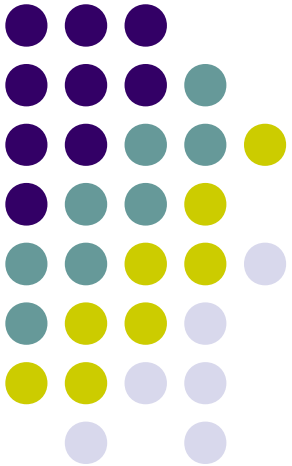
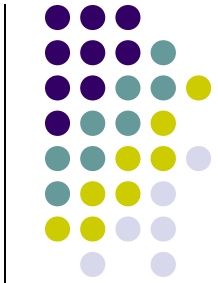
EECS 3451
Signals and Systems

H. Chesser (PSE 246)

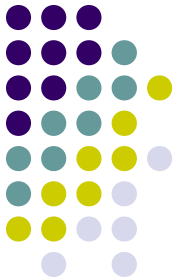


Agenda



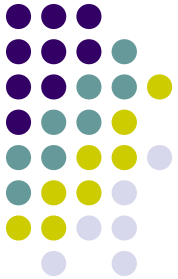
- Course Overview and Mechanics:
  - Syllabus
  - Marking
  - Schedule
  - Labs
  - Etc
- Intro to Signals (Chapter 1)
- Assignment 1

Course Content, Format



- Continuous (CT) and sampled or discrete (DT) signals
- Theory
  - Behaviour of linear differential equations with constant coefficients
  - Signal analysis/synthesis using transforms (Fourier, Laplace, Z) and convolution
- Applications
  - filtering,signal processing
  - feedback controls
- Two 90-minute lectures, 3-hour lab each week

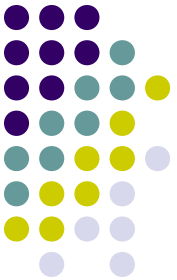
Textbook, Tools



- Wickert, M., *"Signals and Systems for Dummies"*, John Wiley & Son, 2013, ISBN: 978-1-118-47581-2
- Python (Anaconda), Jupyter Notebooks available in Lassonde Bldg computers
- Open source – recommend Anaconda distribution (Python 3.4 - "I want Python 3.4" link):

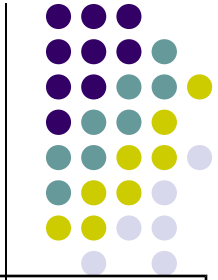
http://continuum.io/downloads#py34

Course Grading



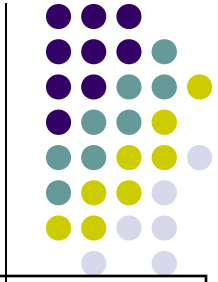
Assignments (4)	10%
Quizzes (2)	10%
Lab Projects	25%
Mid-term	15%
Exam	40%
TOTAL	100%

Rough Lecture/Assignment/Quiz/Lab Schedule



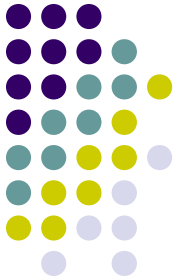
Week	Lab (M, F)	Day	Date	Assignment/Quiz	Lecture Topic (Reading)
1		R	10-Sep		**Introduction to Signals (Chapter 1):** 1. Transformations: Shifting and Scaling, 2. Types: Periodic vs. Aperiodic; Even vs. odd; Energy vs. Power, 3. Examples: Exponential; Sinusoidal; Ramp; Gate; Impulse; Step
2	Lab 1 (Python)	T	15-Sep		
		R	17-Sep		**CT and DT Systems (Chapter 2):** 1. System Connections and Properties
3		T	22-Sep	Assignment 1 due	**Time Domain Analysis, LTIC Systems (Chapter 3):** 1. Constant Coefficient Differential Equations 2. Solution of Differential Equation 3. Convolution
	Lab 1 due	R	24-Sep		
4	Lab 2 (Audio)	T	29-Sep		
		R	1-Oct	Quiz 1	
5		T	6-Oct		**Integral Transforms (4.1, 4.2, 4.3, Chapter 6):** 1. Transformation of LTICs 2. Solution of LTICs using Laplace Transforms 3. Transfer functions from Constant Coefficient Differential Equations 4. Convolution Property, Multiplication Property
	Lab 2 due	R	8-Oct		
6	Lab 3 (B 5th)	T	13-Oct	Assignment 2 due	**Fourier Transform - CT Systems (Chapter 4, 5):** 1. CT Fourier Transform for CT Periodic Signal 2. CT Non-periodic Signals: CT Fourier Transform 3. Properties of CT Fourier Transform
		R	15-Oct		
7	Lab 3 due	T	20-Oct		
		R	22-Oct	Mid-term Test	

