❖ Origin of quantum theory

* No adequate discussion of electronic structure is possible without reference to **quantum theory** and **wave mechanics**.

* The development of quantum theory took place in two stages. In the older theories (1900–1925), the electron was treated as a **particle**. In more recent models, the electron is treated as a **wave** (hence the name wave mechanics).

* At low temperatures, the radiation emitted by a hot body is mainly of low energy and occurs in the ***infrared***, but as the temperature increases, the radiation becomes **dull red**, **bright red** and **white**. Attempts to explain this observation failed until, in 1901 , ***Planck*** suggested that energy could be ***absorbed*** or ***emitted*** only in ***quanta*** of magnitude ΔE related to the frequency of the radiation (υ).The proportionality constant is h, the **Planck** constant ($h = 6.626 * 10^{-34}$ **J s**). eq. (1)

$$\Delta E = h * \upsilon \quad \text{.............................(1)}$$

E = energy in **J**, υ = frequency in s^{-1} or **Hz**

$$C = \lambda * \upsilon \quad \text{.............................(2)}$$

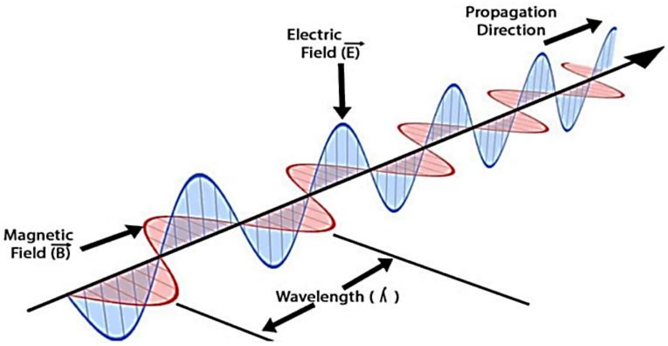
C = speed of light in a vacuum ($2.998 * 10^{8}\ m.s^{-1}$), (λ=wave length, **m**). Since the frequency of radiation is related to the wavelength (λ), we can rewrite eq. (1) in the form of eq. (3) and relate the energy of radiation to its wavelength.

$$\Delta E = \frac{h * C}{\lambda} \quad \text{............................(3)}$$

❖ Electromagnetic (*EM*) Radiation

* **<u>Electromagnetic radiation:</u> Is** a form of energy propagated through free space or through a material medium in the form of electromagnetic waves.

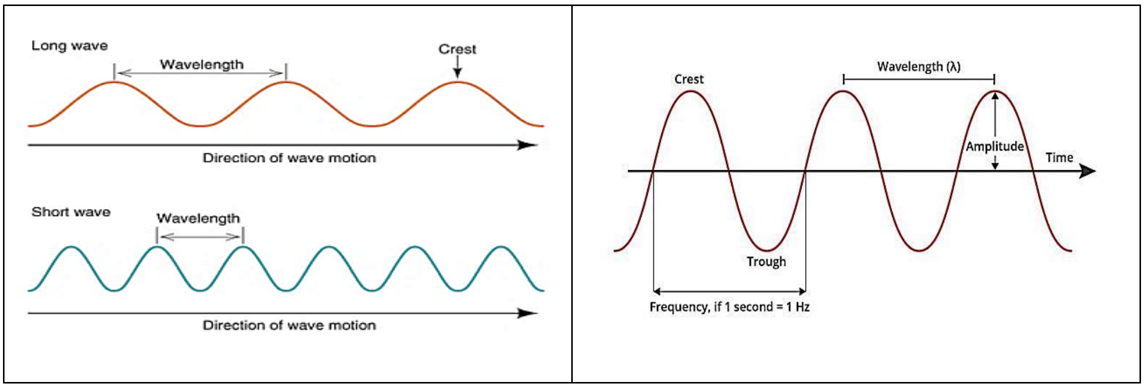
* **EM radiation** is so-named because it has **<u>electric</u>** and **<u>magnetic</u>** fields that simultaneously.



