Welcome to IE 300

Chrysafis Vogiatzis

Department of Industrial and Enterprise Systems Engineering
University of Illinois at Urbana-Champaign

08/24/2020

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ISE | Industrial & Enterprise Systems Engineering
GRAINGER COLLEGE OF ENGINEERING

Welcome to IE 300

In this class, we will study **probability models** in engineering and the **statistical analysis of data**.

We will separate the class into four components:

- Basic probability theory and probability models.
- Descriptive statistics.
- Inferential statistics.
- Model building.

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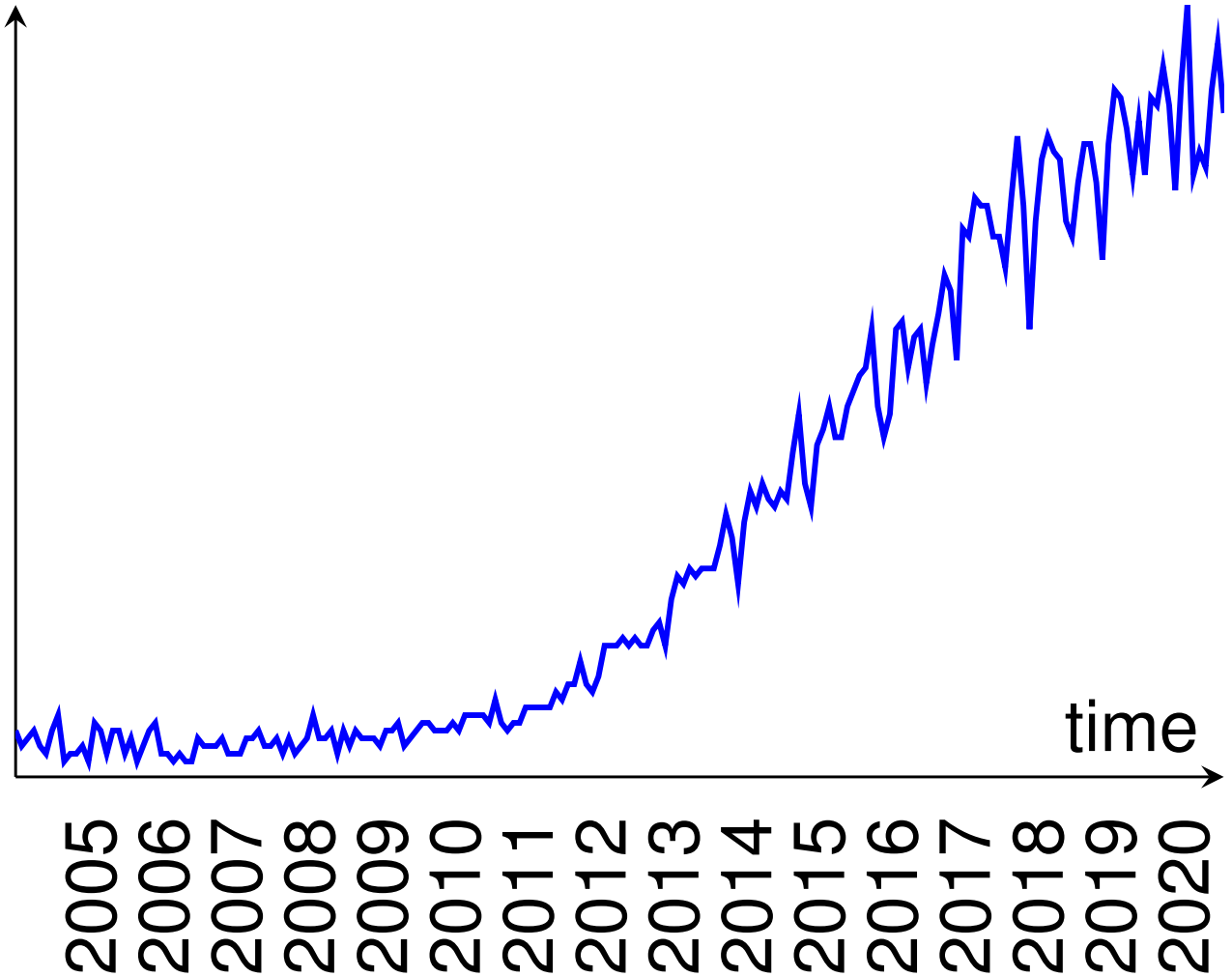
Why now?



