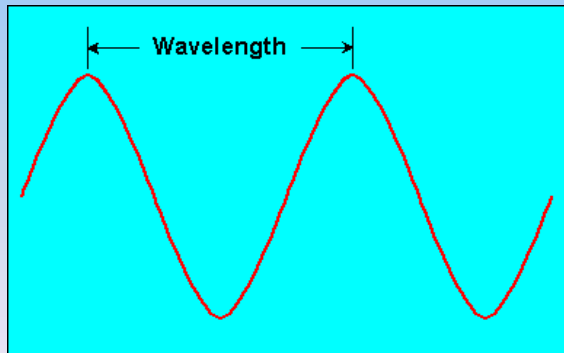


Photoelectric effect

Light is commonly described as a wave with the properties: **wavelength**, **frequency**, **energy** and **speed**

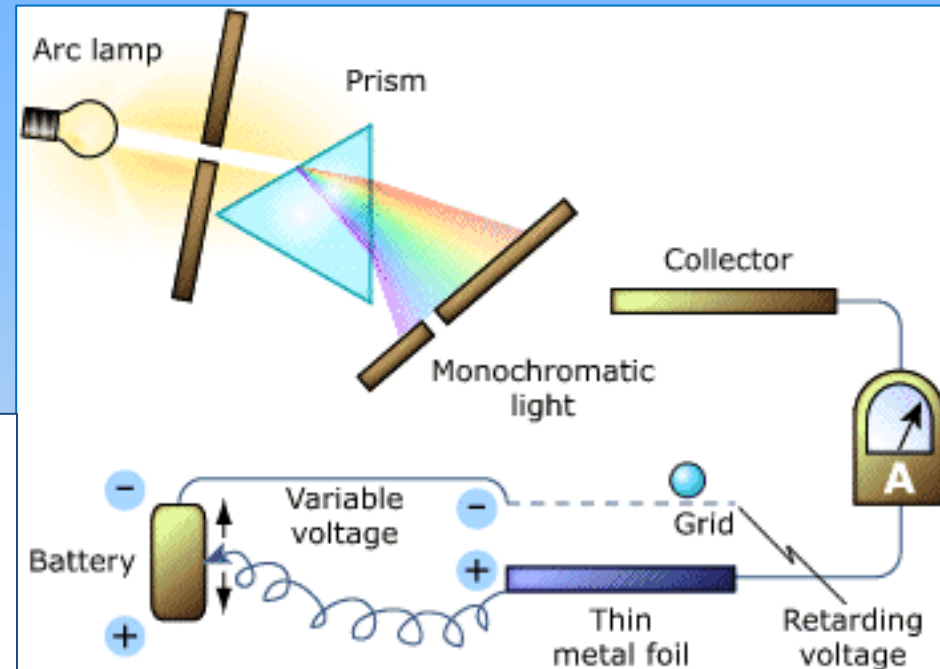
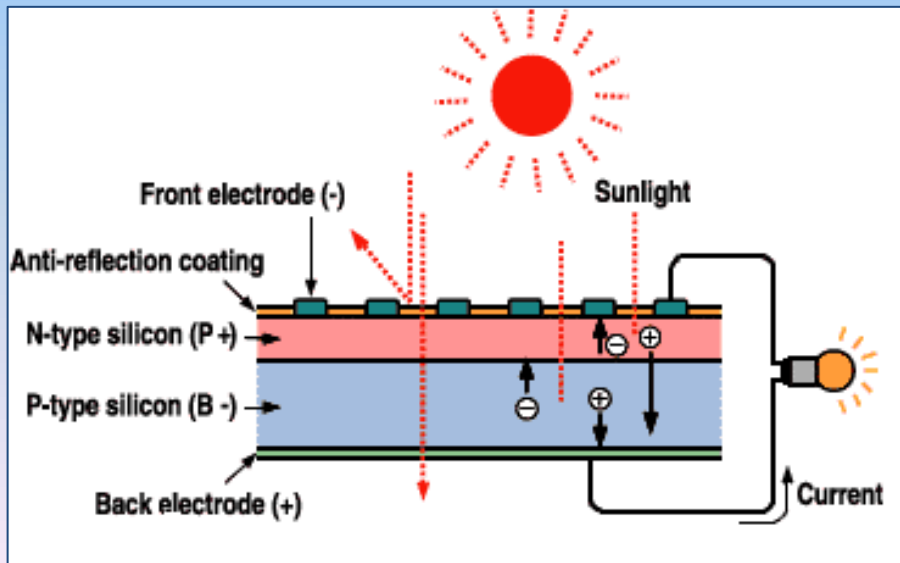
For the waves experienced in daily life (sound and water waves) we also describe their **amplitude**.

