

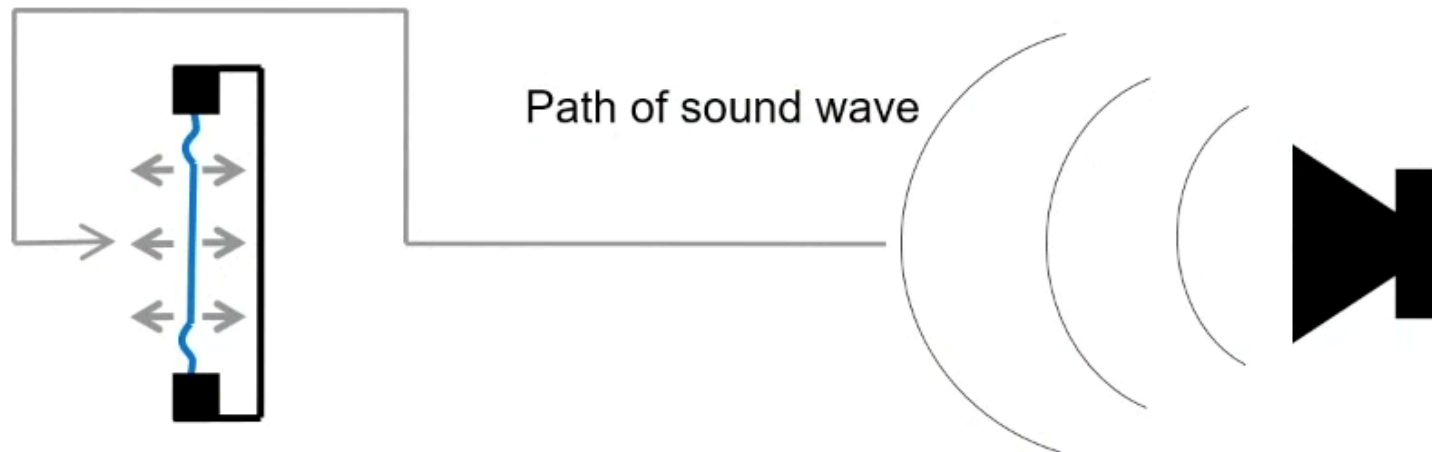
Polar Pattern and Directionality

Omni-directional Response

When sound is prevented from reaching the rear side of the diaphragm, the force acting on the diaphragm is the same regardless of sound source orientation.

Diaphragm response is *Omnidirectional*

Sound source at **180°** to diaphragm



*Force acts only on front side of diaphragm!

Directivity of the sound can be recreated by bending the laws of physics.

In order to make a Microphone to be more sensitive to sounds from one direction vs sounds from another direction, we use

‘The Phase Shift Network’

- Increase of the distance the sound has to travel arriving to the back
- Use of absorption materials to generate attenuation
- Delay or Phase Shift between the signals at the Front & Rear of the Diaphragm - causing the frontal sound to have a stronger signal

Pressure and Force On Diaphragm

- What if sound can access both the front and rear of diaphragm???
- Now there's force on the front and rear of the diaphragm.
- The *net* force causes the diaphragm to move.

