ECE- 314
SIGNALS AND SYSTEMS
Summer 2013

INTRODUCTION

- ✓ Basic operations on signals: Review, combining time shifting and time scaling (predecence rule)
- ✓ Elementary signals
- ✓ Properties of Systems

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SIGNALS AND SYSTEMS

- Basic operations on signals: Review
  - DT: Shifting: In x[n], `n` is replaced by `n-m`
  - DT: Scaling: In x[n], `n` is replaced by `k*n`
  - `sin(n)` vs. `sin(n/10)`. Recall that in MATLAB, the argument of the function sin is in radians, not in time → `sin(ω)`

    We can make ω=`n`, but the sinusoid won't look nice

    If we make, say ω =`n/10`, the sinusoid looks nice

    Note that our signal is `x[n] = sin(n/10)`, where n=0,±1±2±3

- Combining time shifting and time scaling:

  $y(t) = x(at-b)$, $y[n] = x[n*k - m]$

  Verification: $y(0) = x(-b)$, $y(b/a) = x(0)$

  `y[0] = x[-m], y[m/k] = x[0]`

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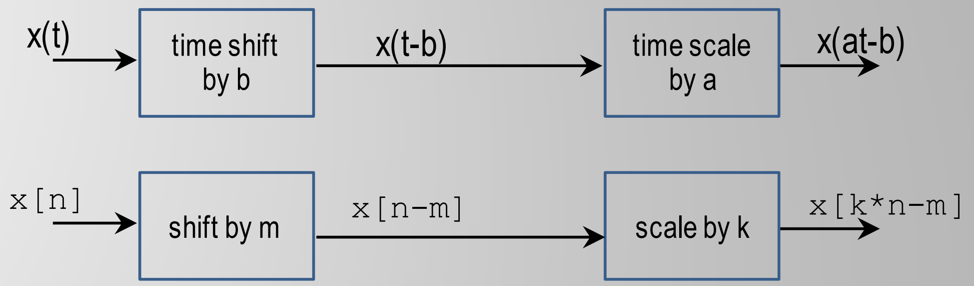
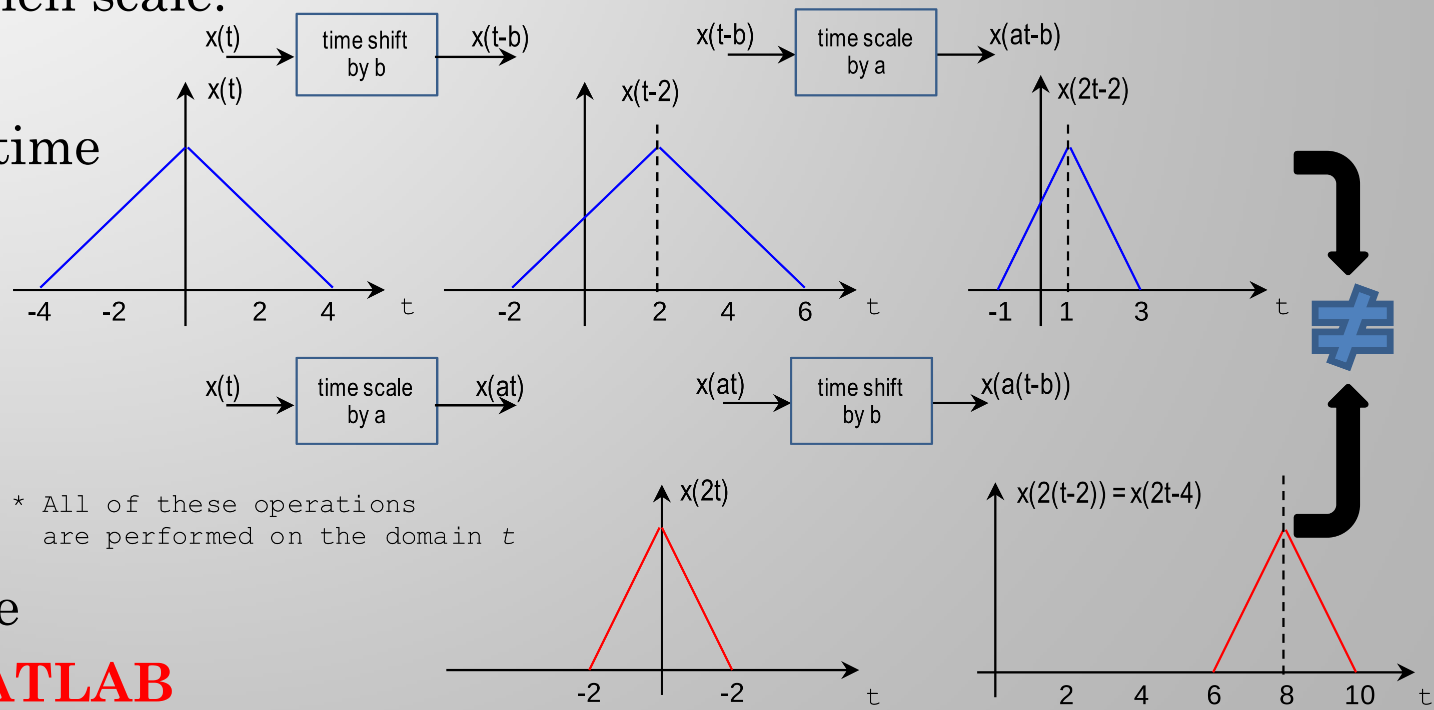
- Combining time shifting and time scaling:

