Outline

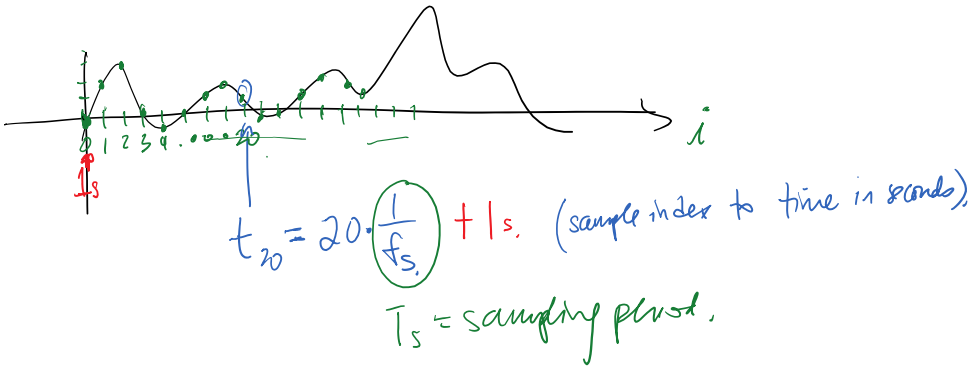
Thursday, March 3, 2022 11:18 PM

- Sampling
- Quantization
- Ensemble averaging
- SNR
- Cross-correlation (phase shifting)
- Discrete Fourier transform (fft)
- Aliasing

ADC - sampling

Monday, March 7, 2022 2:51 PM

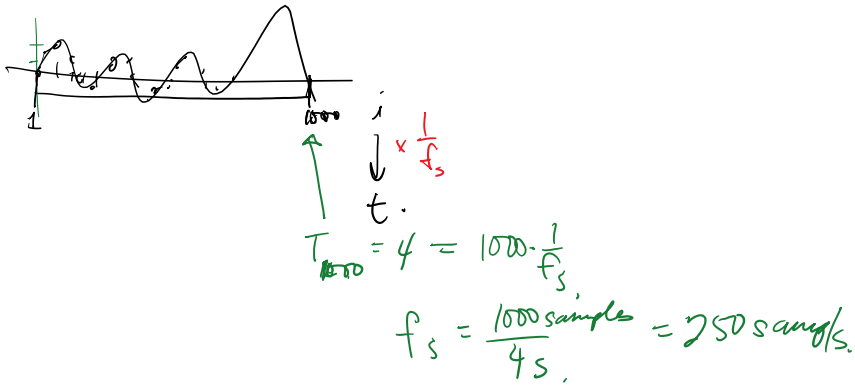
Sampling, quantization



Suppose

Suppose I am given signal x acquired at a sampling rate of fs. What is the sampling rate if I tell you the total duration of x is 4 seconds?

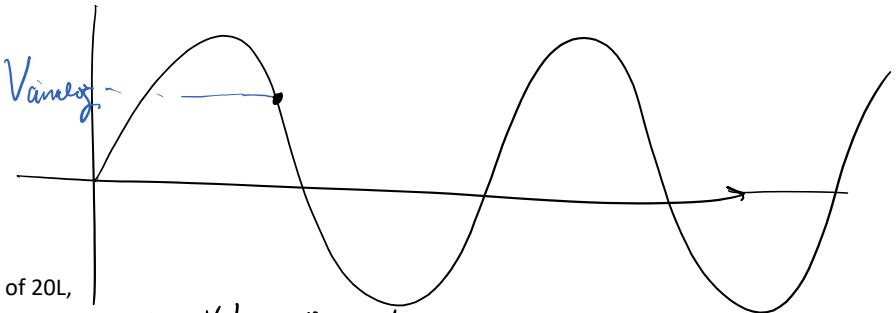
```
>> whos
  Name      Size            Bytes  Class     Attributes

  x         1x1000           8000  double
```



Quantization

Monday, March 7, 2022 3:29 PM

$$\Delta_q \triangleq \frac{V_{max} - V_{min}}{2^N - 1}$$



If I need 500 buckets to fill a bathtub of 20L,
Then each bucket holds $\frac{20L}{500 \text{ buckets}} = 0.04L = 40mL$.

$$D = \left[\frac{V_{analog}}{\Delta_q}\right]$$

round to nearest whole "bucket"

Problem Set 1 Review #16

$$\Delta_q = \frac{1 - (-1)}{2^8 - 1} = 7.8mV$$

$v(t) = \sin(2\pi 5t)$ given in problem.

