DIFFRACTION

DIFFRACTION is the bending of the wave path when the waves meet an obstruction. The amount of diffraction depends on the wavelength of the wave. Higher frequency waves are rarely diffracted in the normal world. Since light waves are high frequency waves, they are rarely diffracted. However, diffraction in sound waves can be observed by listening to music. When outdoors, behind a solid obstruction, such as a brick wall, hear mostly low notes are heard. This is because the higher notes, having short wave lengths, undergo little or no diffraction and pass by or over the wall without wrapping around the wall and reaching the ears. The low notes, having longer wavelengths, wrap around the wall and reach the ears. This leads to the general statement that lower frequency waves tend to diffract more than higher frequency waves. Broadcast band(AM band) radio waves (lower frequency waves) often travel over a mountain to the opposite side from their source because of diffraction, while higher frequency TV and FM signals from the same source tend to be stopped by the mountain.

Diffraction, results in a change of direction of part of the wave energy from the normal line-of-sight path making it possible to receive energy around the edges of an obstacle. Although diffracted RF energy is usually weak, it can still be detected by a suitable receiver. The principal effect of diffraction extends the radio range beyond the visible horizon. In certain cases, by using high power and very low frequencies, radio waves can be made to encircle the Earth by diffraction.

Mechanism for Diffraction:

Diffraction arises because of the way in which waves propagate; this is described by the Hugyens-Fresnel Principle and the principle of superposition of waves. The propagation of a wave can be visualized by considering every point on a wavefront as a point source for a secondary spherical waves. The wave displacement at any subsequent point is the sum of these secondary waves. When waves are added together, their sum is determined by the relative phases as well as the amplitudes of the individual waves so that the summed amplitude of the waves can have any value between zero and the sum of the individual amplitudes. Hence, diffraction patterns usually have a series of maxima and minima.

There are various analytical models which allow the diffracted field to be calculated, including the Kirchoff-Fresnel diffraction equation which is derived from wave equation, the Fraunofer diffraction approximation of the Kirchhoff equation which applies to the far field and the Fresnel diffraction approximation which applies to the near field. Most configurations cannot be solved analytically, but can yield numerical solutions through finite element and boundary element methods.

It is possible to obtain a qualitative understanding of many diffraction phenomena by considering how the relative phases of the individual secondary wave sources vary, and in particular, the conditions in which the phase difference equals half a cycle in which case waves will cancel one another out.

The simplest descriptions of diffraction are those in which the situation can be reduced to a two-dimensional problem. For water waves, this is already the case; water waves propagate only on the surface of the water. For light, we can often neglect one direction if the diffracting object extends in that direction over a distance far greater than the wavelength. In the case of light shining through small circular holes we will have to take into account the full three dimensional nature of the problem.

Effect of Diffraction of Waves:

Speed…………………………does not change
Frequency………………………. does not change
Wavelength……………………..does not change
Amplitude ………………………decreases

If diffraction is due to mountain or a hill, Knife edge diffraction model is used to study the properties of the diffracted ray, and if is due to a building, rounded surface diffraction model is used.

Knife Edge Diffraction Model:

In EM wave propagation knife-edge effect or edge diffraction is a redirection by diffraction of a portion of the incident radiation that strikes a well-defined obstacle such as a mountain range or the edge of a building.

The knife-edge effect is explained by Hugyens- Fresnel principle which states that a well-defined obstruction to an electromagnetic wave acts as a secondary source, and creates a new wave front. This new wave front propagates into the geometric shadow area of the obstacle.