

Mobile Communications

ECS 455

Dr. Prapun Sukksompong

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Office Hours:

BKD 3601-7

Tuesday 15:00-16:00

Friday 14:00-16:00

ECS455

Introduction

Office Hours:

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Tuesday 15:00-16:00

Friday 14:00-16:00

Marty Cooper: Cellphone Inventor

- 1973
- Motorola
- Weighed nearly two kilos
- Cost approximately \$1 million for Motorola to produce.
- 20 minutes battery life
Not a problem because you could not hold it up for twenty minutes; it was so heavy.



[<http://gizmodo.com>]

Some Quotes from Marty Cooper

“We had no idea that in **as little as 35 years more than half the people on Earth** would have cellular telephones, and they give the phones away to people for nothing.”

“I carry two phones – one very simple phone that I can flip open that has a very simple phonebook and nothing else. But when I want to twitter... **tweet**... then, I use my Droid.”

Old Cell Phone



Motorola's DynaTAC

First **commercially available** cell phone in 1983

- Weighed about 2 lbs (1 Kg)
- 10 inches high, making it larger than some Chihuahuas
- Battery life: 30 minutes of talk time
- \$4,000



World Market Penetration

**IN 2000, 1 OUT OF 10 PEOPLE
IN THE WORLD OWNED A CELL PHONE...**



**BY THE END OF 2009, THAT STATISTIC
GREW TO 6 OUT OF 10 PEOPLE!**



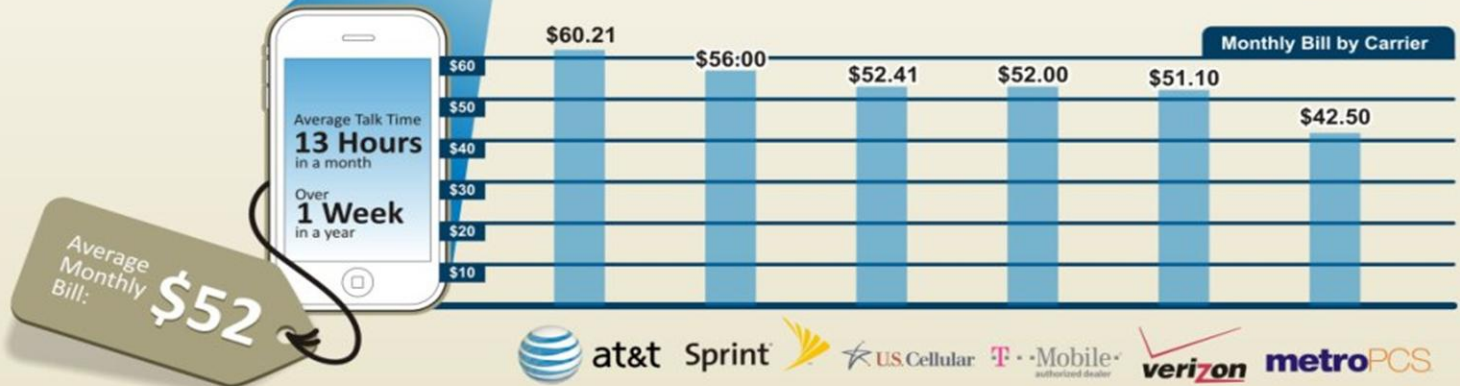
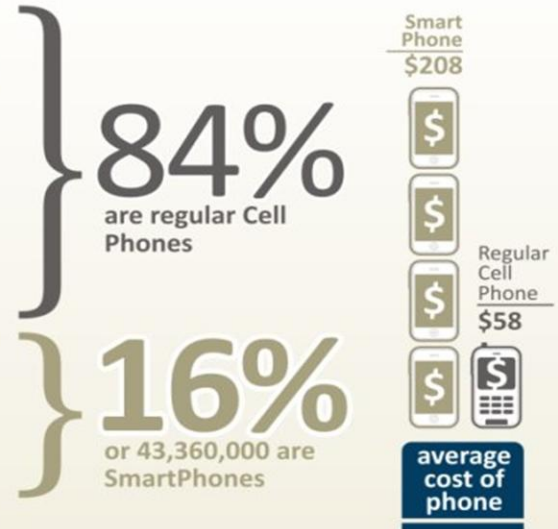
4,239,956 PEOPLE
are having a cell
phone conversation
at any given **SECOND**
in the world

