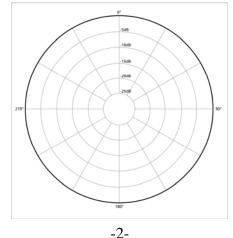
When an over-pressure $\tilde{p}(\vec{r},t) = \tilde{p}_o(\vec{r})e^{i\omega t}$ is present at the diaphragm of the microphone, located at the listener point \vec{r} , if the characteristic size of the microphone -e.g. the radius of the microphone diaphragm $a_{dia} \ll \lambda$, the variation of the over-pressure amplitude $\tilde{p}_o(\vec{r})$ over the surface of the microphone diaphragm is ~ negligible, *i.e.* $\tilde{p}_o(\vec{r}) \simeq \tilde{p}_o$ for $a_{dia} \ll \lambda$. The {net} force acting on the diaphragm {+ coil} of mass m_{dia} is $\vec{F}(t) = \int_{A_{dia}} -\tilde{p}(\vec{r},t) d\vec{a} \simeq -\tilde{p}_o \vec{A}_{dia} e^{i\omega t} (N)$ {where $\vec{A}_{dia} = A_{dia}\hat{n}$ and \hat{n} is the outward-pointing normal to the diaphragm} , accelerating it {by Newton's 2^{nd} law: $\vec{F}(t) = m_{dia}\vec{a}_{dia}(t)$ if no other forces acting on the diaphragm are present - which, in general, there are – see Appendix to these lecture notes...} thereby causing it to vibrate/oscillate, which in turn induces a voltage signal in the coil due to the time rate of change of magnetic flux $\tilde{\Phi}_m(t) = \vec{B}(t) \cdot \vec{A}_{coil}$ threading the coil as it vibrates along its axis. The induced *EMF* in the coil of the dynamic microphone is: $\tilde{\varepsilon}_{coil}(t) = -N_{coil} d\tilde{\Phi}_m(t)/dt = -N_{coil} (d\vec{B}(t)/dt) \cdot \vec{A}_{coil}$ (Volts).

Note that the basic physics of how a dynamic microphone works is simply the time-reversed physics of how a dynamic loudspeaker works – arising from the manifest time-reversal invariant nature of the *EM* interaction at the microscopic level!

Because of the need to attach a coil (usually copper wire) to the diaphragm, the diaphragm + coil assembly of a dynamic microphone is considerably heavier than the pressure-sensitive elements associated *e.g.* with condenser microphones. Thus, dynamic microphones often do not have as flat a frequency and phase response as condenser microphones for this (and other) reason(s) – hence dynamic microphones are not often thought of as "research/lab-grade" quality... However, the intrinsic output impedance of dynamic microphones is (relatively speaking) quite low (the industry standard is 600 Ω) which is very appealing *e.g.* for use in live performances of music, from the {important} perspective of noise immunity...

If the microphone element is completely <u>sealed</u> (as in the above figure), the over-pressure sensed by the device is the instantaneous <u>difference</u> between pressure on the front vs. back side of the diaphragm. This is an <u>omni-directional</u> microphone – for frequencies f with wavelengths $\lambda = v/f$ that are <u>large</u> in comparison the physical size a_{dia} of the microphone, it responds uniformly to sound coming from any/all directions, as shown in the polar plot below:



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