MATLAB

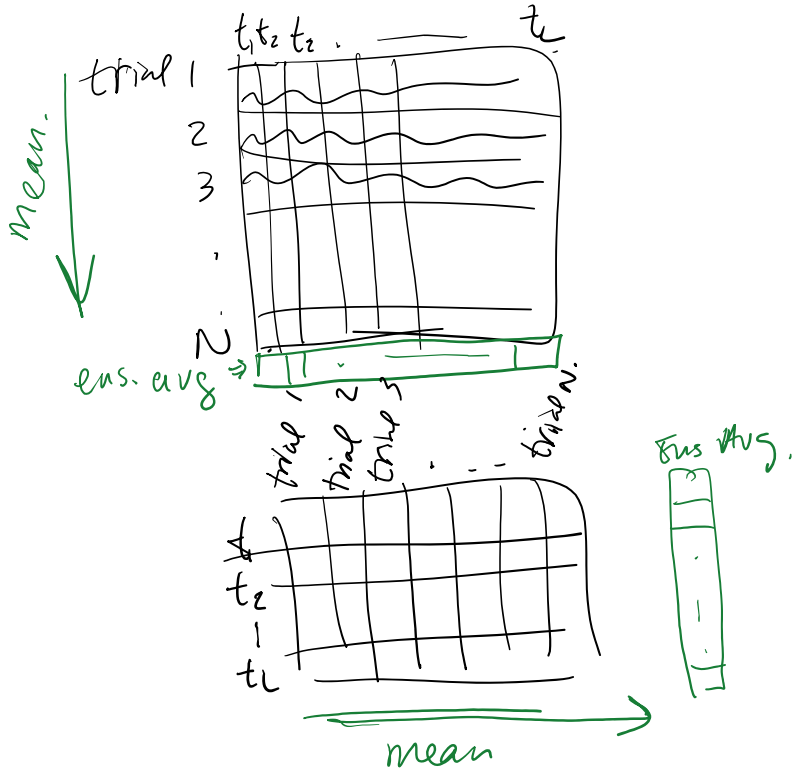
k	i	t_i	$v(t_i)$	D_i
1	0	0	$\sin(2\pi 5 t_i)$	
2	1	$1/f_s$		
3	2	$2/f_s$		
4	3	$3/f_s$	$\sin(2\pi 5(.006)) = 0.1874$	$\left[\frac{0.1874}{0.0078}\right] = 24.$
⋮				

Ensemble avg

Monday, March 7, 2022 2:50 PM

(SNR) = signal to noise ratio

= 20*log10(Vrms, signal / Vrms, noise)