People in countries
with no running water
are able to keep in
touch with others
thanks to cellular
technology

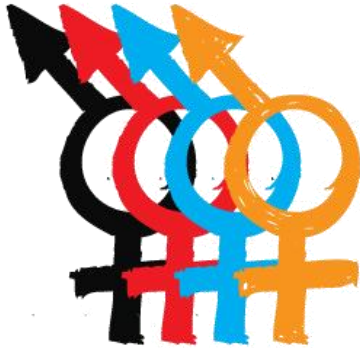
US Market



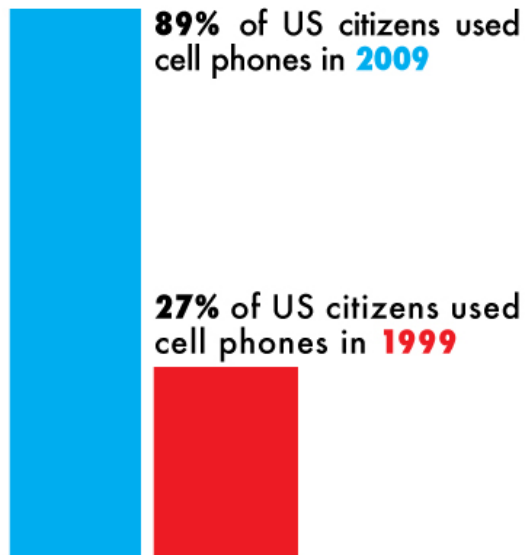
Cell Phones by the Numbers



Social Influence



32% OF MEN and **23% OF WOMEN** say they **CAN'T LIVE WITHOUT** their cell phone



IN AMERICA, 50% OF YOUNG ADULTS NEVER USE A TRADITIONAL LAND LINE...

LAND LINE REVENUES PLUMMETED 30% THIS DECADE AND THEY WILL CONTINUE TO DIMINISH OVER 50% IN THE COMING YEARS...

47% OF TEENS say their social lives would end without text messaging.



Perception



BREAKING NEWS FROM 2000:

FDA REMAINS UNDECIDED WHETHER CELL PHONE RADIATION IS DANGEROUS OR MYTH...

THE CELL PHONE EVOLVED FROM
 **HEALTH SCARE GIMMICK**

TO

 **GROUNDBREAKING &**
ESSENTIAL SOCIAL TOOL.
(WITH THE RIGHT APPS, OF COURSE)



BREAKING NEWS FROM 2009:

CELL PHONE VIDEO AND TWITTER REVEAL DEATH OF IRANIAN PROTESTOR, NEDA AGHA-SOLTAN...

ECS455

Class Organization

Office Hours:

BKD 3601-7

Tuesday 14:00-16:00

Friday 14:00-16:00

Course Organization

prapun.com/ecs455

- **Course Web Site:**

<http://www2.siit.tu.ac.th/prapun/ecs455/>

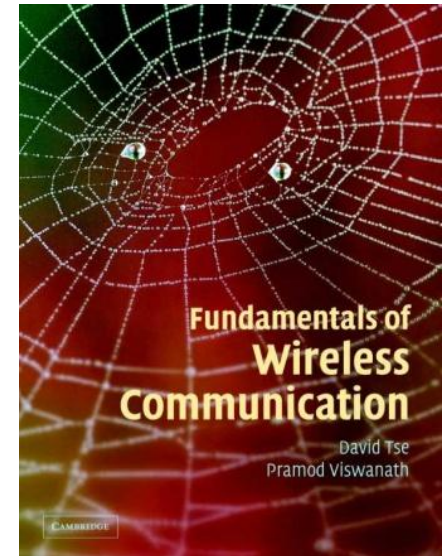
- **Lectures:**

- **Tuesday** 13:00-14:20 BKD 3509
- **Friday** 10:40-12:00 BKD 3509

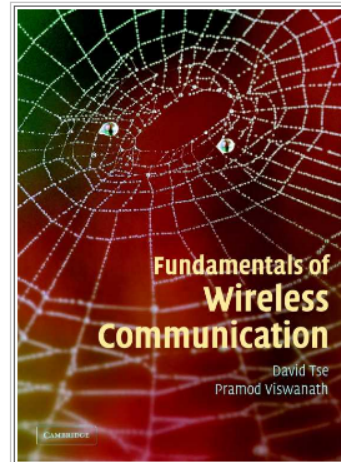
- **Textbook:**

- **Fundamentals of Wireless Communication**

- By D. Tse and P. Viswanath
- Cambridge University Press, 2005
- Companion Site: <http://www.eecs.berkeley.edu/~dtse/book.html>



