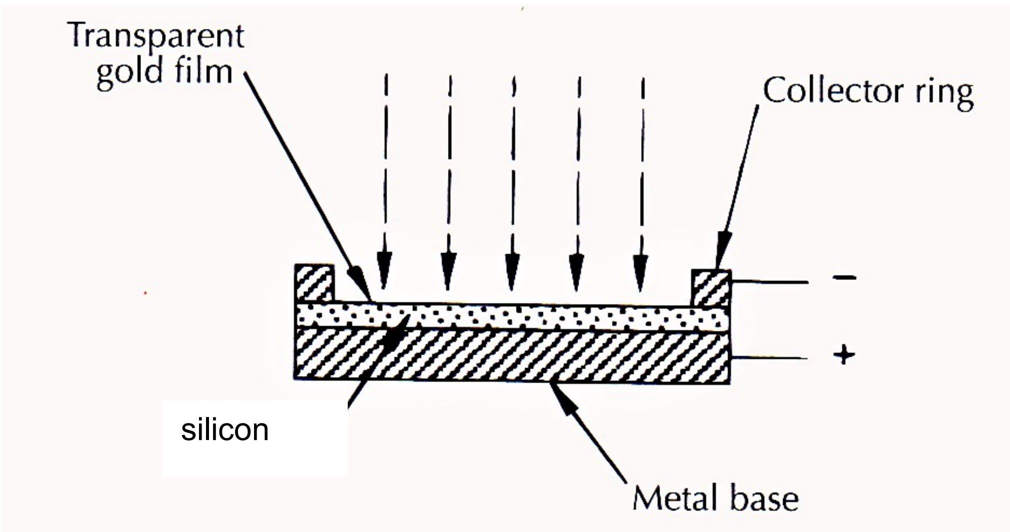
A layer of silicon is deposited onto a metal base.
A thin transparent layer of gold is then deposited onto this silicon layer.

Light energy passes through the transparent gold layer and produces free electrons at the surface of the silicon.
This produces a negative charge on the gold layer, developing an EMF of 0.6v from the base to the gold layer.

The output current varies proportionally with the light intensity.
This relationship can be exploited to read lighting levels in a camera or other light meter.

Increasing the size and number of cells can result in significantly higher voltages and currents, enabling storage batteries to be recharged.

This system is very efficient at remote communication stations and is becoming increasingly viable as an alternative power source in eco homes.



Friction or static electricity

Static electricity is an accumulation of electrons or charge. This charge may increase until the electrons flow by discharge.
The charge builds up between 2 isolated surfaces of insulating material and can be measured as an EMF.

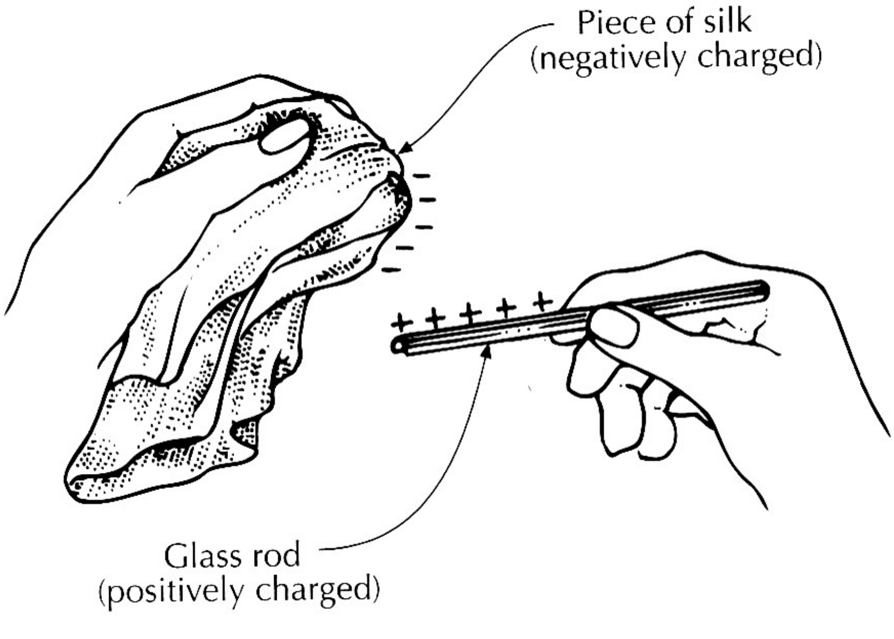
Electrons are “rubbed off” one surface, accumulating on the other surface. The build up of electrons causes this side to become negatively charged relative to the other.