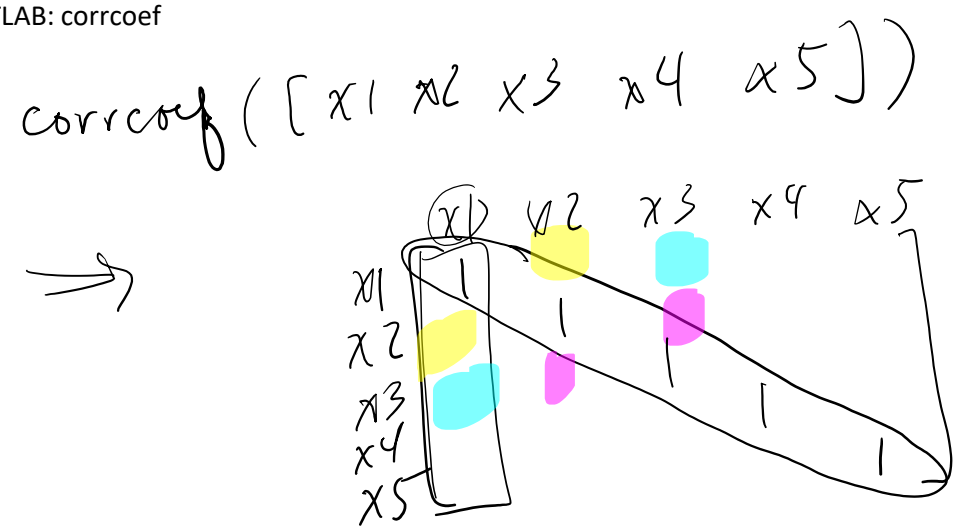
Correlation

Monday, March 7, 2022 2:50 PM

Pearson's correlation coefficient - measures correlation between pairs of signals

And the coefficient is normalized to be between -1 and 1.

In MATLAB: corrcoef



Questions we could answer:

- How similar are two signals with each other?
- How well could one signal estimate or predict another?
- How well does an estimate (from some algorithm) track the actual predicted signal?