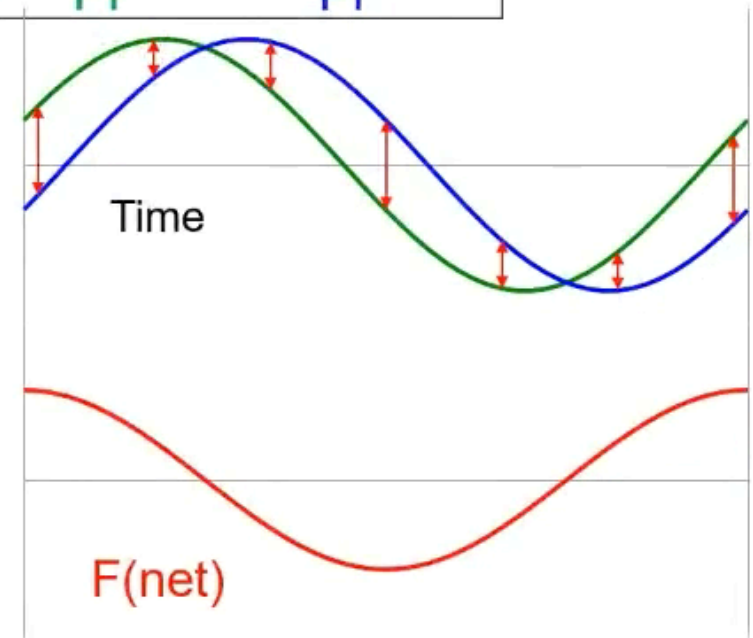
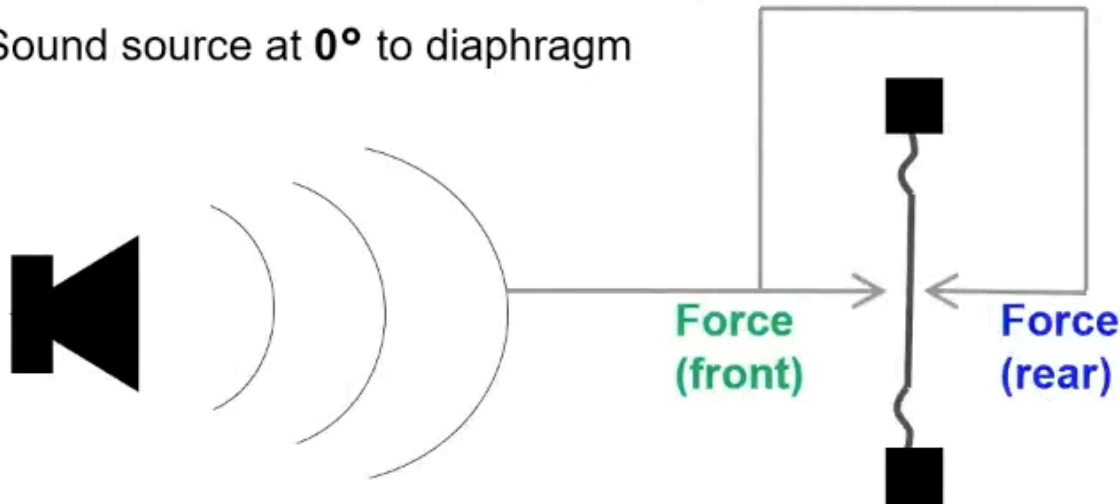
$$\text{Force}(\text{net}) = \text{Force}(\text{front}) - \text{Force}(\text{rear})$$