Tse's Web Site



Fundamentals of Wireless Communication

[David Tse](#) and [Pramod Viswanath](#)

[Cambridge University Press](#), 2005

Buy the book: [Cambridge University Press](#)

[Amazon.com](#)

[BookFinder.com](#)

All chapters of the textbook can be downloaded.

<http://www.eecs.berkeley.edu/~dtse/book.html>

Now with exercises included!

1. Introduction; [PDF](#)
2. The wireless channel; [PDF](#)
3. Point-to-point communication: detection, diversity and channel uncertainty; [PDF](#)
4. Cellular systems: multiple access and interference management; [PDF](#)
5. Capacity of wireless channels; [PDF](#)
6. Multiuser capacity and opportunistic

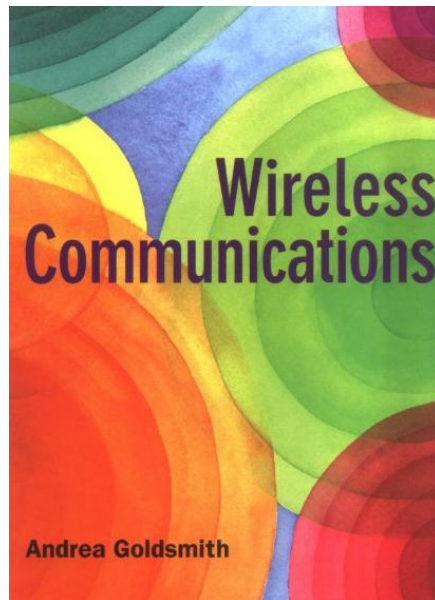
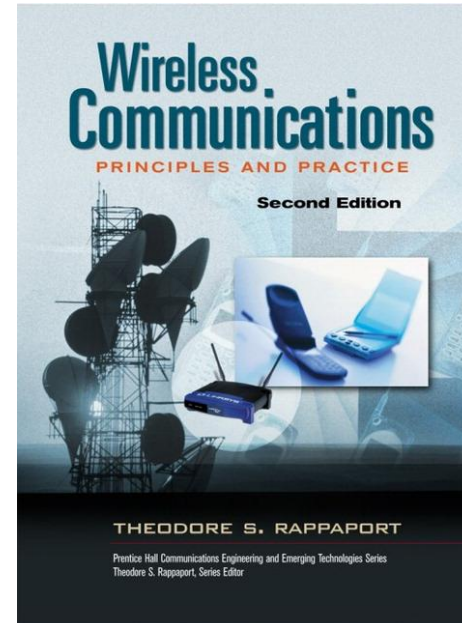
Book Description

The past decade has seen many advances in physical-layer wireless communication theory and their implementation in wireless systems. This textbook takes a unified view of the fundamentals of wireless communication and explains the web of concepts underpinning these advances at a level accessible to an audience with a basic background in probability and digital communication. Topics covered include MIMO (multiple input multiple output) communication, space-time coding, opportunistic communication, OFDM and CDMA. The concepts are illustrated using many examples from wireless systems such as GSM, IS-95 (CDMA), IS-856(1xEV-DO), Flash OFDM and ArrayComm SDMA systems. Particular emphasis is placed on the interplay between concepts and their implementation in systems. An abundant supply of exercises and figures reinforce the material in the text. This book is intended for use on graduate courses in electrical and computer engineering and will also be of great interest to practicing engineers.

[Reviews](#)

More References

Theodore S. Rappaport, “*Wireless Communications: Principles and Practice*,” 2nd Edition, Prentice Hall PTR, 2002.



A. Goldsmith, “*Wireless Communications*,” Cambridge Press, 2005.

More references after the midterm.