Thousands of volts can build up between these 2 surfaces.
If the separating air breaks down the electrons may “spark” across to their starting side.

This may be seen or felt when you exit a car or touch a door knob and a sparking discharge is heard or felt.

This ionized effect can be used to clean dust particles from the air.

Care must be taken where static builds up in dust or materials flowing in pipes where a static spark could ignite the combustible material and cause a flash fire.



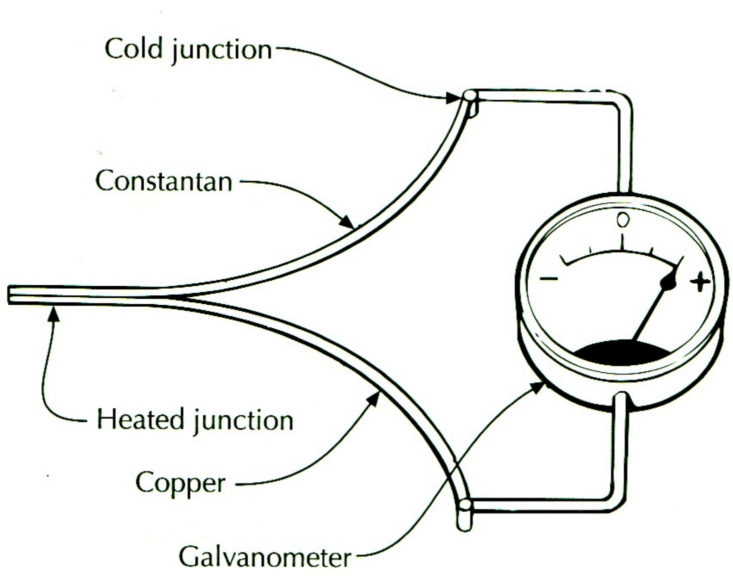
Thermocouples

Two dissimilar metal wires are welded together at one end.
When that joined end is heated up the free ends produce an EMF across them.
When the circuit is closed a current will flow proportional to the heat applied at the welded end.

The EMF produced is very low, around 0.002v for a 200°C rise or microvolts per degree celcius.

A common application is a thermometer measuring high temperatures. The small mass of the probe has little effect sampling heat and responds quickly to temperature change.

Another common use is for thermal alarms and trips in motor or generator windings.



<u>Chemical</u> (this method not listed in curriculum but supplements battery care)

An electric cell or battery will produce an EMF.
A cell consists of 2 electrodes of dissimilar metals, immersed in an electrolyte. Chemical action within the cell draws electrons to the negative plate where they accumulate.

Cells are divided into 2 groups.

Primary cells which can be used once then discarded.

Secondary cells which can be recharged or kept cycled.

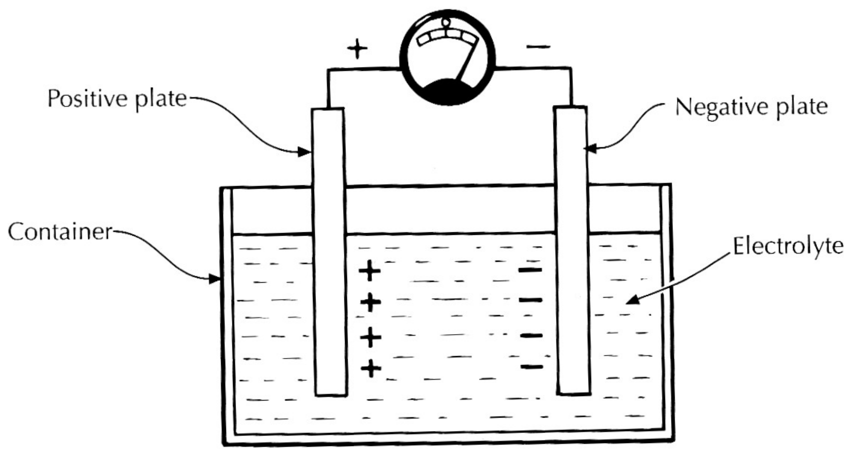
Rechargable batteries are commonly used in power tools and electronic appliances using NiCad, NiMH, lithium-ion and similar.

Lead acid and lithium-ion are used for emergency power supplies and energy storage cells.

Lead acid cells are common for automotive applications to produce high starting currents.