Created with data from Google Trends for “data analytics”

Fields

Various fields have a need for proper analysis of data under uncertainty:

1. Healthcare
   - How should we schedule outpatient operations?
   - What is the best treatment for our patients?
2. Logistics
   - Should we choose supplier *A* or supplier *B*?
   - How many products should we have on hand?
3. Manufacturing
   - Are our products of high quality to sell in the market?
   - Do our manufactured cell phones bend easily?
4. Transportation
   - How big of a parking lot should we build in downtown Champaign?
   - Which routes should we choose for public transportation?

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- Ph.D. in ISE @ UF.
- Worked at NDSU, NCAT.
- Teaching Assistant Professor in ISE @ UIUC.
- OR, mathematical programming, combinatorial optimization, **network optimization and analysis**.
- Teaching IE 300 (Analysis of Data) and IE 532 (Analysis of Network Data).
- I come from a small island in the Aegean Sea in Greece

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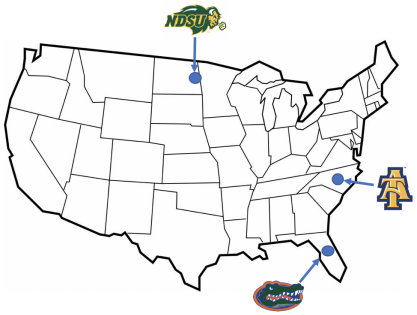

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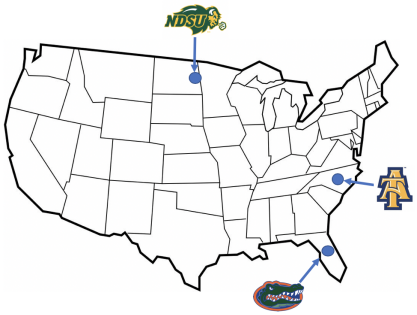

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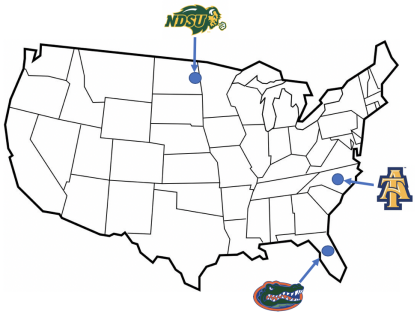

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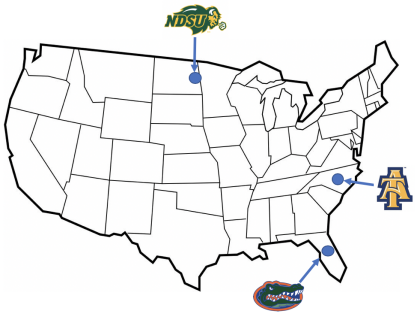

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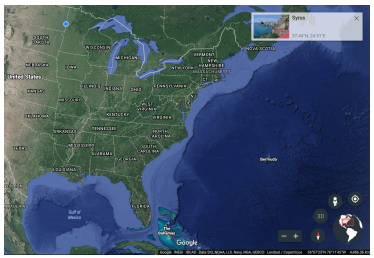

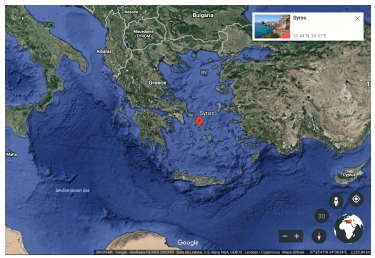

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- Evacuation and disaster management.
- Biological networks and phylogenetics.
- Data analytics using combinatorial optimization.