Rough Lecture/Assignment/Quiz Schedule (Cont'd)



Week	Lab (M, F)	Day	Date	Assignment/Quiz	Topic/Exercises
8	No Labs	T	27-Oct		**Design of Frequency Selective Filters (Chapter 7)** 1. Design of CT (analogue) filters 2. Butterworth filters **Sampling and Quantization (Chapter 9)** **Time Domain Analysis of DT Systems (Chapter 10)** **z Transform for DT Signals and Systems (Chapter 13)** 1. z Transform: Definition 2. DTFT for DT Periodic Signal 3. Properties of DT Fourier Transform 4. Convolution Property, Multiplication Property: Circular Convolution. Digital Signal Processing
		R	29-Oct	Fall Reading Day	
9	Lab 4 (4-Sound Synth)	T	3-Nov	Assignment 3 due	
		R	5-Nov		
10	Lab 4 due	T	10-Nov		
		R	12-Nov		
11	Lab 5 (6 – Speech)	T	17-Nov	Assignment 4 due	
		R	19-Nov		
12	Lab 5 due	T	24-Nov		
		R	26-Nov	Quiz 2	
13	Lab 6 (12 – AM radio)	T	1-Dec		**CT and DT Control Systems** 1. Transfer functions from Constant Coefficient Difference Equations
		R	3-Dec		
14	Lab 6 due	T	8-Dec	No class	
		R	10-Dec	No Class	

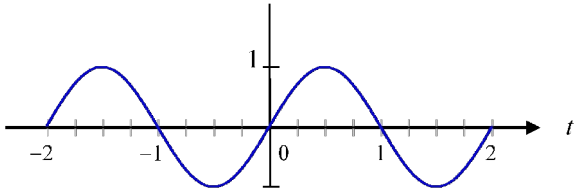
Course Web Site

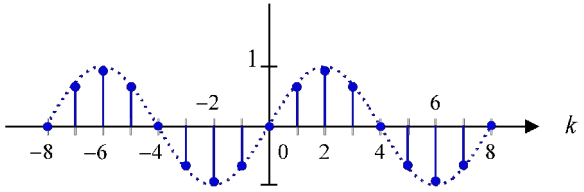


- Course resources available online - wiki.eecs.yorku.ca
- You can check site to:
  - Review lecture material
  - Lab manual
  - Check schedule, due dates, marks
  - Submit assignments, labs – use web submit
  - Ask course-related questions via the forum

Intro to Signals (Chapter 1)

- Typically we are talking about:
  - Time-varying – continuously (CT) OR sampled (DT)
  - Electrical (voltage/current) output…
    - …from a transducer which is monitoring some ongoing process (sending analog information), OR
    - …from a processor or ADC which is sending digital information
  - Main idea is that there is a “sender” and “receiver” that exchange information via the signal