Lithium-ion are now the choice for electric vehicles.

Voltage levels vary around 1.2 to 2.0 volts per cell, with cells being wired in series to produce higher voltages or parallel to produce higher currents.



Magnetic or Electromagnetic Induction

Traditionally this method is the heart of power generation.

Many primary energy sources can be employed to rotate a generator to produce an EMF.

If we move a magnet within a coiled conductor an EMF is produced across the open coil leads.
As the magnetic field surrounding the magnet cuts across the coils conductors, an EMF is induced across the coil.

This EMF is present only while the magnet is in motion.
The effect would be the same if the coil was moving and the magnet was stationary.

This is the principle employed in rotary generators.

Three things influence the value of EMF produced.

1) The faster the magnetic field cuts the coil, the greater the EMF.
2) Increasing the number of turns or loops on the coil increases the EMF produced.
3) An increase in the strength of the magnetic field would also increase the magnitude of EMF

This is shown in the formula

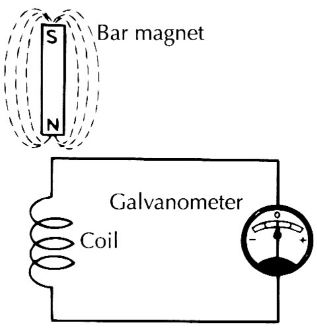
$$E = Blv$$

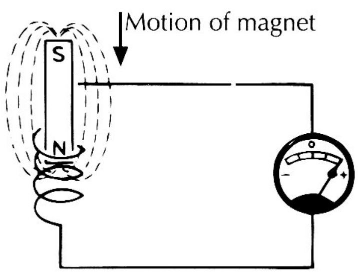
Where **E** = the induced electromotive force in ***volts***

B = flux density of the magnetic field in ***teslas***

l = length of the conductor at right angles to the magnetic field in ***metres***

v = velocity of the conductor in ***metres per second***





The permanent magnet could be replaced with an electromagnet where an iron core has two separate coils wound around it.
The primary coil is connected to a variable supply to adjust the magnitude of the magnetic field.

Generators vary in size from common car alternators at 12 volts to power generation stations at 11,000 volts.

Applications vary but the primary purpose is to utilize power by converting mechanical energy to electrical energy.

Summary

Method	**applications**	**Emf levels**
Piezoelectric	Cigarette lighters Gas igniters Record players Crystal sets	Around 6000v
Photoelectric	Camera exposure meters Light meters Remote recharging Eco generations	0.6v per cell (silicon)
Friction or static	Air cleaners and filters Insulation resistance testers Electrostatic painting	Many 1000's or 10,000's of volts
Thermocouple	Temperature measurement Thermal alarms	microvolts
Electrochemical	Rechargeable batteries Automotive batteries Generator starting batteries	Around 1 to 2 volts per cell
Magnetic	**Steam generators** • oil • coal • geothermal • natural gas • peat • biogas • fission • solar furnace **Mechanical generators** • Hydro • Wind • Tidal or wave • Small petrol or diesel motors	12v to 11,000v

EE3103 Electricity generation in New Zealand

How and where is the electricity produced

A total of 43,401 GWh of electrical energy was generated in New Zealand in 2010. The method of generation and the percentages of each are shown alongside in table A

Table A

56.4%	**Hydroelectricity,**
21.2%	**Natural gas**
12.8%	**Geothermal,**
4.5%	**Coal burning,**
5%	**Wind turbine,**
<0.1%	**Oil burning,**
1.4%	**Other sources.**

Wind power

This method is continuing to grow rapidly - as of January 2011, a total of 115 MW capacity is under construction and is expected to commissioned by mid-2011. Another 1109 MW of capacity has been given resource consent, and there is at least another 2500 MW of capacity under proposal or yet to receive consent. It is predicted to produce 20% by 2030

Who uses the electricity

In 2009, New Zealand consumed a total of 37,589 GWh of electricity.

Industrial consumption made up 35.8 percent

Agricultural consumption made up 4.8 percent,

Commercial consumption made up 25.0 percent,

Residential consumption made up 34.3 percent.

There were just over 1.92 million connections to the national electricity network.

86.0 percent of these connections were residential customers

The main electricity consumers are located in Auckland, Wellington and Christchurch but another major energy consumer which uses 15% of the national energy production is the

Tiwai Point Aluminium Smelter in Southland, which effectively has a dedicated power station at the Manapouri power station.