Our Mission: *Accelerate the Pace of Engineering and Science on Campus*

**Comprehensive suite of products**
- Standard technical computing tools for research and classroom use
- Integrate and enhance your lab and classroom experience
- Strengths: *data acquisition, instrument control, data analysis, computation, visualization, algorithm development, signal processing, system-level modeling, simulation, control design, rapid prototyping, embedded system development, code generation, test and verification, and more…*

**Learning tools and resources online**
- Product demonstrations, tutorials, webinars
- Online and customized onsite training courses
- User community for file exchange, newsgroups
- Academic resources for faculty and students:
  - New MATLAB & Simulink Student Version
  - 1000+ MATLAB & Simulink based books
  - Book program for book development
Key Industries

Core

- Aerospace and Defense
  Boeing, Airbus, Lockheed Martin, NASA, Raytheon
- Automotive
  Toyota, GM, Ford, DaimlerChrysler, Honda
- Communications, Electronics, Semiconductor
  3Com, Motorola, Cisco, Nokia, Panasonic
- Computers and Office Equipment
  IBM, NEC Corp, Lucent, Sony

Fast Growing

- Biotech, Pharmaceutical and Medical
  Abbott Labs, Johnson & Johnson, Pfizer
- Financial Services
  Bank of America, Goldman Sachs, J.P. Morgan Chase
- Industrial Automation and Machinery
  Eaton, GE, Honeywell, Siemens, Teradyne
- Process Industries (ie. Chemical and Petroleum)
  DuPont, ExxonMobil, 3M, Corning, Nippon Steel
Product Applications

MATLAB:
- Math, Optimization, Statistics and Data Analysis
- Data Acquisition, Instrument Control
- Signal Processing and Communications
- Control System Design and Analysis
- Video and Image Processing
- Computational and Systems Biology
- Financial Modeling and Analysis
- Application Deployment

Simulink:
- Fixed Point Modeling
- Event-Based Modeling
- Modeling and Simulating Physical Systems
- Control System Design and Analysis
- Signal Processing and Communications
- PC-Based Rapid Control Prototyping and HIL
- Product Code Generation
- Verification, Validation and Testing
Search for jobs on Monster.com reveals 900 for MATLAB and 200 for Simulink

Fun Google Facts
- 20 million web results - non-MathWorks sites only
- 896,000 Google Groups results since Jan 2001
  36% more than Fortran
- 75,000 results for “matlab tutorial”
New Student Version (R2007a)

MATLAB 7.4 and Simulink 6.6!

Add-on products included:
- Control System Toolbox
- Signal Processing Toolbox
- Signal Processing Blockset
- Statistics Toolbox
- Optimization Toolbox
- Image Processing Toolbox
- Symbolic Math functions

Documentation Included:
- Three printed manuals
- DVD contains complete product documentation

Platforms available:
- Windows (Vista), Linux, Mac OS X (Intel)
Today’s Agenda

Introduction to MATLAB

Data Gathering
Analysis and Visualization
Communicating your results
Distributed Computing
Questions/Answers and Wrap up
Life Science Necessities: Flexibility and Breadth

- Microsoft Excel
- Microsoft Access
- Oracle
- NCBI
- SQL Server
- HTML
- my_app.exe
MATLAB Desktop Tools

Workspace Browser: See your data

Editor: Edit and debug m-files

Command Window
Benefits of the MATLAB programming environment

- **User-friendly programming environment**
  - Not your typical command prompt programming tool
  - Desktop, import wizard, help browser, etc.

- **Flexible programming tool**
  - Command-line versus user-interface
  - Scripts, functions, etc.

- **Broad range of functionality all in one programming environment**
  - Statistics
  - Publishing to HTML
  - UI development
Today’s Agenda

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Summary and Questions
Life Science Necessities: Flexibility and Breadth
Data Gathering

- Common file formats
  - Excel, CSV and other text
  - Image (jpeg, tiff, gif, bmp, png, etc.)

- Specialized formats
  - Sequence data (fasta, embl, genbank, etc.)
  - Microarray (Affymetrix, GenePix, GEO, etc.)
  - BLAST Reports, Mass Spec, Phylogenetic Trees, etc.

