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# POLARISATION

## INTRODUCTION

- You would have encountered problem in receiving signal when you watch TV or listen to your stereo system.
- In order to overcome this problem, you adjust the position of an antenna attached to the stereo system or align the TV antenna (receiving antenna) in the proper orientation.
- Did you ever think why this is necessary and what physics is involved in doing so? Actually this is required as some types of antennas, via the electrons, respond to the electric field of an electromagnetic wave (signal).
- If the orientation of the receiving antenna matches with the orientation of the electric field of the wave, the electric field causes the electrons to flow along the wires to generate a current.

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- So the plane of the receiving antenna must be horizontal if the electric field of the signal broadcast by the station vibrates in a horizontal plane.
- If the field vibrates in a vertical plane, the orientation of the antenna should be changed to the vertical plane.
- So this is clear that by doing the adjustments of position or orientation of the antenna, we increase the strength of the signal, i.e. we improve the reception of the signal. The proper orientation of vibration of the electric field is nothing but the polarisation of the wave.

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- A light wave is an electromagnetic wave whose electric field and magnetic field vectors vibrate perpendicular to the direction of wave propagation.
- In order to completely identify the electromagnetic wave, it is sufficient to specify the electric field since the magnetic field can be determined once the electric field is known (discussed later in the chapter on Electromagnetic Wave Propagation).
- So a light wave whose electric field vector, also called as light vector, is vibrating in more than one plane is referred to as unpolarised light.

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- The light emitted by the sun, by a lamp, or by a candle flame is unpolarised light. It is possible to convert unpolarised light into polarised light in which the vibrations occur only in a single plane.
- The process of converting unpolarised light into polarised light is known as polarisation.
- There are a variety of methods of polarising light. Any interaction of light with matter whose optical properties are asymmetrical along the directions transverse to the propagation vector provides a means of polarising light.

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## MECHANICAL EXPERIMENT SHOWING POLARISATION OF TRANSVERSE WAVE

- In order to explain the polarisation of light, we consider a mechanical experiment by using a string whose two end points are P and Q and which is kept fixed with point Q.
- The string passes through two parallel slits S1 and S2 . When the end point P is shaken up and down parallel to the slit S1, a transverse wave is generated that travels towards the point Q and reaches there if the slit S2 is parallel to the slit S1.
- Now we rotate the slit S2 through 90°. Under this situation, the vibrations of the string are completely stopped by this slit and the string does not vibrate in the region between S2 and Q.
- As is clear from this experiment, the vibrations of this wave are confined to a plane parallel to the axis of the slit S1.
- Therefore, this wave is called plane polarised wave or linearly polarised wave.

