# Resonance & Volume II

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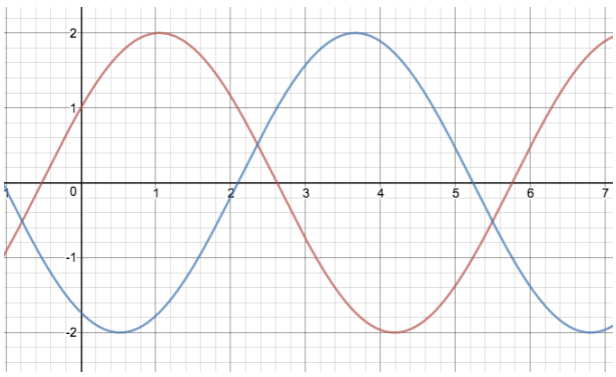
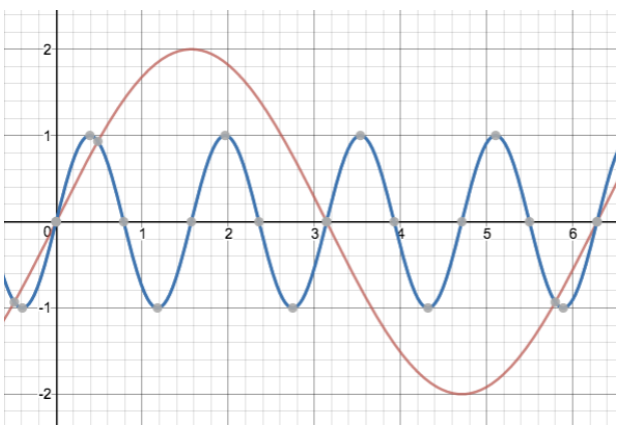
## I. Wave-Interference in 1D

Each of the graphs below shows two waves that are traveling on the SAME piece of string (or, maybe, column of air). The x-axis is horizontal position. The y-axis is vertical position (or maybe pressure). For each pair (A and B), draw the (approximate) waveform resulting from their interference.

A.




B.




Check your work by playing around on desmos. Go to desmos.com and enter a sine or cosine function. Try y = 2sin(x).

Go to the next line down and enter another sine or cosine function with different parameters. Try y = sin(4x).

Go another line down and enter the sum of these two functions. For example, y = 2sin(x) + sin(4x). This third function will give you the resulting waveform from the interference of the first two.

## I. Wave-Interference in 2D

Two speakers are placed 5 m apart. Both play an identical 440 hz tone at the same volume, in phase with each other. Assume that the speed of sound in air is 340 m/s.

Find the two point-locations closest to the midpoint between the speakers at which a tiny microphone could be placed and perpetually pick up (detect, measure) nothing but silence.

i.e.: Find the *nodal* locations nearest to the *central antinode*.

## II. Energy, Power, Intensity, & Volume.

A. The master volume knob at a P-Funk concert is turned up: as a result, the intensity of sound waves, measured in Watts/$m^2$, increases by a factor of 10,000.

   *By how many decibels does the sound increase?*

B. A microphone measures a sound volume of 140 dB at a distance of 10 m from a cloud that is producing a thunder clap.

   *i.* *In **Watts/$m^2$**, what is the **intensity** of the sound at this location?*

   *ii.* Assume that the thunderclap is isotropic: i.e. the wave is of equal intensity in all directions from the source.

   Imagine a spherical shell surrounding the sound source at a distance of 10 m. Assume for convenience that the sound source is a *point*. So the sphere has a radius of 10m, with the sound source at its center. Since the sound is isotropic, all points on this sphere will experience the same sound intensity.

   *In **watts**, what is the total sound-wave **power** passing through this sphere during the thunderclap?*

   **Hint:** Surface area of a sphere = $4\pi r^2$

   *iii.* Now imagine a spherical shell of r = 200 m surrounding the sound source.

   *How much sound-wave **power** passes through this shell in a given minute?*

   *iv.* Assume that the thunderclap lasts for 10 seconds. Assume that, during this time, the intensity/power/energy of sound output is essentially constant.

   *How much total sound-wave **energy** passes through through the 200-m shell shell from the entire thunder-clap?*

   *v.* *What is the sound intensity at a randomly-chosen point on the 200-m shell during the thunderclap?*