Cross-correlation

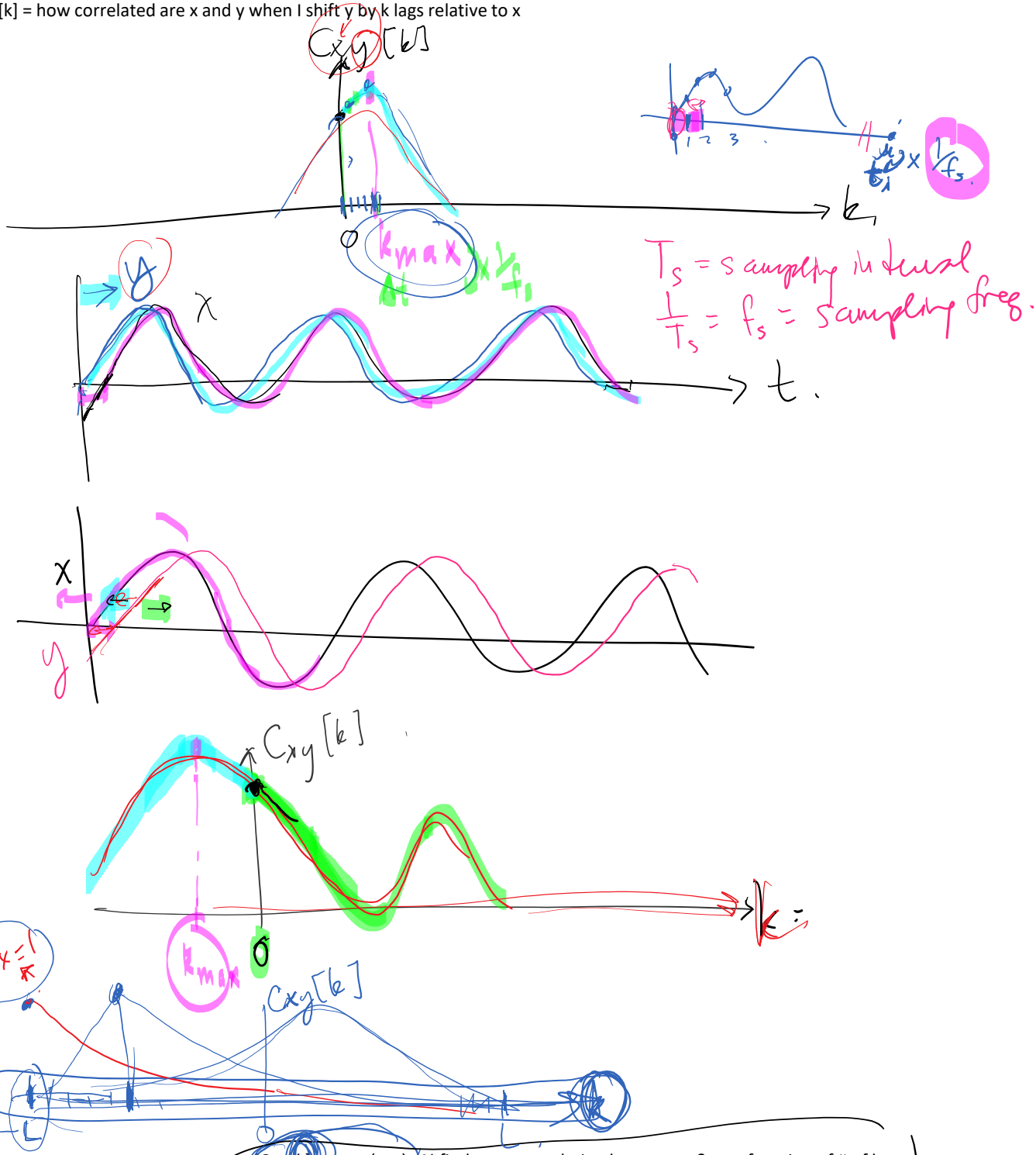
Monday, March 7, 2022 2:51 PM

Not normalized (does not have to be between -1 and 1)

Calculate correlation as the second signal is shifted relative to the first.

Is a function of k, the number of lags, or how many time samples the second signal was shifted

Cxy[k] = how correlated are x and y when I shift y by k lags relative to x



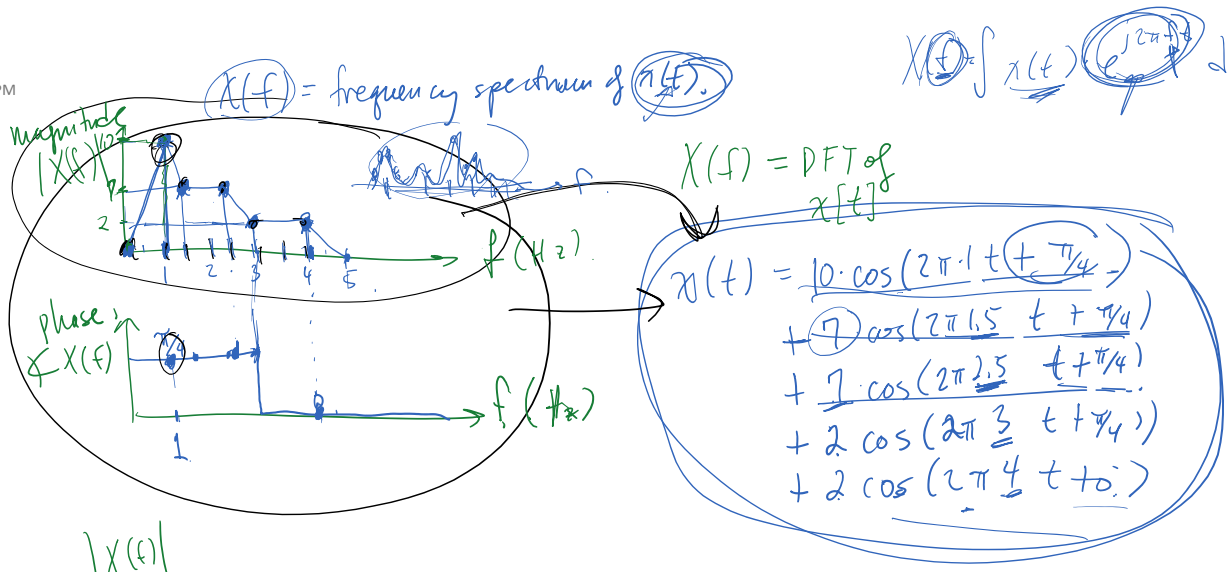

```
[Cxy, k] = xcorr(x, y); % find cross correlation between x & y as function of # of lags
[Cmax, imax]= max(Cxy) % determine at what lag did Cxy reach its max
kmax = k(imax)
```

```
[Cmax, imax]= max(Cxy) % determine at what lag did Cxy reach its max

kmax = k(imax)

Tdelay = kmax / fs % convert the delay in number of lags to delay in seconds
```