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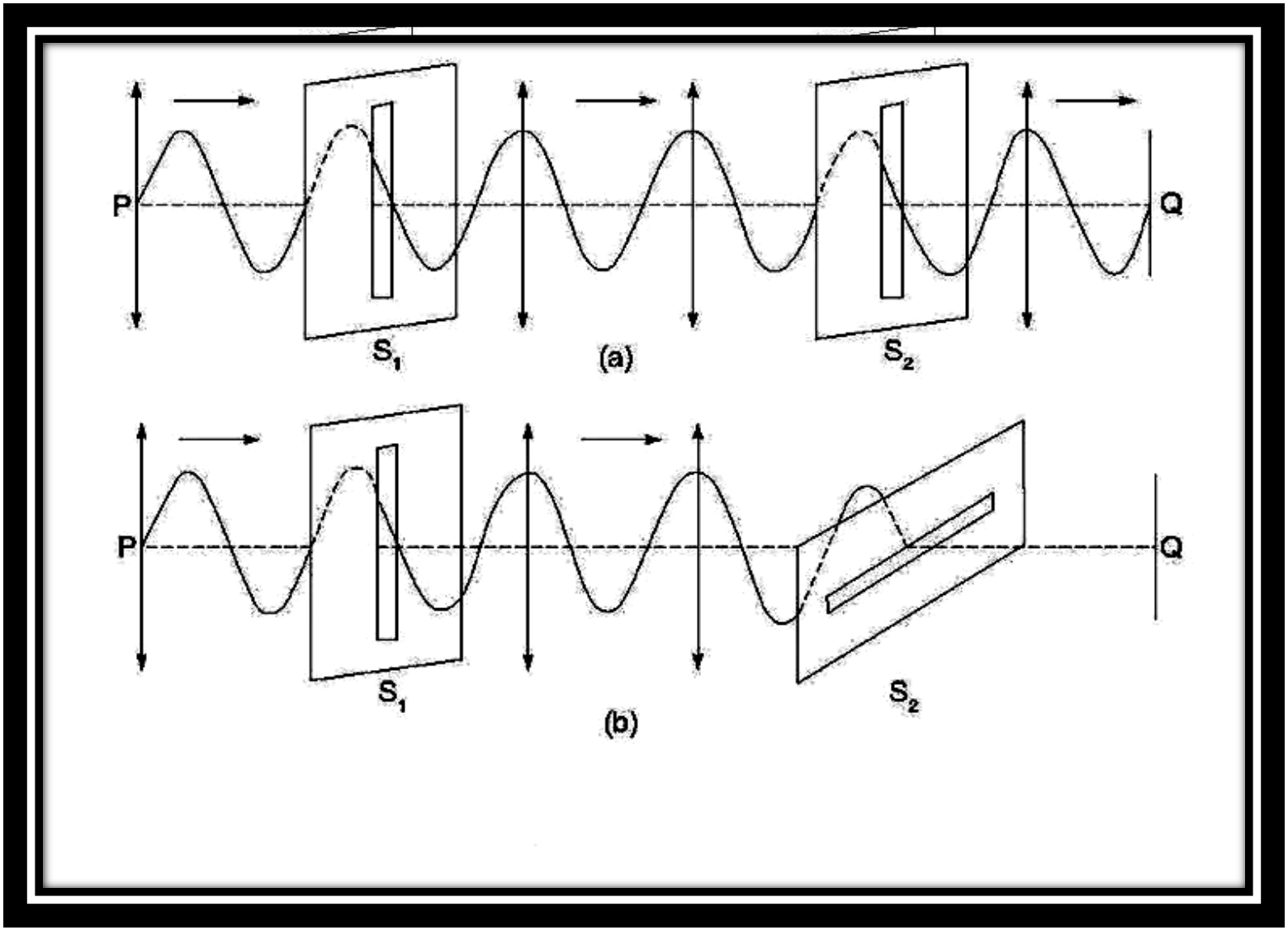

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## 3. DIFFERENCE BETWEEN UNPOLARISED LIGHT AND POLARISED LIGHT

- An unpolarised light is symmetrical about the direction of propagation as the light vector vibrates along all possible directions perpendicular to the direction of propagation of light.
- In polarised light lack of symmetry is found about the direction of propagation of the light.
- Since light is an electromagnetic wave, the polarisation describes the orientation of the vibrations of the wave.
- The vibrations may be oriented in a single direction in linearly polarised light , the vibrations of light vector are in vertical direction (in the plane of paper) whereas the vibrations are taking place in horizontal direction (perpendicular to the plane of paper).