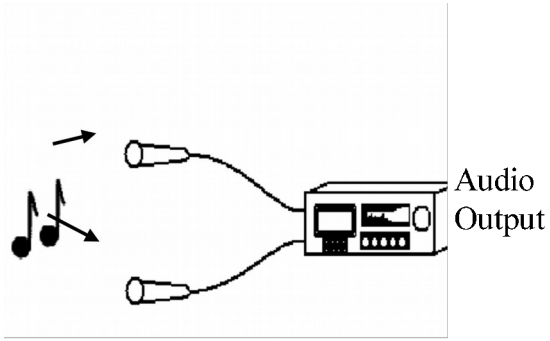


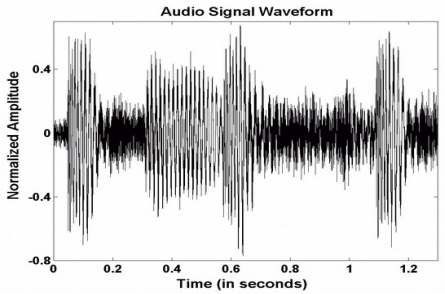


$T_s = 0.25$

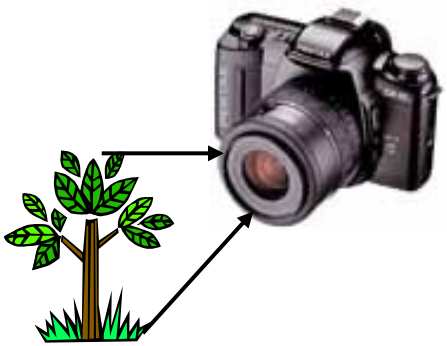
Signal Examples

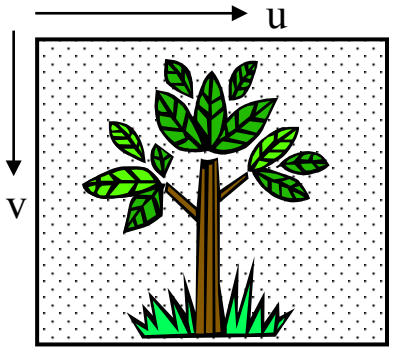
- Sound (pressure) - CT





- Light - DT

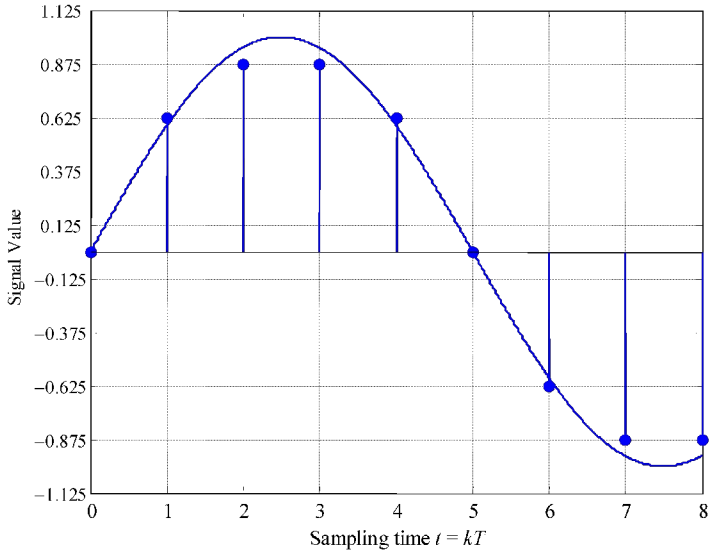




Analog vs. Digital Signals

- CT and DT classification is a mathematical one

$$x(t) = \sin(0.2\pi t)$$
$$x[k] = \sin(0.2\pi k)$$



- Analog/Digital classification is based on hardware and how it operates on signals
- In general CT = Analog, DT = Digital

Periodic vs. Aperiodic

- Signal (CT, DT) is periodic if $x(t)=x(t+T_0)$

  $x[k]=x[k+K_0]$

- CT, sinusoidal signals are periodic by definition

  $x(t)=A\sin(2\pi ft+\theta)=x(t+T_0)=A\sin(2\pi ft+2\pi fT_0+\theta)$

  $fT_0=m$

  $T_0=1/f \quad (m=1)$

- Sampled sinusoidal signals may NOT be periodic

  $x[k]=A\sin(2\pi fT_sk+\theta)=x[k+K_0]=A\sin(2\pi fT_sk+2\pi fT_sK_0+\theta)$

  $fT_sK_0=m$

  $K_0=m/fT_s=mT_0/T_s$

To be periodic, the sampling period and sinusoidal frequency (period) MUST be expressible as a rational fraction (n/m).

