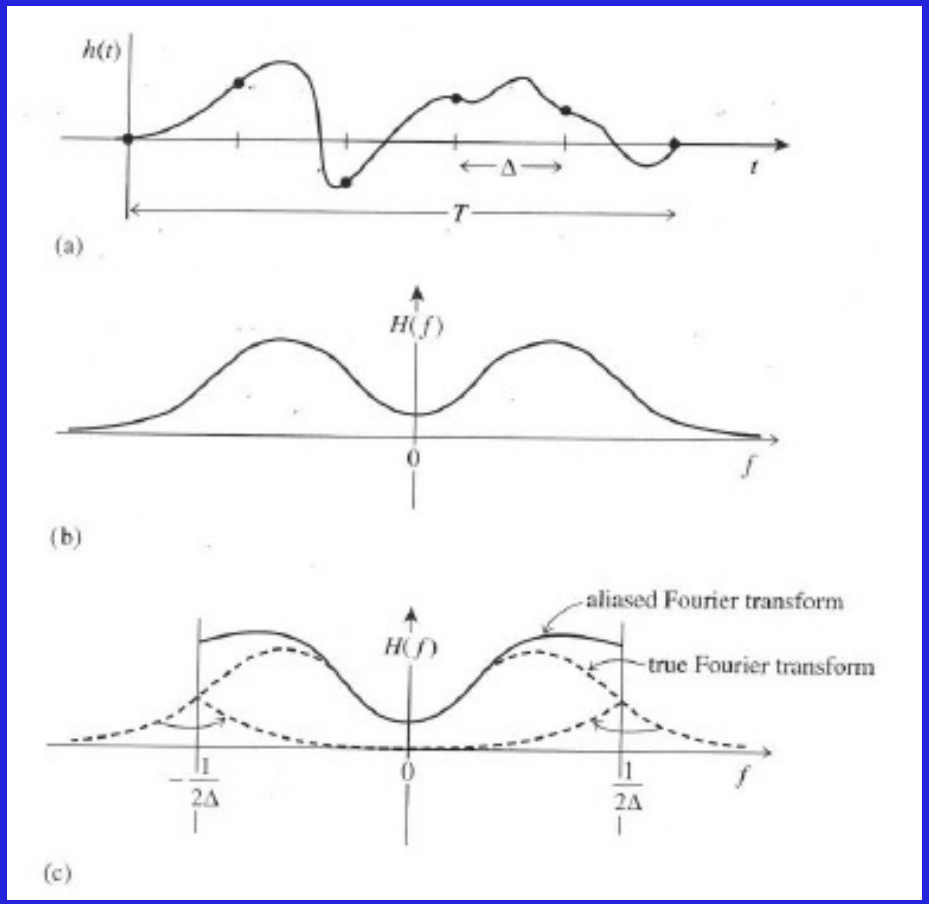
Lecture 22 Review

DFT Review (i.e., significance of H_n).

FFT (+ Nyquist critical frequency)

Sampling Theorem and Aliasing (2)



Limit sampled frequencies to < f_c

Fast Fourier Transform (again)

DFT is slooow. Execution time ∝ N*N.

Compare N = 1000 to N = 5000

Fast Fourier Transform (FFT) to the rescue.

Not a new type of transform, but a new way to calculate FT.

$W \equiv e^{2\pi i/N}$ "twiddle factor"

$$H_n \equiv \sum_{k=0}^{N-1} W^{nk} h_k$$

$$F_k = \sum_{j=0}^{N-1} e^{2\pi ijk/N} f_j$$

$$= \sum_{j=0}^{N/2-1} e^{2\pi i(2j)k/N} f_{2j} + \sum_{j=0}^{N/2-1} e^{2\pi i(2j+1)k/N} f_{2j+1}$$

$$= \sum_{j=0}^{N/2-1} e^{2\pi ijk/(N/2)} f_{2j} + W^k \sum_{j=0}^{N/2-1} e^{2\pi ijk/(N/2)} f_{2j+1}$$

repeat… $= F_k^e + W^k F_k^o$ $0 \le k \le N - 1$

Execution time ∝ N $\log_2$ N

Fast Fourier Transform (2, again)

```
make_fourier_data.cc
gsl_fft.cc
gsl_inv_fft.cc
```

GSL FFT routines store Imag(Hn) differently from DFT
H(k) = H(N-k)* (Not all 2N H(k) numbers independent.)

- Compare DFT output w/ FFT output.
- Compare execution times. DFT v. FFT w/ N = 5000

Octave

Often need to perform calculations quickly (i.e., w/o writing code)

Use `octave` (freeware)

```
prompt> octave
octave:1>
```

Use as caclulator: `2/83`

Standard set of math functions:

cos	cosine
exp	exponential
log	Natural log
log10	Lg base 10
tanh	Hyperbolic tangent
atan	Arc-tangent
round	Round to nearest integer

Colon notation:

```
octave:31>: e= 2:6
octave:31>: f= 2:6:40
```

Semicolon usage:

```
octave:31>: f= 2:6;
```

Octave

Matrix manipulation

```
octave:45> a= [ 1,3;2,7]
```

```
octave:46> a'
octave:47> f = [ 1:6]'
```

Built-in functions for large matrices.

octave:51>: `s = zeros(M,N)` w/ M,N = integers
octave:52>: `r = ones(M,N)`
octave:53>: `rr = linspace(x1,x2,N)`
octave:53>: `r = logspace(x1,x2,N)`

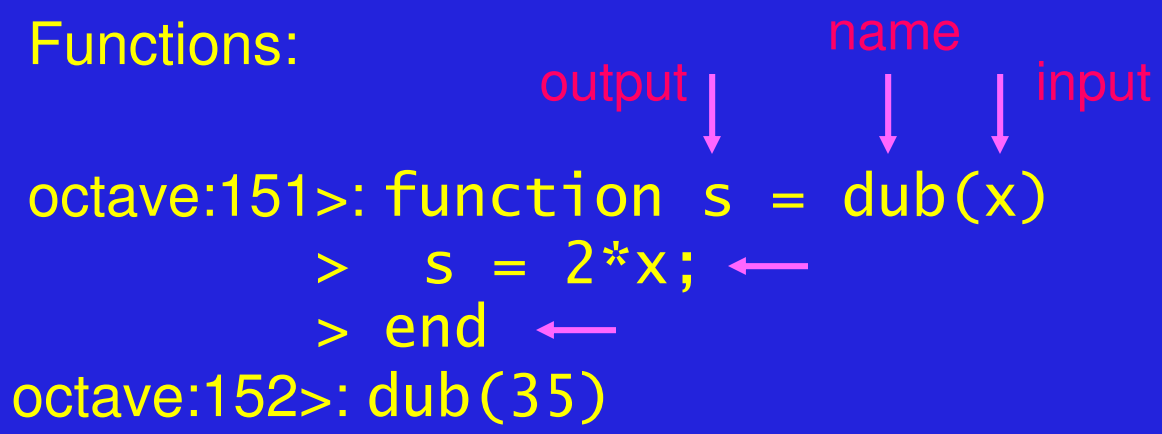
Octave

Plotting: basic command is `plot(x,y)`

uses gnuplot

```
octave:85> angles = [ 0:pi/3:2*pi];
octave:87> y = sin(angles)
octave:88> plot (angles, y)
```

Functions:



Summary

FFT fun.

`octave` introduction

Don’t suffer in silence. Scream for help!!!