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- Graduate student **teaching** award (2012, UF).
- ISE **teaching** award (2012, UF).
- Now You See Me: Best paper award of the European Intelligence and Security Informatics Conference (2018).
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How do I call you?

Over the years, I've been called or emailed as:

- Professor/Prof. Chrysafis/Chrys;
- Sir/Mister/Mr. Chrysafis/Chrys;
- Man/Dude/Bro;
- Chrysafis/Chrys;
- Dr. Vogiatzis/Dr. V./Dr. Chrys;
- Greek guy.

I'm 100% fine with:

- Professor/Prof. Vogiatzis/V./Chrysafis/Chrys;
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Phonetically:

chree-SAH-fees vo-yah-JEES

For the last name it helps to think of VOYAGE + YAHTZEE.

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Class logistics

- Class time:
  - MWF 11.00am–11.50pm at ~~TB 201~~ this zoom link.
- Textbook:
  - Applied Statistics and Probability for Engineers
  - by Doug Montgomery and George Runger.
  - 7th edition – you will be totally fine with the 5th or 6th edition.
  - ISBN-13: 978-1119231943 ISBN-10: 1119231949
  - **Highly** recommended, not required.
  - If you do not have it, I will provide all material for the class.
- Course materials:
  - All material (slides, lecture notes, worksheets, examples, videos etc.) will be posted on Compass 2G.
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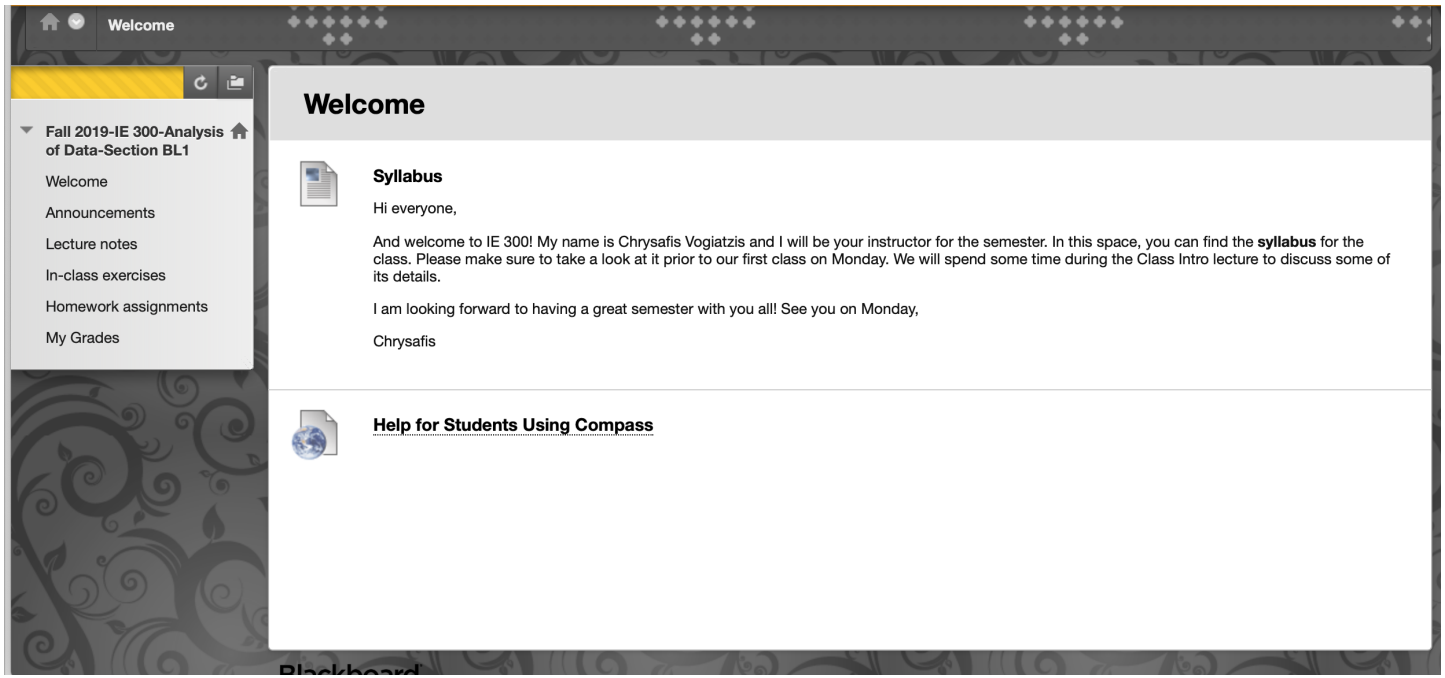
Compass 2g

