ECE600: Random Variables and Waveforms

Prof. Mark R. Bell
mrb@ecn.purdue.edu
(765)494-6412

ECE600 Contact Info.

- Instructor: Prof. Mark R. Bell
  - Phone: (765) 494-6412
  - email: mrb@ecn.purdue.edu
- TA: Brad Fitzgerald
  - email: fitzge45@purdue.edu
  - Phone: TBD

Course Webpage:

http://www.ece.purdue.edu/~ mrb

(and follow the ECE600 drop-down menu.)

All course information, except lecture videos, will be distributed through the course webpage.

Lecture Videos are automatically recorded and uploaded to the course Brightspace page.

Prerequisites

- Graduate Standing
- Solid Understanding of **Calculus** and **Fourier Transforms**.
- Some mathematical maturity.

Textbook

- A. Papoulis, **Probability, Random Variables, and Stochastic Processes**, **4th ed., McGraw-Hill, 2002.**
- The third edition of Papoulis is acceptable if you already have it.

Course Grading

- 3 Midterms Exams: 20% Each
- 1 Final Exam: 40%
- Homework will not be collected —but you must do it!!!

Course Grading (Cont.)

- **No Make-up Exams.**
  - If you miss a midterm exam, your final exam score will be used in its place.
- **Homework:**
  - There will be regular homework assignments. They will not be collected.
  - Homework solutions will be posted to the course website
  - **Do the homework!!!**

Course Schedule

ECE600 Spring 2022 Course Schedule

Session No	Date	Event
1	1/11/22	Lecture
2	1/13/22	Lecture
3	1/18/22	Lecture
4	1/20/22	Lecture
5	1/25/22	Lecture
6	1/27/22	Lecture
7	2/1/22	Lecture
8	2/3/22	Lecture
9	2/8/22	Exam 1
10	2/10/22	Lecture
11	2/15/22	Lecture
12	2/17/22	Lecture
13	2/22/22	Lecture
14	2/24/22	Lecture
15	3/1/22	Lecture
16	3/3/22	Lecture
17	3/8/22	Lecture
18	3/10/22	Exam 2
19	3/22/22	Lecture
20	3/24/22	Lecture
21	3/29/22	Lecture
22	3/31/22	Lecture
23	4/5/22	Lecture
24	4/7/22	Lecture
25	4/12/22	Exam 3
26	4/14/22	Lecture
27	4/19/22	Lecture
28	4/21/22	Lecture
29	4/26/22	Lecture
30	4/28/22	Lecture

Midterm Exam Schedule

- Exam 1: Session 9 (Feb. 8)
- Exam 2: Session 18 (Mar. 10)
- Exam 3: Session 25 (Apr. 12)

Prof. Bell's Office Hours

- **Zoom Office Hours (EST/EDT):**
  - M: 10:00 – 11:30am
  - W: 1:30 - 3:00pm

A Zoom link will sent out five minutes before each Office Hour session to all registered students.

Brad Fitzgerald's Office Hours

- In Person Office Hours (MSEE 292)
  - Tuesdays1:30-3:30pm
  - Wednesdays 2:30–4:00pm
  - Fridays 10:00–11:30am
- Zoom Office Hours
  - Wednesdays 9:00–11:00am
  - Thursdays 3:00–4:00pm
  - Fridays 11:30am–1:00pm

1.12

Random Models in ECE

- Communications and Information Theory
- Computer Networks
- Solid State (Quantum Mechanics)
- Optics
- Control Theory
- Electromagnetics and Antennas
- Machine Learning, Big Data and Statistical Pattern Recognition

Probability is Used to Model Uncertainty

- **Systems that are too complex to model deterministically: (Ignorance)**
  - Maxwell: Theory of Gases
  - Boltzmann: Statistical Mechanics
- **Systems that are inherently random:**
  - Games of Chance
  - Quantum Mechanics
  - Other "fundamentally random" systems.

Set Theory

- Why Set Theory?
- A random experiment: roll a fair die

$$S = \{1, 2, 3, 4, 5, 6\}$$

- We can define events:

$A_1 = \{1, 2, 3\}$

A_2 = outcome is divisible by 3 = $\{3, 6\}$

A_3 = outcome is prime = $\{2, 3, 5\}$

- Each event of interest is a subset of

$$\mathcal{S} = \{1, 2, 3, 4, 5, 6\}.$$

- There are $2^6 = 64$ distinct subsets of $\mathcal{S}$.

Events:

- Events are subsets of $\mathcal{S}$.
- The collection of all events is called the event space:

$$\mathcal{F}(\mathcal{S}) = \{A_1, A_2, \ldots, A_{64}\}$$

Our random experiment is completely characterized by

$$\{\mathcal{S}, \mathcal{F}(\mathcal{S}), P(\cdot)\}$$

where

$$P(\cdot): \mathcal{F}(\mathcal{S}) \rightarrow [0, 1]$$

and assigns probabilities to each event in $\mathcal{F}(\mathcal{S})$.

This framework - with minor modifications - will be used to describe all of the random experiments in this course.

A solid understanding of set theory will be important.

Basic Set Theory Definitions

- A set is simply a collection of objects.
  We intentionally leave this undefined.

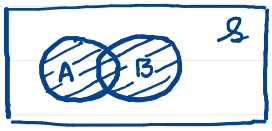
Defn: In any given set problem, the set containing all possible elements called the *universe*, the *universal set*, or the *space*. We typically denote it by $\mathcal{S}$.

n.b In probability the universal set is typically the sample space $\mathcal{S}$.

Set Operations:

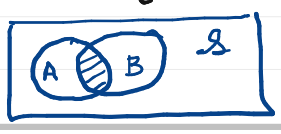
Defn: The *union* of two sets A and B, denoted $A \cup B$, is defined as

$$A \cup B \triangleq \{w \in \mathcal{S} : w \in A \text{ or } w \in B\}.$$



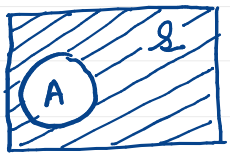
Defn: The intersection of two sets A and B, denoted $A \cap B$, is defined as

$$A \cap B \triangleq \{w \in \mathcal{S} : w \in A \text{ and } w \in B\}.$$



Defn: The **complement** of a set A (with respect to $\mathcal{S}$), denoted $\overline{A}$, A' or A^c, is defined as

$$\overline{A} \triangleq \{ \omega \in \mathcal{S} : \omega \notin A \}$$



Defn: The empty set, denoted ϕ, contains no elements.