F_f

F_r

Sound source at 0° to diaphragm

*Time delay due to longer path length to rear

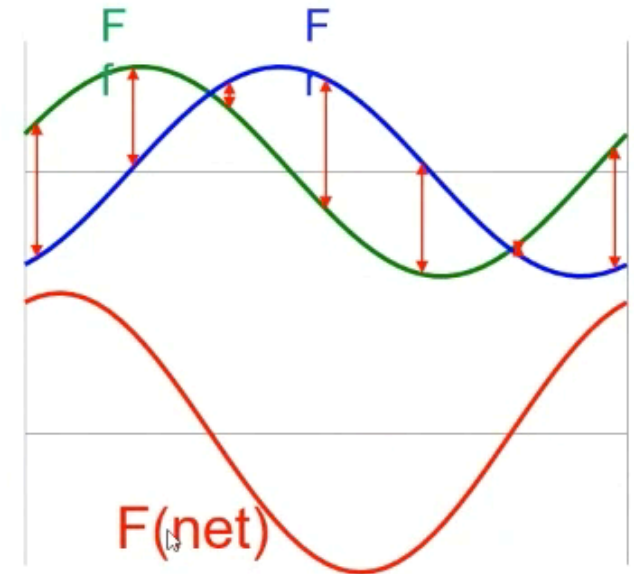
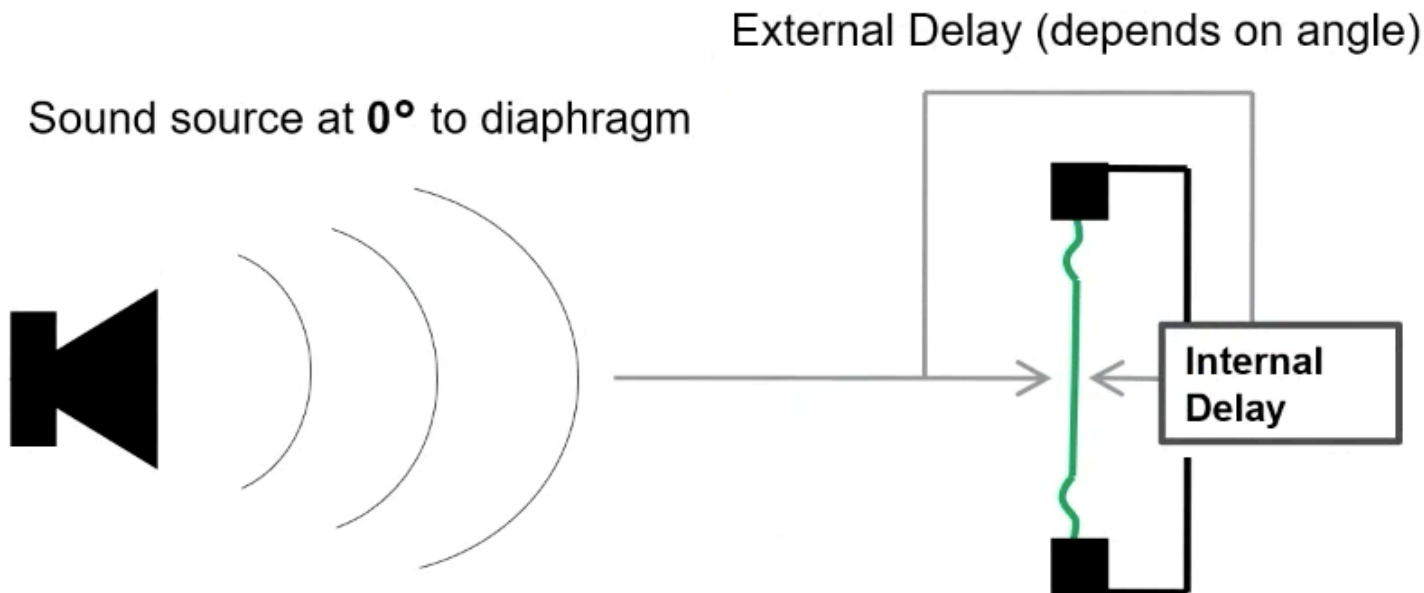


- In order to make the Diaphragm to reject the sound from the back or other directions and respond to the Sound coming from the front
- We need to create a Phase difference either in time or being forced with materials built in to the Microphone
- This is achieved by creating a Window built-in around and behind the Diaphragm
- This Window will allow sounds to come in to the microphone from the back of the Diaphragm
- By creating a Resistance to Sounds inside this window in the back side of the Diaphragm
- It will generate Delay and Cancellations on sounds coming from the back in relation to sounds coming from the front



Uni Directionality

- Now, what if we want the diaphragm to favor sound coming from *one* direction?
- We add a fixed *internal* time delay (also called a phase shift network)