- http://compass2g.illinois.edu/.
- Only available to registered students.



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Your letter grade in the class will be calculated based on:

- In-class worksheets (10% of the grade).
- Three (3) 1-hour midterm exams (15% each, for a total of 45%):
  - open books/notes, **no collaboration** between students allowed.
  - set to take place on or near 09/23, 10/19, 11/16.
  - all will be announced in class and on compass at least one week before they take place.
  - all will have a review session prior to that.
- One (1) final exam (25% of the grade), set to take place 12/14:
  - open books/notes, **no collaboration** between students allowed.
  - cumulative.
- 12-15 online quizzes (10% of the grade):
  - The two lowest quiz grades of every student will be dropped.
- Lab case studies (10% of the grade).

Wait? **No homeworks**?

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The class is designed to be **flipped-classroom**.

- Watch smaller pre-lecture videos at home (about 30 minutes weekly).
- Study the lecture notes (prepared by me) before and during class time.
- Solve **during class** small **activities** with a **group of students** and with **my help**.
- Submit the worksheets for feedback and points in the class.
  - You are highly encouraged and expected to work with others; but everyone needs to submit their own copy.
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You know what? Let's try this out. **I will assign you to breakout rooms. Go in and answer the Worksheet 0 questions.**

I will bring you back in 5 minutes.

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Quizzes

At the end of something interesting (after the video(s), the lecture notes, and the worksheets have been released), you will have to complete a quiz.

- On gradescope.
- Typically open for 3 days.
- Once you begin a quiz, you will have 20-30 minutes to complete and submit it.

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Exams

The exams will be offered after 10 lectures (roughly) each.

- **Exam 1**: basic probability theory, Bayes' theorem, continuous/discrete random variables, expectations and variances.
- **Exam 2**: joint distributions, covariance and correlation, descriptive statistics, point estimators, parameter estimation.
- **Exam 3**: confidence intervals and hypothesis testing.
- **Final exam**: everything from the class, including model building (linear regression, multiple linear regression, etc.).

The class time before the exam will not have a Zoom session, but instead it will be replaced with a **review** session.