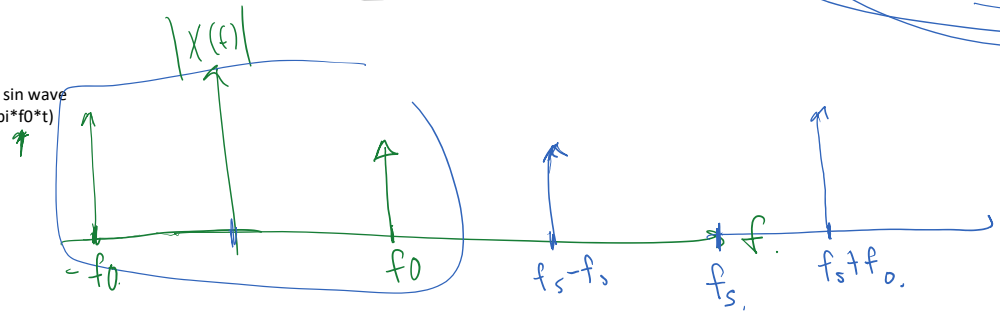
DFT

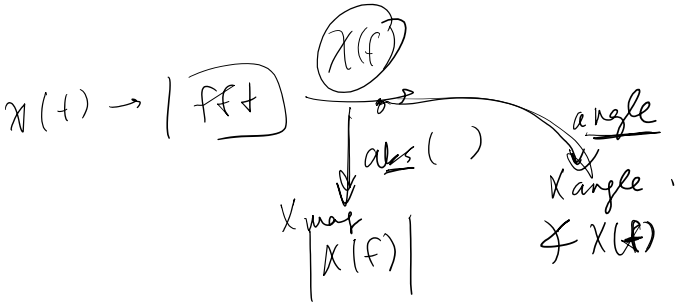
Monday, March 7, 2022 2:50 PM

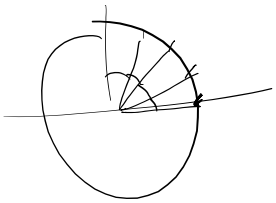
Discrete Fourier transform



Spectrum of sin wave
x(t) = sin(2*pi*f0*t)







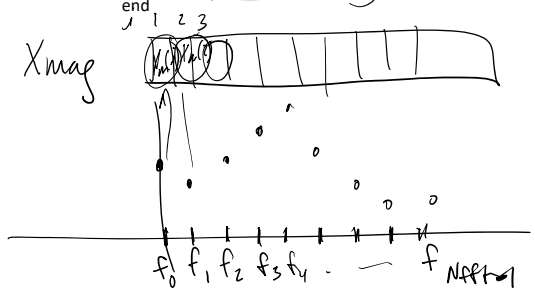
$X_{mag} = [|X(f_1)| \; |X(f_2)| \; \cdots \; |X(f_{Nfft-1})|]$

$f = (f_1 \quad f_2 \quad \cdots \quad f_{Nfft-1})$

$X_{angle} = [\angle X(f_1) \; \angle X(f_2) \; \cdots \; \angle X(f_{Nfft-1})]$

```
Xf = fft(x, Nfft);
Xmag = abs(Xf);  % magnitude
Xangle = unwrap(angle(Xf));
```

```
For i= 1:Nfft,
      Y = y +  Xmag(i)*cos(2*pi*f(i)*t +  Xangle(i))
end
```



Exam 1 a nnouncement

Monday, March 7, 2022 4:25 PM

Wed. 3/9

Allowed 1 side of 1 8.5 x 11" page of notes

You will not be using the computer at all. You will write fill in the blank code	