  Precedence rule for time shifting and time scaling: First shift, then scale.



  Continuous-time example:



  Discrete-time example: **MATLAB**

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- About discrete sequences in MATLAB.

  MATLAB does not allow indices lower than 1!

  Example: (**MATLAB command window**)

  `n =   -4:4  = [-4 -3 -2 -1 0 1 2 3 4];`

  `x[n] = n.*n = [16  9  4  1 0 1 4 9 16];`

  `x[-4]=16, x[-3]=9, x[-2]=4, x[-1]=0, x[0]=0,`
  `x[1]=1,   x[2]=4,  x[3]=9,  x[4]=16`

  But for MATLAB, the signal 'x' is indexed by:

  `x(1)=16, x(2)=9, x(3)=4, x(4)=0, x(5)=0,`

  `x(6)=1, x(7)=4; x(8)=9, x(9)=16`

  Thus, `x[i] = x(i+5), i=-4:4 (x[-4] = x(1))`

  # of samples whose indices are lower than 1 = `5`

  `If n = -L:L --> x[i] = x(i+L)`

- **MATLAB:** Show `y[n] = n*x[n],` and `z[n] = x[k*n + m]`

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- Elementary signals: Exponential
  - Continuous Time: $x(t) = Be^{a*t}$

    a < 0 → decaying exponential

    a > 0 → growing exponential

  - Discrete Time: $x[n] = Be^{a*n} = Br^n$ → $r = e^a$

    0 < r < 1 → Decaying exponential

    r > 1 → growing exponential

    -1 < r < 0 → Alternating decaying exponential

    r < -1 → Alternating growing exponential

    * Note: r < 0 implies that 'a' is complex

    * x[n] is positive for 'n' even, and negative for 'n' odd.

    MATLAB examples (continuous-time, discrete-time)

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- Elementary signals:
  - **Sinusoidal**: In the discrete-time case, there is a difference between the fundamental angular frequency of the discrete signal and the fundamental angular frequency of the continuous sinusoid.
  - Fundamental period of the DT signal (obtained from the CT signal). Examples
  - Sampling a CT sinusoid and getting a DT signal.
  - Relationship between sinusoidal and complex exponential signals (show complex plane)

  - Exponentially damped sinusoidal signal
  - **Impulse** function: $\delta(t)$, $\delta[n]$
  - **Step** function: $u(t)$, $u[n]$

SIGNALS AND SYSTEMS

- System viewed as integration of operations
  - Moving average system

- Properties of systems:
  - Stability
  - Systems with and without memory
  - Causality
  - Invertibility
  - Time invariance
  - Linearity