Answer the following questions. You may consult the supplementary reading material.

1. It is fair to assume that in a multiple slit scenario, all the electric fields originating from different slits have same magnitude. Justify. [Hint: Are the slits all similar or dissimilar?]

2. Should the phasors have same magnitude or different magnitudes? Explain. [Hint: Phasors are related to electric fields at the slits. If slits are identical, what about the electric fields?]

3. In double slit experiment what is the phase difference between two electric fields from two slits? Explain all symbols in the expression for the phase difference.
Supplementary reading.

By now hopefully you have realized that all these different types of interferences are applications of one law that you have learnt eons ago – The superposition principle. Let’s try to understand the situation a little better now.

Before we delve deep into interference with light let’s try to understand interference with sound. A very useful concept to understand interference is the concept of “phasor” and “phasor diagram”. Say you have two sources of sound (S1 and S2). You are standing at point P. The sound waves generated from S1 and S2 (that are denoted by y₁ and y₂) are going to interfere with each other at point P. Note, sound wave consists of a repeating pattern of high-pressure and low-pressure regions moving through a medium and for that reason it is sometimes referred to as a pressure wave. When two waves interfere at a point we are supposed to add them to get the resultant wave. If we assume that both the sound sources are identical, the value of the waves (i.e. the value of change in air-pressure caused by sound from S1 and S2) at S1 and S2 respectively are also identical. But as the waves propagate to point P the values of the waves change according to the acquired phase (which in turn depends on the path lengths S1P and S2P). We introduce an abstract vector called a “phasor” (short for “phase vector”) whose x-component is the value of the wave (at the point where we are trying to study the interference) from an individual source (say S1) and the angle between the “phasor” and the x-axis is the phase acquired. We can come up with another phasor at point P corresponding to S2. Thus to add the waves at P taking into consideration the phases, all we need to do is to add the phasors corresponding to S1 and S2. Note that sound is a scalar wave (pressure is a scalar not a vector). The description of a wave by a phasor is unrelated to the amplitude being a vector (as in light), since it is also applicable to scalar waves such as sound.

Now let’s try to apply the same concept to interference caused by light from several sources. Interference for light involves putting light rays from different slits together (another word for “putting together” is “superposition”). We also have learnt from the Huygen’s principle (recall Workshop: 2, PART: II) that each slit in an interference experiment behaves as a coherent secondary source of the incident wave. From last semester on the other hand we have learnt that each source for electromagnetic wave (e.g. light) gives rise to oscillating electric and magnetic field. These electric and magnetic fields propagate from the slit to the screen. So when we say “we are putting light rays from different slits together”, what we really mean is that we are adding electric fields from different sources. Recall there is a nice relation between electric and magnetic field that originate from the same source. Thus If we know how to add electric fields we are all set. Instead of adding actual electric fields we make up a bunch of fictitious vectors (named as “phase-vectors” or “phasors”) that are related to the original electric field vectors. When these fictitious vectors are added, the magnitude of the resultant vector is proportional to the magnitude of the actual electric field at the point of the screen where we are looking.
Let’s recapitulate once again how to add multiple vectors.

*Addition of Vectors:* If a number of vectors can be represented both in magnitude and direction by the sides of an open convex polygon taken in the same order, then the resultant is represented completely in magnitude and direction by the closing side of the polygon, taken in the opposite order.

In the picture $\vec{R} = \vec{P} + \vec{Q} + \vec{S} + \vec{T}$.

A nice by-product of the above law is that if a number of vectors form a closed polygon, the resultant of all such vectors is equal to the null vector that has zero magnitude.

Thus in interference or in diffraction (diffraction is nothing but interference from infinite sources) all we do is add phasors (that are related to electric fields). We don’t want to write a bunch of math. So we draw pictures. To make these pictures seem important, we have given them a special name – “Phasor Diagrams”.

It is fair to assume that in a multiple slit scenario, all the electric fields originating from different slits have the same magnitude, since all the slits are identical. Thus it is only logical to draw the phasors in a way such that all of them have the same magnitude. What about direction? There is a phase difference between two electric fields from two consecutive slits, which can be written as $\phi = \frac{2nd}{\lambda} \sin \theta$ (see Fig: IB). Thus in a Phasor Diagram we draw the phasors related to consecutive electric fields from consecutive slits in a way such that the magnitudes of all the phasors are the same and the angles between two consecutive phasors are the respective phase differences. Finally we invoke the polygon law to find out the resultant phasor. The magnitude of the phasor at a particular point gives the amplitude of the electric field at that point. The square of the magnitude of the resultant phasor tells us about all the intensity ($I \propto |\vec{E}|^2$).