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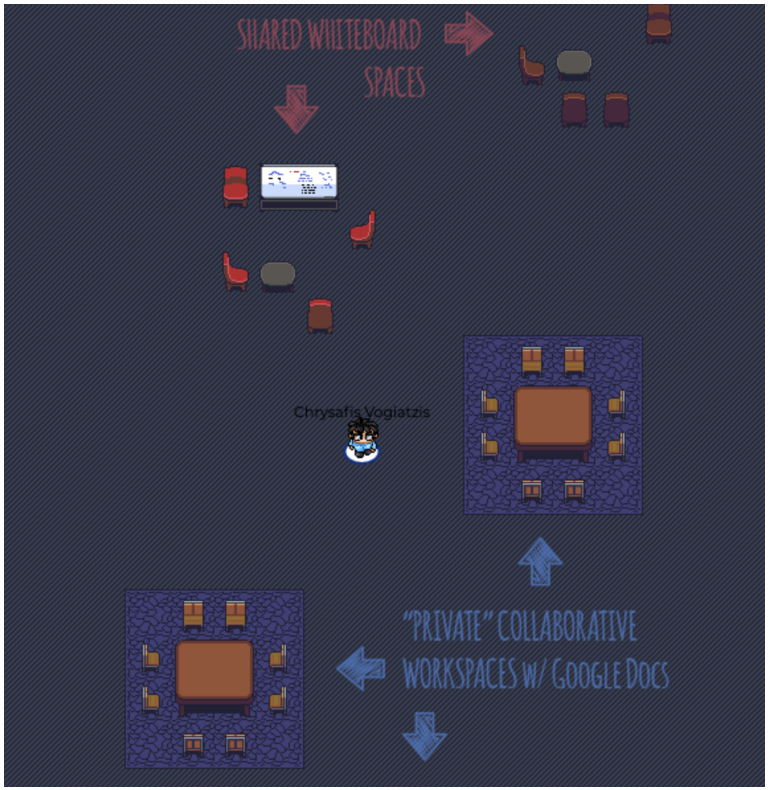
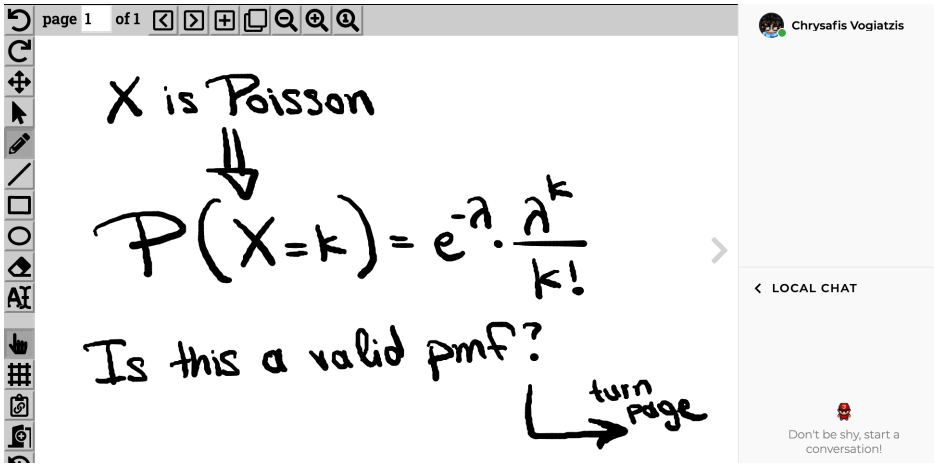
Review sessions

Review sessions will be offered on gather.town.





Labs

- Lab times (you only need register for one of them):
  - BD1: T 5.00pm–5.50pm, BD2: R 5.00pm–5.50pm, BD3: W 12.00pm–12.50pm, BD4: R 12.00pm–12.50pm
- Also online; led by one of the TAs.
- Working in groups (or by yourself, if you so prefer) will undertake two case studies that will have you practice Python, perform data cleaning and manipulation, and finally perform a full statistical analysis!
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Labs will not begin until the third week of classes. I will let you know when your first lab session will be.

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Prerequisites and outcomes

Prerequisites:

- **Calculus III** (MATH 241).
- **An interest to read and write simple mathematical proofs**: In the class, I will be explaining the mathematics of how things work, and I will be expecting you to do more than a simple revisiting of the proofs!
- **A passion to learn something new.** And fun!

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Learning outcomes:

- understand and quantify the role of **uncertainty** in engineering models and data;
- understand and successfully apply **probability concepts** in the development of engineering models;
- identify and use proper discrete and continuous random variables and their distributions
- formulate and conduct **statistical analyses** and **experiments** of observed data to reach statistically sound conclusions;
- perform statistical analyses using **Python**.

