We don't *need* to use complex variables/complex notation to realize that whenever the path length difference $\Delta r \equiv r_2 - r_1 = n\lambda$, where n = 0, ±1, ±2, ±3, ±4, … and $\lambda = v/f$ where v = speed of sound in air (~ 343 *m/s* @ NTP), constructive interference will occur – the two individual sound waves are precisely in-phase with each other at the observation point *P*, thus sound intensity maxima will be heard at such locations, whereas whenever the path length difference $\Delta r \equiv r_2 - r_1 = n'\lambda/2$, where n' = ±1, ±3, ±5, ±7, … destructive interference will occur – the two individual sound waves are precisely 180^o out-of-phase with each other at the observation point *P* – thus intensity minima will be heard at such locations.

Acoustical Interference Phenomena

Whenever two (or more) periodic sine-wave type signals are linearly superposed (*i.e.* added together), the resultant/overall waveform depends on the ***amplitude***, ***frequency*** **.and.** ***phase*** associated with the ***individual*** signals. Mathematically, this is often most easily and transparently described using complex notation.

Basics of / A Primer on Complex Variables and Complex Notation:

We can use complex variables/complex notation to describe physics situations whenever *relative* phase information is important. A complex quantity, denoted as $\tilde{Z}$ consists of two components: $\tilde{Z} = X + iY$. X is the known as the "*real*" part of $\tilde{Z}$, denoted $X = \text{Re}\{\tilde{Z}\}$ and Y is the known as the "*imaginary*" part of $\tilde{Z}$, denoted $Y = \text{Im}\{\tilde{Z}\}$. If a *reference* signal is present, the real component $X = \text{Re}\{\tilde{Z}\}$ of complex $\tilde{Z}$ is in-phase (180^o out-of phase) with the reference signal if X is +*ve* (–*ve*), respectively. The imaginary component $Y = \text{Im}\{\tilde{Z}\}$ of complex $\tilde{Z}$ is +90^o (–90^o) out-of-phase with the reference signal if Y is +*ve* (–*ve*), respectively.

The number $i \equiv \sqrt{-1}$. The magnitude of the complex variable $\tilde{Z}$ is denoted as $|\tilde{Z}| \equiv \sqrt{\tilde{Z}\tilde{Z}^*}$ or $|\tilde{Z}|^2 \equiv \tilde{Z}\tilde{Z}^*$ where $\tilde{Z}^*$ is the so-called complex *conjugate* of $\tilde{Z}$, which changes $i \to -i$, such that $i \cdot i^* = \sqrt{-1} \cdot -\sqrt{-1} = +1$ (note that $i^2 = -1 = (i^*)^2$ and $i \cdot i^* = i^* \cdot i = +1$), thus we see that:
$\tilde{Z}^* = (\tilde{Z})^* = (X + iY)^* = X - iY$. Hence we see that:
$|\tilde{Z}| \equiv \sqrt{\tilde{Z}\tilde{Z}^*} = \sqrt{(X + iY)(X - iY)} = \sqrt{X^2 + i\cancel{XY} - i\cancel{XY} + Y^2} = \sqrt{X^2 + Y^2}$. Thus, we realize that the magnitude of $\tilde{Z}$, $|\tilde{Z}|$ is analogous to the hypotenuse, c of a right triangle ($c^2 = a^2 + b^2$) and/or *e.g.* the radius of a circle, r centered at the origin ($r^2 = x^2 + y^2$).

Because complex variables $\tilde{Z} = X + iY$ consist of two components, $\tilde{Z}$ can be graphically depicted as a 2-component "vector" (*aka* "phasor") $\tilde{Z} = (X, Y)$ lying in the so-called 2-D complex plane, as shown in the figure below.