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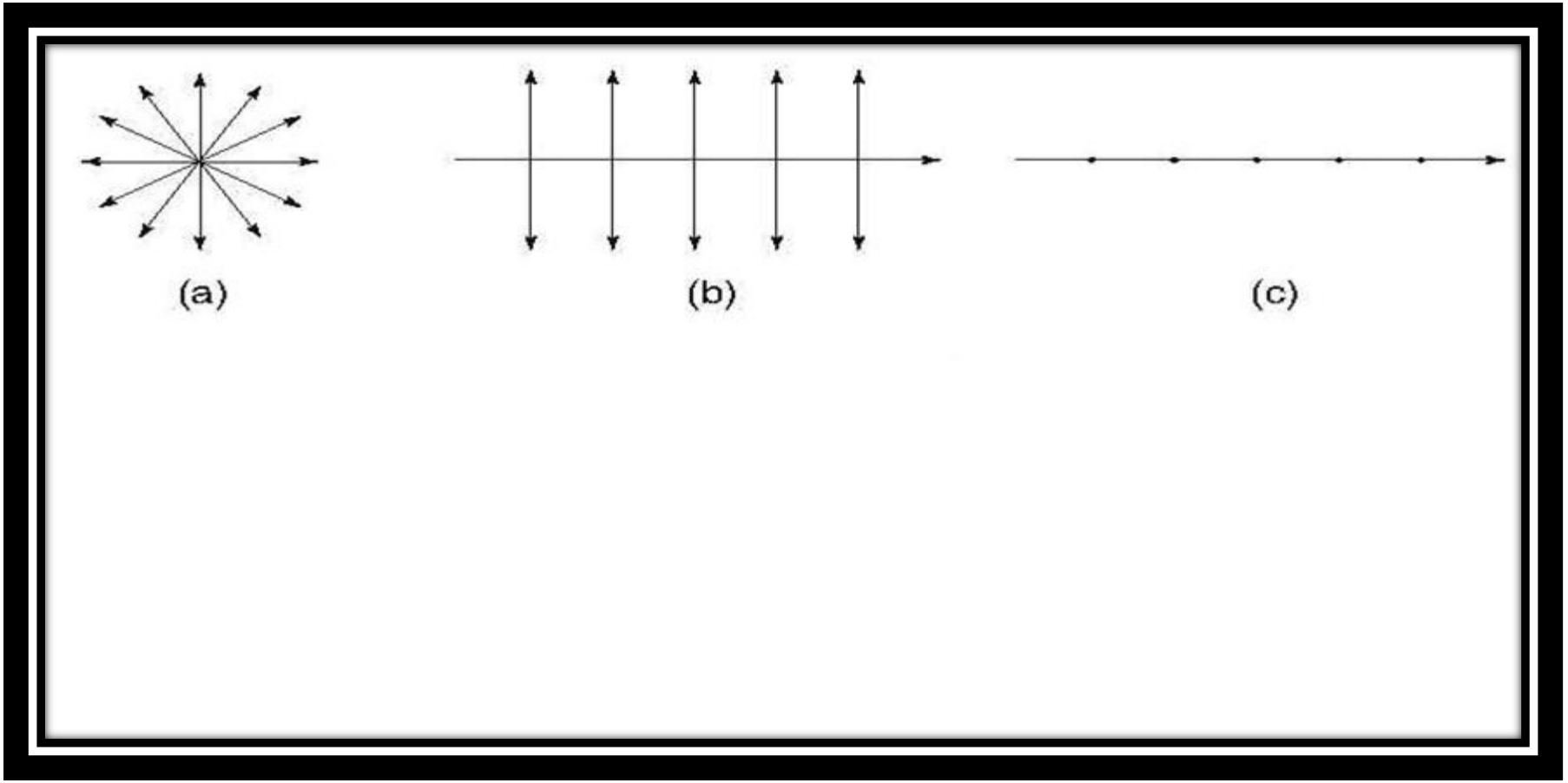
- However, in circularly polarised light and elliptically polarised light, the direction of vibrations may rotate as the wave propagates. Circularly polarised light can rotate rightward or leftward in the direction of wave propagation.
- Which of these two rotations is present in a wave is called the wave's chirality. Chirality is a Greek word which means handedness.
- This is a property of asymmetry which is significantly useful in several branches of science.

# POLARISATION



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## Plane of Polarization and Plane of Vibration

- As discussed earlier, the electric field and magnetic field vectors of the light waves are perpendicular to each other and to the direction of propagation of the wave.
- As per convention, the direction of electric field vector E is taken as the direction of polarization of the wave.
- In view of this, the plane determined by the electric vector E and the direction of wave propagation (vector k), is called the plane of polarization, particularly for the plane (linearly) polarized light.
- This term is sometimes applied to the plane at right angles to this, i.e. to the plane containing the magnetic field vector.

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- Then the plane containing the electric vector E and wave vector k is named as the plane of vibration.
- However, in a plane electromagnetic wave with elliptic polarisation and circular polarisation, the electric field vector E has components (out of phase) in both the directions perpendicular to k. So the plane that contains only vibrations of E field can be called as the plane of polarisation.
- Hence, the plane of vibration and the plane of polarisation will be the same in this case

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## Plane of Polarisation and Plane of Vibration

- Polarisation can also take place by the refraction of light, which occurs when a beam of light passes from one material into another material.
- Under this situation, the path of the light beam changes its direction at the surface of the two materials and then the refracted beam acquires some degree of polarisation.
- Mostly, the polarisation occurs in a plane perpendicular to the surface.
- The light is split into two beams upon entering the crystal and both the refracted light beams are polarised - one in a direction parallel to the surface and the other in a direction perpendicular to the surface.
- Since these two refracted rays are polarised with a perpendicular orientation, a polarising filter can be used to completely stop one of the images.