Class topics

Specifically, we will see the following topics. You are also encouraged to check the syllabus for a day-to-day calendar.

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- **Joint probability distributions**:
  - Joint probability distributions;
  - Marginal and conditional distributions;
  - Covariance, correlation, and independence;
  - Common joint distributions.
- **Random variables**:
  - Definitions;
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Class topics (cont'd)

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- **Other topics (time permitting):**
  - Multiple linear regression;
  - Analysis of variance.

How to get help

I will not lie: this class can be hard.

- Reach out to me, **early** and **often** – I take pride in being available for your learning and advising.
- Email me your questions: I try to respond to every email about the class as fast as possible!
- Come to my office hours and set up appointments to meet with me.
- The class is designed to help you understand probability and statistics. Some of the material might be very interesting to what you want to do, others not so much. This is *normal*!

Please do not call or visit me at home :)

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The teaching assistants

I am very excited to present the teaching assistants for the course this semester.

- Each of them will be leading one of the lab sessions.
- They will also be available to help answer any of your questions and concerns.

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They are (in alphabetical order):

- Rachneet Kaur;
- Timothy Murray;
- Xiyitao Zhu.

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What I know about you

- You are interested in probability theory;
- You'd like to know how to make decisions under uncertainty [1];
- *If you are in ISE*, then you need this class to graduate;
- And that's pretty much all!

Help me amend this by filling in the (anonymous) survey online. I will give you 10 minutes in the end of the class to go through it:

https://surveys.illinois.edu/sec/1917812857

For the time zone question, you may use and time zone converter tool online, such as

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[1] is there really any other kind of decision-making?

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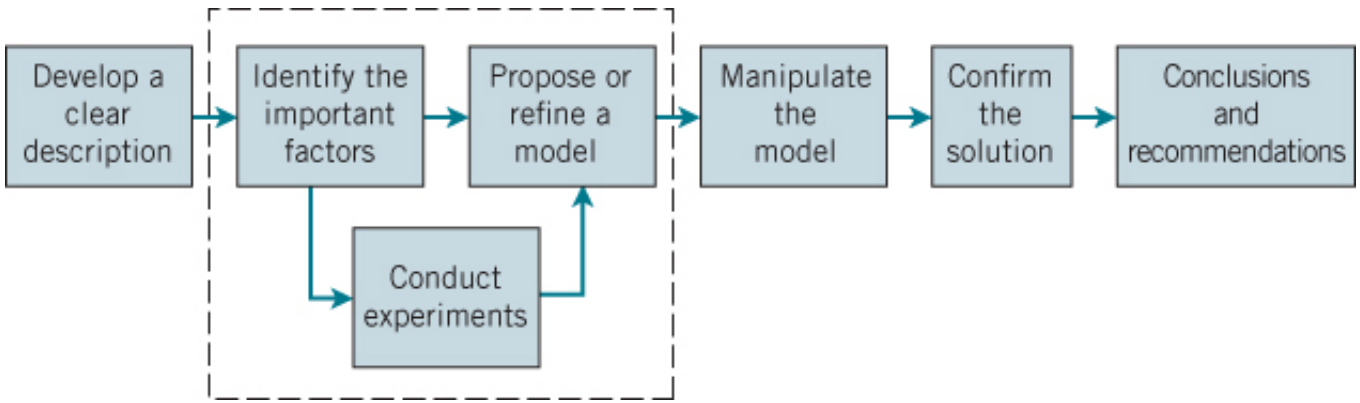
Analysis of engineering data

1. Clearly state the problem. **DESCRIBE**
2. Identify the important factors that you think affect the problem. **GUESSTIMATE**
3. Model the problem by stating your assumptions and limitations. **MODEL**
4. Collect data to test the model. **TEST**
5. Refine the model. **REFINE**
6. Collect more data to validate the new model. **VALIDATE**
7. Draw conclusions. **RECOMMEND**



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Example 1: A multi-server example

Example

A new restaurant (owned by an ISE graduate) employs three servers. On the first day of operations, the three servers have been serving multiple tables each: the time (in minutes) that a table stayed in the restaurant is shown in the table below. Server 3 got really bad tips throughout the day.