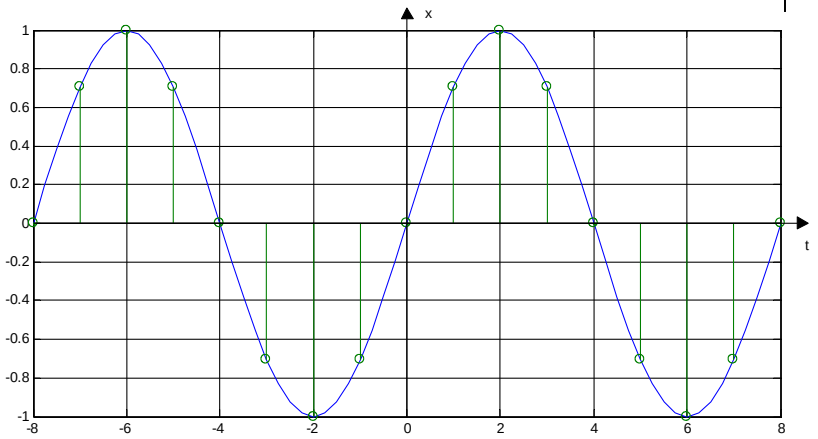
Example Problems

(1) CT signal is $x(t)=\sin(0.25\pi t)$

What is period?

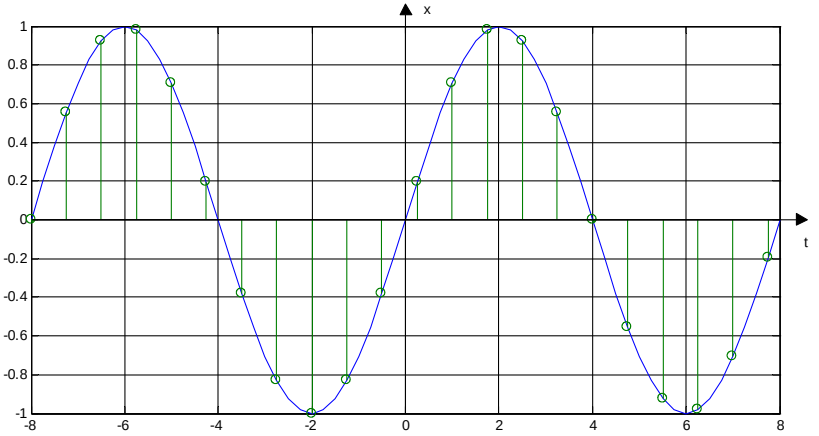
Top plot also shows the sampled DT signal for T_s = 1 s

Is $x[k]$ periodic? If so, what is K_0?



(2) Bottom is the DT sampled signal for T_s = 0.75 s.

Is $x[k]$ periodic? If so, what is K_0?



Complex Number Review (Chapter 2)