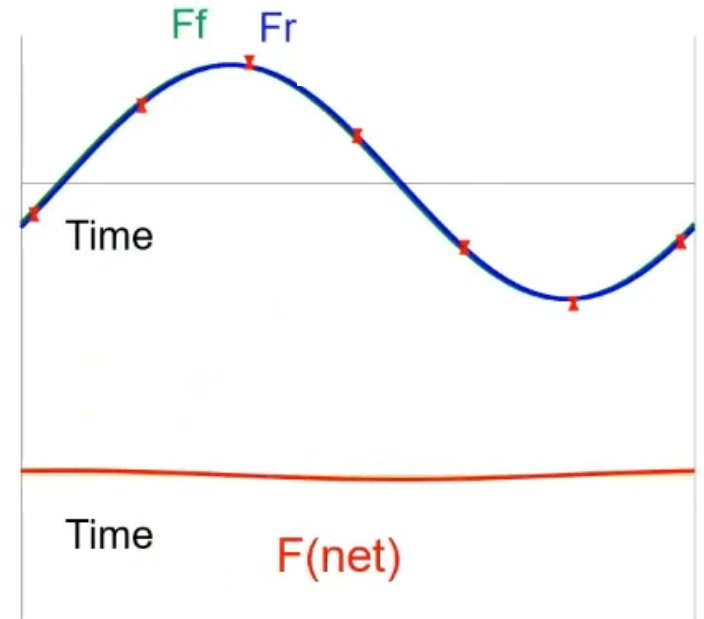


Internal delay is always the same regardless of sound source angle

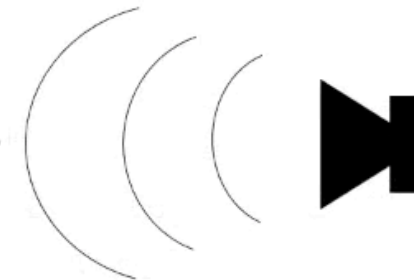
Cardioid

- Let's look at the 180° response.
- What if external delay = internal delay?
- Sound arrives at both sides of the diaphragm at the same time.

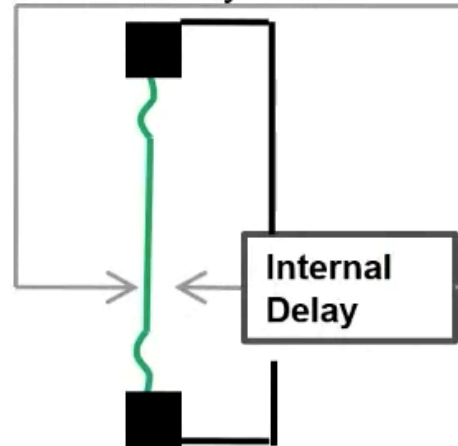
Remember: **Force(net)** = **Force(front)** - **Force(rear)**



Sound source at 180° to diaphragm



External delay = internal delay



$F(\text{front}) = F(\text{rear})$
 $F(\text{net}) = 0$

No force on diaphragm
 No movement
No output!

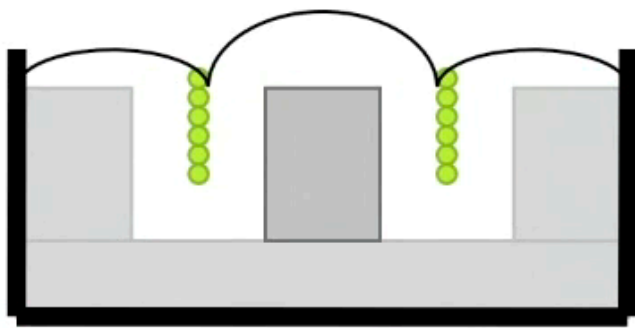
If both sounds are applying equal force on the front and back of the Diaphragm, it will not move!

In order for Microphone Diaphragm to move and respond to sounds

We need to subtract the Sounds coming to the back from the Sounds coming from the front of the Diaphragm