We know that the speed of **Light** is independent of everything else (constant 300,000 km/sec), wavelength and frequency are seen by the eye as colour. However, it is not obvious what corresponds to brightness or energy.



The Photoelectric Effect

- occurs when light shines on certain metal surfaces, causing electrons to be ejected from the metal and hence an electric current flows
- is used in electronic circuits for automatic doors, solar cells and night vision goggles
- is the crucial phenomenon in the creation of electricity by photovoltaic (solar) cells

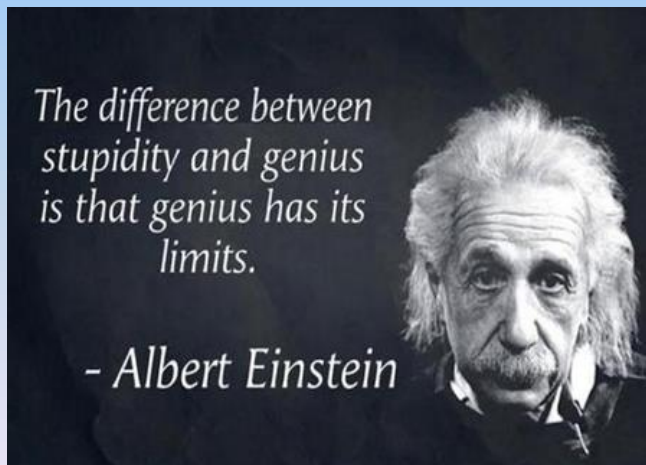


It was observed that during the **Photoelectric Effect** :

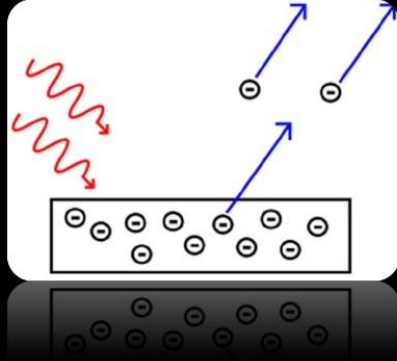
- Increasing the amount of light shining on a photoelectric cell increases the current produced but not the voltage
- Certain metals will not produce an electric current. Red light will not cause electrons to flow no matter how bright it is.
- Very dim blue light will still generate some electric current.

Albert Einstein

won a Nobel Prize for his explanation of the Photoelectric effect



The Photoelectric Effect



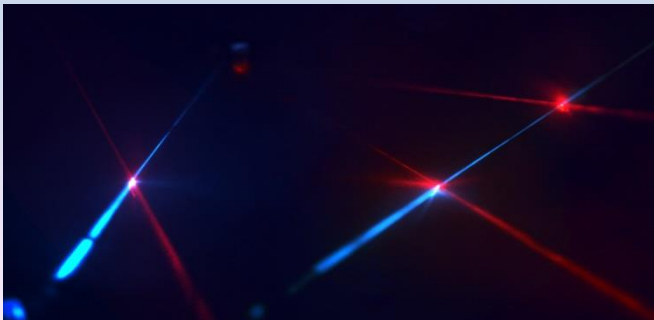
The diagram illustrates the photoelectric effect. On the left, a red wavy arrow represents an incident photon striking a metal surface. The surface is shown as a rectangular box containing several small circles with minus signs, representing electrons. Two blue arrows point upwards and to the right from the surface, representing emitted electrons. The entire diagram is set against a white background with a black border.

The photoelectric effect is a phenomenon in which electrons are emitted from matter after the absorption of energy from electromagnetic radiation such as x-rays or visible light. Einstein hypothesized that the number of electrons released would not depend on that light's energy. Confirming his hypothesis through several experiments, Einstein won the Nobel Prize of 1921 for his works in his field.

Einstein proposed that light travels in discrete packets called photons, each with discrete amounts of energy known as **quanta**.

Einstein described the following observations about the Photoelectric Effect:

- light **photons** are received individually, with each photon emitting a photoelectron
- bright lights have more photons than dim lights
- **high frequency light** has **high energy photons** and **low frequency light** has **low energy photons**
- brightness (**intensity**) is a measure of how many photons are emitted
- **frequency** is a measure of the energy of the light



Quantum Theory of the Photoelectric Effect

- Electrons can absorb or emit energy only in discrete amounts called **quanta**.
- Energy of each quanta (photon) is proportional to the frequency of radiation.
- $E=hf$ is a linear relationship. When graphing Energy (J) vs Frequency (Hz), the gradient of this relationship is equal to Planck's constant $h = 6.63 \times 10^{-34}\text{Js}$
- Since $c=f\lambda$ where c = speed of light = 3×10^8 m/s
- And $f = c/\lambda$ therefore $E= hc/\lambda$