Believing in Imaginary Numbers

$$j = \sqrt{-1}$$

- Quick refresher for Lab 1
- Contain a real part and an imaginary part

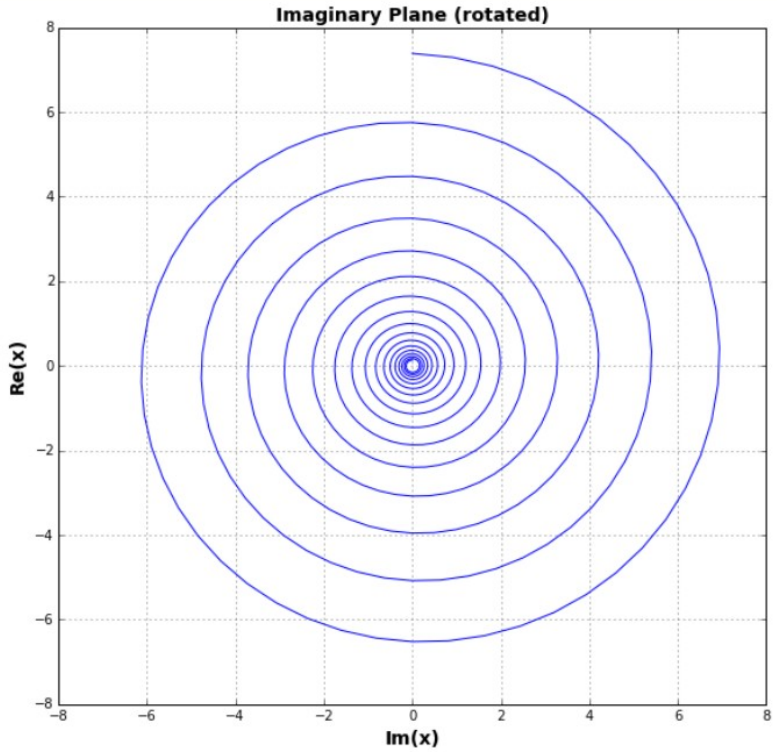
$$a + jb = A \angle \theta = A e^{j\theta}$$

$$A = \sqrt{a^2 + b^2}$$

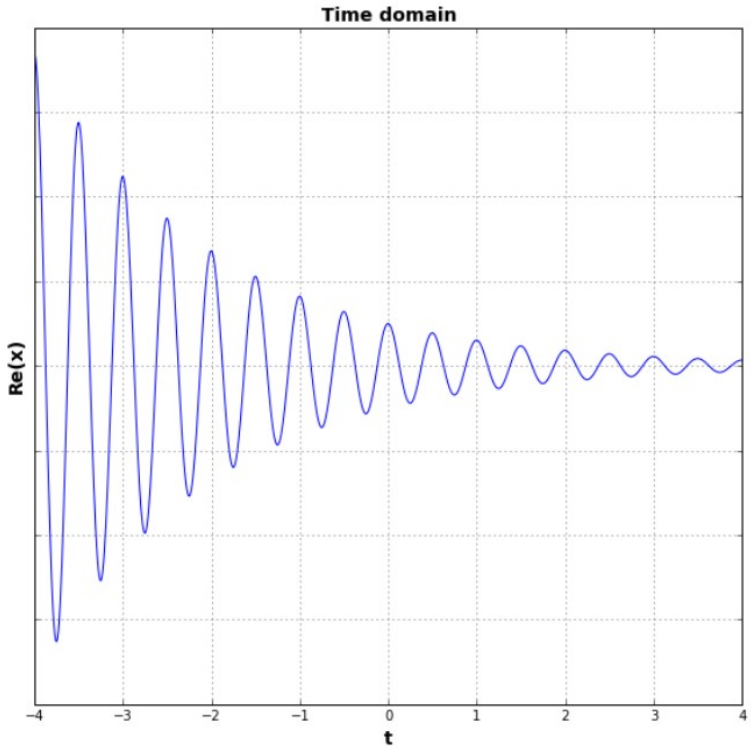
$$\theta = \tan^{-1} \frac{b}{a}$$

Leonhard Euler, 1707 - 1783

Phasor Diagram Example



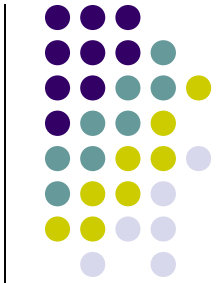
Phasor Diagram



Time Domain (Real Component)

$$s = -0.5 + j4\pi \quad x(t) = e^{st}$$

Assignment 1



- Will post to course page today