- Databases

- External Hardware
  - Video Cameras, Medical Equipment, etc.
Example: Seamless Database Connections

Visual Query Builder
- Access data without knowing SQL
- Scroll through tables and fields
- Customize your query
- Built-in visualization tools
- Plotting and charting
- Creating HTML reports
- Handling date strings
- Reuse SQL statements in your own program
Patient Monitoring Demo: Pulse Oximeter + Video
Data Gathering – Breadth and Depth

- Easily load common file formats
  - Excel, CSV and other text
  - Image (jpeg, tiff, gif, bmp, png, etc.)

- Access to many specialized formats
  - Sequence data (fasta, embl, genbank, etc.)
  - Microarray (Affymetrix, GenePix, GEO, etc.)
  - BLAST Reports, Mass Spec, Phylogenetic Trees, etc.

- Complete integration to SQL and ODBC sources

- Direct Access to External Hardware
  - Video Cameras, Medical Equipment, etc.
Today’s Agenda

- Introduction to MATLAB
- Data Gathering
- Analysis and Visualization
- Communicating your results
- Distributed Computing
- Summary and Questions
Life Science Necessities: Flexibility and Breadth

What can we do once we’re in MATLAB?
Analysis in MATLAB

- Signal processing
- Image processing
- Statistics
- Control design
- Mass Spec analysis
- PK/PD modeling
- Neural Networks
- Microarray analysis
- And others ...
Let’s look at a few examples....

- Quantification of tissue metastasis
- Determination of retinal blood flow
- Biochemical pathway analysis
- PK/PD modeling
Consider this image from National Cancer Institute:
Quantifying Tissue Metastasis

- **Goal:** To quantify the amount of tissue metastasis for a given image

- **Initial method:** Post-doc sits behind microscope and counts the number of metastatic spots

**Pros**
- Relatively simple
- Not too time consuming for one image

**Cons**
- Error-prone
- Boring
- Not a very convincing metric
Quantifying Tissue Metastasis

- **Goal:** To quantify the amount of tissue metastasis for a given image

- **Initial method:** Post-doc sits behind microscope and counts the number of metastatic spots

- **How automation helped:**
  - Obtain objective results
  - Reduce costs and boredom
  - Decrease processing and analysis time
  - Alleviate human errors and transcription errors
Let’s look at a few examples….

- Quantification of tissue metastasis
- Determination of retinal blood flow
- Biochemical pathway analysis
- PK/PD modeling
Fluorescein Angiogram of a Rat
Analysis of Fluorescein Angiogram

- Goal: Determine mean circulation time (MCT) and retinal blood flow (RBF)

- Fit Intensity-vs-Time to lognormal curve parameterized by $I_0$, $I_p$, $t_p$, $\beta$ (shape factor)
Analysis of Fluorescein Angiogram

- Task Requirements
  - Manually track vessels, collecting time-intensity data (40 minutes in a dark room!)
  - Manually identify arteries, veins
  - Transfer intensity information to statistics package to calculate fit parameters
  - Determine MCT
  - Manually measure vessel pairs
  - Calculate RBF
  - Log results in lab notebook
Analysis of Fluorescein Angiogram

- **Goal:** Determine mean circulation time (MCT) and retinal blood flow (RBF)

- **Previous Method**
  - Time consuming
  - Heavily based on human subjectivity

- **Automation allowed us to:**
  - Obtain objective results
  - Decrease processing and analysis time
  - Reduce costs and boredom
Let’s look at a few examples….

- Quantification of tissue metastasis
- Determination of retinal blood flow
- Biochemical pathway analysis
- PK/PD modeling
Challenges with *in silico* biochemical modeling

- Integrating knowledge from experimental data, intuition, literature, and other models is difficult.
- Modelers and scientists have difficulty communicating knowledge and sharing work.
- The mathematics for solving these models is evolving faster than the tools.
- Many different tools are needed to complete entire workflow.
SimBiology

- Provides one environment for both graphical and programmatic pathway analysis
- Provides one tool for modeling, simulating, and analyzing pathways
- Used by modelers or programmers to gain insight into their pathway and to communicate their pathway with biologists
Let’s look at a few examples…

- Quantification of tissue metastasis
- Determination of retinal blood flow
- Biochemical pathway analysis
- PK/PD modeling
**Pharmacokinetics**
The study of what the body does to a drug after administration

The study of Absorption, Distribution, Metabolism, and Excretion (ADME) of drugs in the body

**Pharmacodynamics**
The study of what the drug does to the body

The study of the biochemical and physiological effects of drugs mechanisms of drug action relationship between drug concentration and effect
Challenges in PK/PD modeling

- Many tools are not user-friendly
  - NONMEM, Basic, Fortan, C: Building and maintaining models can be difficult.