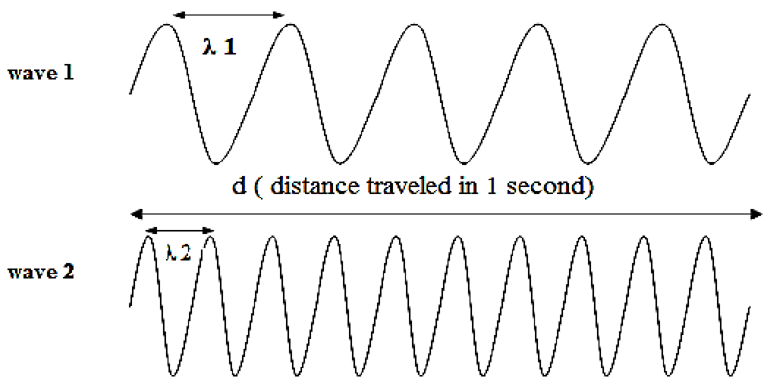
* Electromagnetic radiation has the **<u>dual nature</u>**: its exhibits **<u>wave</u> properties** and **<u>particulate</u> (photon) properties**.

* Electromagnetic radiation is an electromagnetic wave that travels through space at the speed of light, **c**.

* Inverse relationship between wave size and frequency: as wavelengths get smaller, frequencies get higher.



* In the diagram below, the distance (d) represents the distance the waves travel in 1 second.



* **Wave 1** has **5** complete waves passing by in one second, while Wave **2** has **10** waves passing by in the same time.

* The frequency of Wave **1** is 5 waves per second **5 Hz**., While the frequency of Wave **2** is 10 **Hz**.

* **wave**: - A disturbance that transmits energy through matter or space.

* **Wavelength** ***(λ):*** Is the distance between two consecutive peaks (crests) or troughs. ***(*****λ Lambda)**

* **Frequency (υ):** Number of waves that occurs in a given amount of time. **(υ Nu)**

* **Wavenumber:** Is the number of waves in one centimeter of light in a given wavelength; the reciprocal of the wavelength.

1 m = 10^2 cm, [1 cm = 10^{-2} m].

1 m = 10^6 µm, [1 µm = 10^{-6} m]

1 m = 10^9 nm, [1 nm = 10^{-9} m]

1 m = 10^{10} A^0, [1 A^0 = 10^{-10} m]

* **EX.** **An FM radio station broadcasts at a frequency of ($91.5 * 10^6\ s^{-1}$). Calculate the wavelength of the radio waves in m, cm, nm, and A^0.**

Ans.:- C = wavelength **(λ)** * frequency (**υ**)

$2.99 * 10^8$ m/s = wavelength * $91.5 * 10^6\ s^{-1}$ = 3.27 m

3.27 m * ($1*10^2$ cm / 1 m) = $3.27 * 10^2$ cm

3.27 m * ($1*10^6$ μm / 1 m) = $3.27 * 10^6$ μm

3.27 m * ($1*10^9$ nm / 1 m) = $3.27 * 10^9$ nm

3.27 m * ($1*10^{10}$ A^0 / 1 m) = $3.27 * 10^{10}$ A^0

Ex.** ***The radiation emitted from the sodium vapor lamp has a wavelength of 589 nm, what is its frequency.

Ans.:- 589 nm * (1 m / $1*10^9$ nm) = $589*10^{-9}$ m

υ = (C/ λ) = ($3*10^8$ m.sec^{-1}) / ($589 * 10^{-9}$ m) = **$5.09 * 10^{14}$ Sec^{-1}**

* **H.W**. ***Find the wavelength of a radio wave with a frequency of 900 kHz.*** (**Ans. 330 m**).

* **H.W. Find the wavelength of a radio wave with a frequency of 90 MHz. . (Ans. 303 m).**