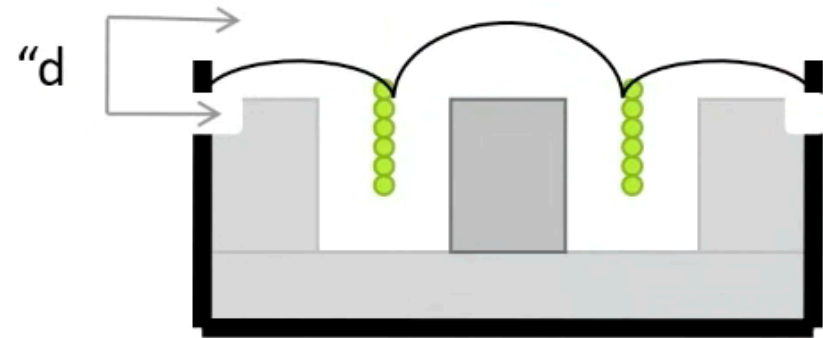
Creating A Directional Microphone Rear Entry Ports

- The opening shown on the Unidirectional Diaphragm ("d), allows the sound to come from the back side of the microphone
- As mentioned previously, we need to create a time difference and attenuation to achieve cancellations on the sounds arriving to the back



Omnidirectional

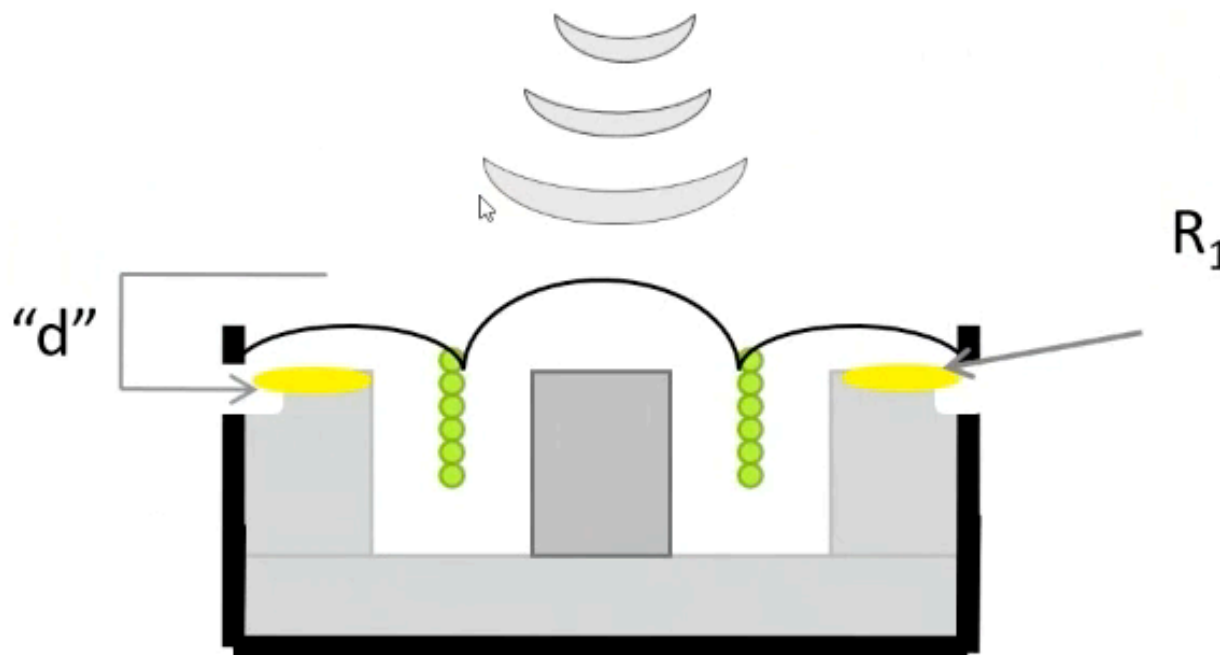
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Unidirectional