- Organ Specific or niche Simulation tools are too complex and/or blackbox
  - Organ models not editable, methods are not viewable
  - Flexibility is limited

- Workflow is manual, not automated
  - Modelling, simulation, statistics, and visualization all require different tools
  - Manual integration is time consuming
PK Example – Transdermal Input

- Nicotine patch is applied to the skin for 16 hours
- Overlapping zero-order input rates
- Drug concentration monitored for 24 hours
- Single compartment model

\[
\frac{dC}{dt} = \left( F_{\text{fast}} + F_{\text{slow}} - Cl \cdot C \right) / V
\]

\[
F_{\text{fast}} = \frac{\text{Total dose} - Dose_{\text{slow}}}{\text{Time}_{\text{fast}}}
\]

\[
F_{\text{slow}} = \frac{Dose_{\text{slow}}}{\text{Time}_{\text{slow}}}
\]
Summary: Analysis in MATLAB

Signal processing  Image processing

Statistics  Control design

Mass Spec analysis  PK/PD modeling

Neural Networks  Microarray analysis

And others ...

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Life Science Necessities: Flexibility and Breadth
Automating Your Work Flow
LCMS Analysis Example
Integrating MATLAB with Excel

Problem:
- Wet-bench scientists prefer to work with Excel
- Many instruments output data to Excel
- Excel is ubiquitous in the bioinformatics field

Solution:
- MATLAB works seamlessly with Excel…..
  - The advantage of the flexible MATLAB programming environment and powerful mathematics in Excel
Integrating with Excel

Spread Sheet Applications

- MATLAB Excel Link can be the computational engine behind your Excel applications
- Transport data and perform MATLAB analysis with the click of a button
- Fast scalable solution

```
MLPutMatrix("data",B2:H43)
MLPutMatrix("Genes",A2:A43)
MLPutMatrix("TimeSteps",B1:H1)
MLEvalString("clustergram(data,'RowLabels',… Genes,'ColLabels',TimeSteps")
```
Deploying to Excel

MATLAB Builder for Excel

- Create Excel plug-in to give to biologists & clinicians
- Appears as user-defined function in formula toolbar
  - As easy to use as sum, mean, etc.
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Summary and Questions
Distributed Computing with MATLAB
Distributed Computing with MATLAB

**Functionality:**
- Create jobs
- Create tasks
- Pass data
- Retrieve results

**Functionality:**
- Queue jobs
- Dynamically license workers
- Evaluate tasks
Support for Parallel Applications
Today’s Agenda

Introduction to MATLAB
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Summary and Questions
Summary

- Today we saw how MathWorks tools help:
  - Gather data from a broad range of sources
  - Eliminate subjectivity and boredom in analysis
  - Share results quickly with colleagues
  - Decrease the time to discovery by using distributed computing
User Support and Community

The MathWorks
Training Services

The MathWorks
Consulting Services

The MathWorks
Book Program

The MathWorks
Connections Program

MATLAB CENTRAL

www.mathworks.com
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- Controls
- Signal Processing
- Image Processing
- Biosciences
- Communications
- Mechanical Engineering

- Mathematics
- Aerospace Engineering
- Environmental Sciences
- Chemistry
- Finance
- Electronics, and more

www.mathworks.com/books
File exchange and newsgroup access for MATLAB and Simulink user community

- 184,000 visitors per month
- More than 4,000 contributed files in the exchange
  - General-purpose functions, industry- and application-specific tools and examples
  - 100 new submissions per month
  - 5,000 downloads per day
- Web interface to the MATLAB Usenet forum – comp.soft.sys.matlab (CSSM): Over 6,000 posts a day
- MATLAB Web Resources, Blogs, Programming Contests, and RSS feeds
Further information

• Stay for questions

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  www.mathworks.com