Table: *Times (in minutes) that every table waited upon stayed in the restaurant for each of the three servers.*

Table	Server 1	Server 2	Server 3
1	65	60	57
2	70	82	50
3	72	80	45
4	80	77	45
5	60	75	44
6	73	63	55
7	51	65	
8		47	

Example 2: Operating room scheduling

Example

An outpatient facility performs three types of operations: let us refer to them as A, B, and C. The facility has performed hundreds of operations, but for the sake of brevity, we will present the ten most recent ones for each of the operations in the table below. The facility works for 8 hours every day. If an operation goes outside regular business hours, the doctors and nurses get paid overtime. Help them schedule their operations for next week so as to minimize overtime paid.

Table: *Times (in hours) that every operation took in the facility.*

#	Operation A	Operation B	Operation C
1	0.47	2.12	3.56
2	1.05	2.83	3.14
3	0.89	5.15	4.00
4	1.49	5.81	3.98
5	1.01	1.69	3.21
6	1.83	3.72	3.54
7	1.45	4.75	3.83
8	1.39	3.75	3.01
9	1.25	1.85	3.70
10	1.97	1.72	3.97

Example 3: Manufacturing (and time studies)

Example

*A foundry makes some expensive castings that need to be cut manually. A group of three industrial engineering students doing their senior design project performed a **time study**: they visited the foundry two times, observed the operations, and timed them. Their findings are in the table below. Help them make sense of the times.*

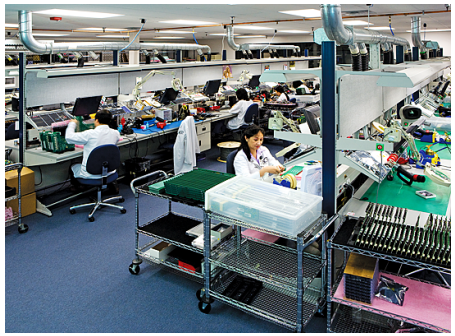
Table: *The times (in seconds) that the three students measured using three stopwatches during two visits to the facility.*

	Student 1		Student 2		Student 3	
Operation	**Trial 1**	**Trial 2**	**Trial 1**	**Trial 2**	**Trial 1**	**Trial 2**
Set up machine	12	10	8	8	8	7
Begin cutting	312	290	308	305	310	304
Move equipment	10	11	8	10	9	11
End cutting	284	246	280	247	280	248
Refine	109	108	110	110	109	110
Label	13	11	9	9	10	9
Total	740	676	723	689	726	689

Time studies

Frederick W. Taylor is considered to be the parent of time studies.

- Breakdown of a process into its components.
- Wrote “The Principles of Scientific Management”.
- Three steps in a time study:
  1. Observe task.
  2. Record times.
  3. Analyze data.



Example 4: The Monty Hall problem

Example

You are the lucky participant of a TV show! You just have to pick one of three folders. Two of the folders contain a picture of Rick Astley; one of the folders contains a check for $20,000. You pick a folder, but you don't open it. Then, the show host opens one of the other two folders to reveal a Rick Astley picture. The host gives you an opportunity to change folders and pick the other unopened one.
Do you? Should you?

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Do you? Should you?

- Named after Monty Hall.
- Host of "Let's make a deal".
- Three doors, two goats, 1 car.

Before you go

- Please submit Worksheet 0 on gradescope.
  - I will stick around on Zoom to answer any questions you might have and help you troubleshoot.
- Please complete the survey.
  - Link to survey: https://surveys.illinois.edu/sec/1917812857
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Next time

We will get *formally* started! I will expect you to:

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Let's have a great semester!