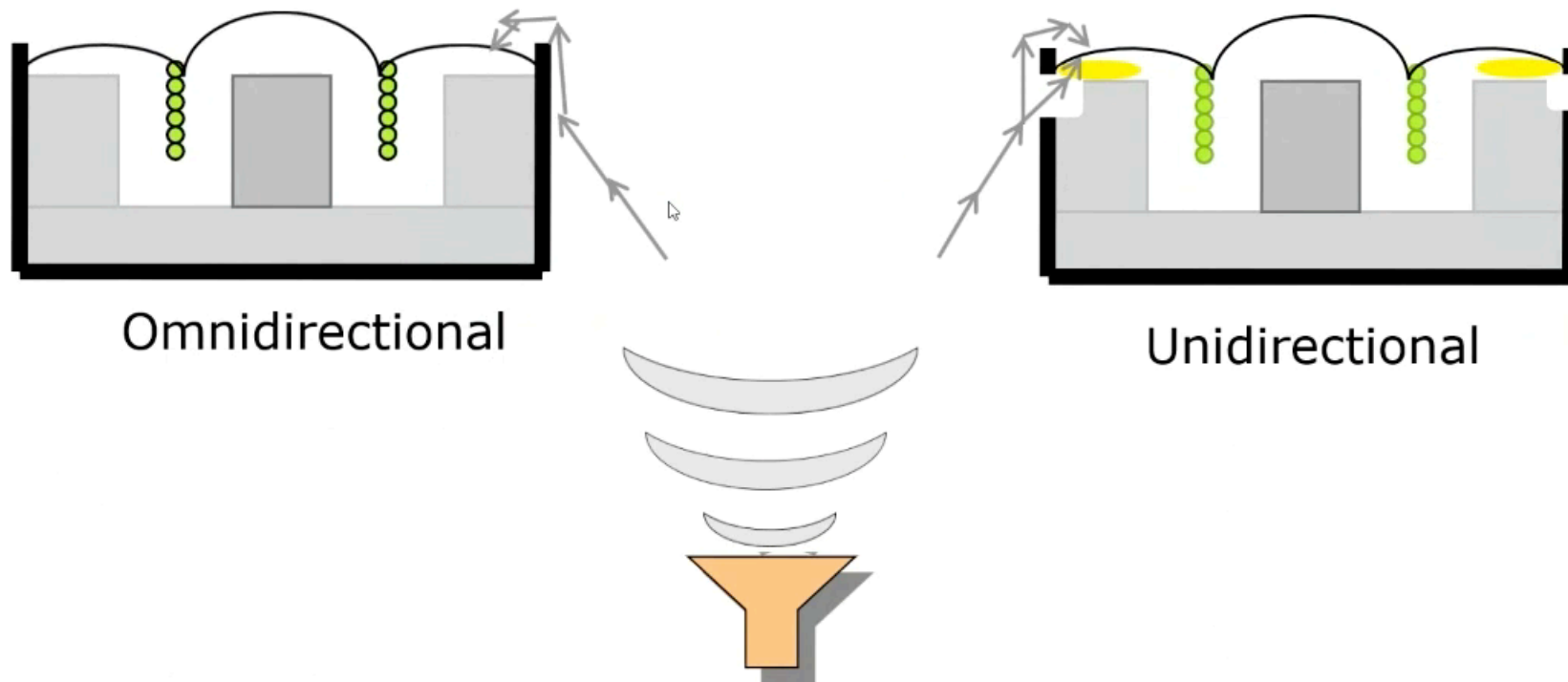
Creating A Directional Microphone Rear Entry Ports

- This is achieved by placing a Resistance (R_1), meaning using a material built-in on the opening (window) that has resistance to sounds
- R_1 will help to delay the sound by being an obstacle
- When Sounds are coming from the back, they have to overcome this obstacle causing a delay



Creating A Directional Microphone Rear Entry Ports

Sounds coming from the back will reach equally the Omnidirectional microphone, whereas with the Cardioid they will be delayed, attenuated and cancelled



Directionality Summary

- Ensuring polar patterns are consistent is difficult
- Counterfeit mics struggle with polar patterns most

Pressure Microphones

- Sample pressure at a single point (front of diaphragm)
- Omni-directional response
- Sound entry to front side of diaphragm only

Pressure Gradient Microphones

- Measure the difference in pressure between two closely spaced points
- Have sound entries to back side of diaphragm
- Exhibit proximity effect
- Exhibit directional response characteristics
 - Cardioid, Super-cardioid, Etc...