**[11:00-11:10] Review of tune-up exercise and review from last lecture**

Plotting a sinusoid in MATLAB may not produce a smooth plot. Increasing the sampling rate can help. When the sampling rates are low, discrete-time plots of sinusoids can be hard to recognize as sinusoids.

A time shift of a sinusoid results in a phase shift. We can calculate the phase shift from the time shift exactly, and we can use phase unwrapping algorithms to estimate the time shift from the phase shift.

The time shift/phase shift of a wave propagating through space can be used for navigation and ranging, including radio navigation and ranging (RADAR), and sound navigation and ranging (SONAR).

**[11:10-11:20] Sound frequency and wavelength**

The lowest audible sound is about 20 Hz. However, it is very difficult to produce a pure 20 Hz sinusoid, since it would require a large and powerful subwoofer.

Wavelength (, in meters) is related to frequency , in Hertz) by the speed of the wave (, in meters per second):

Speed of sound in air: 340 m/s

Speed of sound in water: 1500 m/s

Speed of light/radio waves: 3

To produce larger wavelengths, you need loudspeaker or antenna whose size is proportional to the wavelength. Example:

To reproduce a sampled signal, we require the sampling rate

**[11:20-] Sampling**

Many signals are initially measured as continuous signals (e.g. sound converted from continuous pressure signal to a continuous voltage signal via transducer)

Sampling a continuous signal at equally spaced intervals in time produces a discrete time signal:

Example: sampling a sinusoid:

is the discrete time frequency in units of radians per sample.

How small does need to be (or how high does need to be) to for an accurate plot?

A graph of a graph

AI-generated content may be incorrect.

**[11:35] Exponential signals**

A graph of a function

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Complex exponentials are related to sinusoids:

**[11:45-12:15] Signal properties and spectrum representation**

Signals can be defined or described in many ways:

* As a function (e.g. )
* As a sequence of numbers
* By its properties (e.g. symmetric)
* As a piecewise combination of other signals

Signals can be represented spectrally as a combination of sinusoids:

Where is a real-valued and and

Example (slide 1-16)

|  |  |  |  |
| --- | --- | --- | --- |
|  | 0 |  |  |
|  | 1 |  | 0 |
|  | 440 Hz |  | 880 Hz |
|  | 0 |  | 0 |

|  |  |  |  |
| --- | --- | --- | --- |
|  | ½ |  |  |
|  | 1 |  | 0.5 |
|  | 440 Hz |  | 880 Hz |
|  | 0 |  | 0 |

Two sided spectrum:

Where and

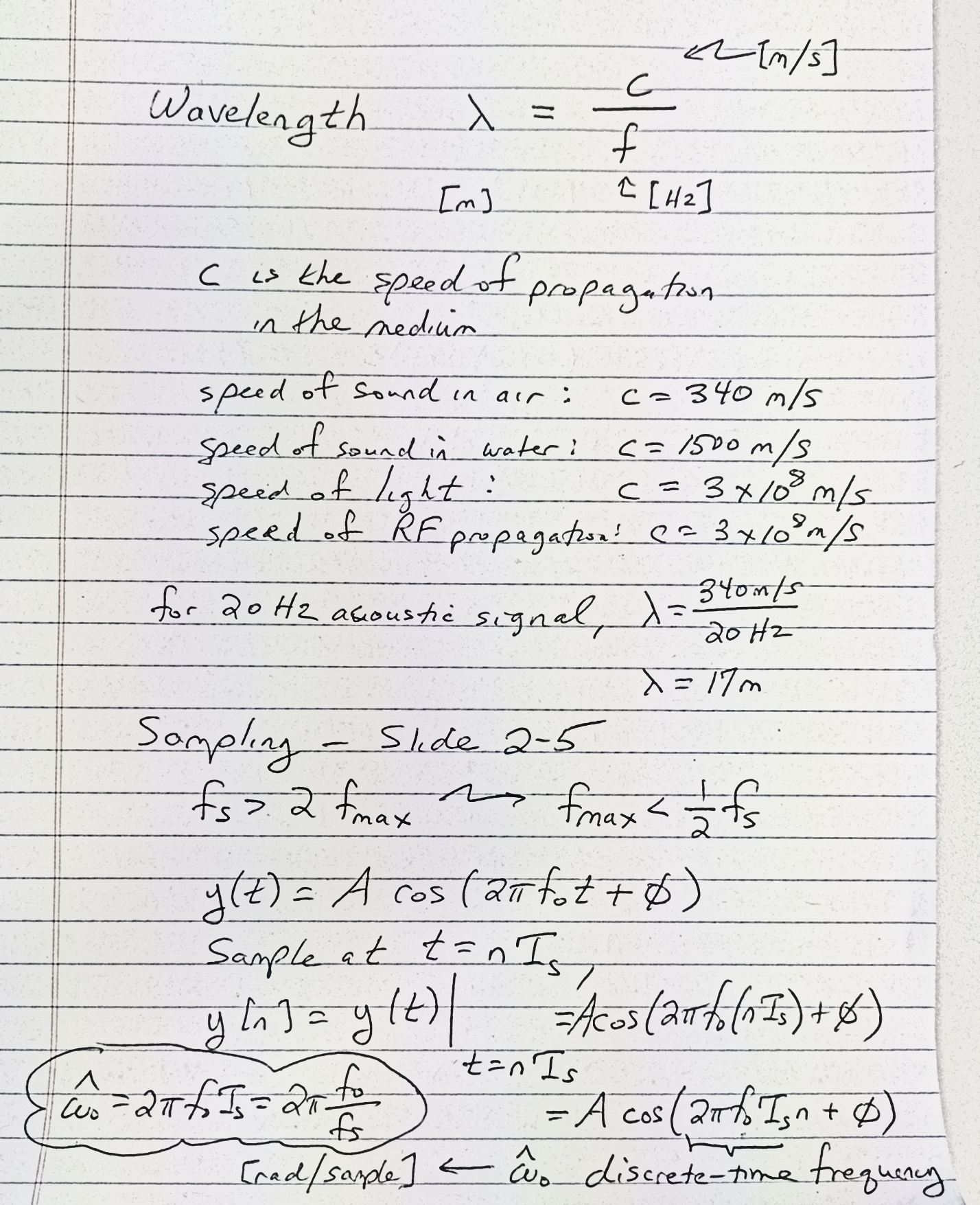
Example:

A graph of mathematical equations

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**[12:15-] Beat Notes**

When two sinusoids are multiplied, the result is two frequencies (sum and difference)

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