Course Web Site

- Please check the course Web site regularly.
- Announcement
- References
- Handouts/Slides
- Calendar
 - Exams
 - HW due dates



www2.siiit.tu.ac.th/prapun/ecs455/

ECS455: Mobile Communications

In less than three decades, the status of cellular telephones has moved from laboratory breadboard via curious luxury item to the world's most pervasive consumer electronics product. Ever though wired telephony is 100 years older and the beneficiary of "universal service" policies in developed countries, the number of cellular phones has exceeded wired phones for a few years and the difference keeps growing. For hundreds of millions of people in developing countries, cellular communications is the only form of telephony they have experienced.

Synopsis

This course provides an introduction to mobile communications system principles, design and technology. It also covers state-of-the-art topics such as LTE (4G-FDMA).

Announcements

- Welcome to ECS455! Feel free to look around this site. (Posted @ 11AM on Nov 3)

General Information

- **Instructor:** Dr. Prapun Sukkompong (prapun@iiit.tu.ac.th)
- **Course Syllabus**
- **Class Information**
- **Office Hours**
 - Room: BKD3601-7
 - 8A2 2PM-4PM
 - **Please feel free to ask any question or express any concern after class.**
- **Main Textbook:** Q. Tao and P. Veevorath, *Fundamentals of Wireless Communication*, Cambridge University Press, 2005.
- **References**
 - Theodore S. Rappaport, *Wireless Communications: Principles and Practice*, 2nd Edition, Prentice Hall PTR, 2002. ISBN-10: 0-13-042223-3. Call No. TK5102.R37 2002
 - There are quite a number of typos in this book. Please go to the update page to download the pdf file of the pages that have been fixed.
 - A. Goldsmith, *Wireless Communications*, Cambridge Press, 2005.
 - M. S. Karim and Mohsen Sarraf, *4G-CDMA and cdma2000 for 3G Mobile Networks*, McGraw-Hill Professional, 2002.
 - J. S. Lee and L. E. Miller, *CDMA Systems Engineering Handbook*, Boston, MA, Artech House, Oct. 1998.
 - R.E. Ziemer, *Fundamentals of Spread Spectrum Modulation*, Colorado Springs: Morgan & Claypool Publishers, 2007
 - A. Bahai, B. S. Sathurberg, and M. Ergen, *Multi-Carrier Digital Communications: Theory and Applications of OFDM*, 2nd ed., New York: Springer Verlag, 2004.
 - H.G. Myung and D.J. Goodman, *Single Carrier FDMA: A New Air Interface for Long Term Evolution*, Wiley, 2006.
- **More References**
 - Whitt, *The Erlang B and C Formulas: Problems and Solutions*, class notes, 2002
 - James R. Norris, *Markov Chains*, Cambridge University Press, 1997.
 - Spectrum Frequency Chart
- Infographic from Cellphones.org
 - Timeline of the Analog Phone
 - How a Cell Phone Call Work
 - 4 Generations of Cell Phones
 - Cell Phones and Airplanes
 - Cell Phones and Radiation
 - Cellphones, Privacy and Data Leaks
- CDMA world Coverage map
- CDMA Asia-Pacific Coverage

Handouts and Course Material

- Slides from previous year are posted to give you a sneak preview of the up-coming class material

Current Year	Previous Year
Part 1	Old slides

Problem Set

- HW1
-

Calendar

Today	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Nov 1	2	3	4	5	6	7	
8	9	10	11	12	13	14	
15	16	17	18	19	20	21	
22	23	24	25	26	27	28	
29	30	Dec 1	2	3	4	5	

Events shown in the zone: Bangkok [Google Calendar](#)

Reading Assignment

- [T&W] Intro of Ch 2
- [T&W] Intro of Sec 2.1
- [T&W] Section 2.1.1, 2.1.2, 2.1.6
- [T&W] Intro of Sec 2.2.
- [T&W] Section 2.2.1, 2.2.2

Course Outline

- Review: Fourier transform and basic communication systems
- Cellular communications, Principles of cellular radio
 - Wireless Channel (Part 1)
 - Spectrum Allocation
 - Frequency Reuse and Sectoring
 - Trunking Theory and Erlang B formula
 - Poisson Process with review of basic probability theory
 - Markov Chain
 - The "beer" introductory textbook on Markov chain is probably the one written by Norris. This again will be an overview for this class but it serves as a good reference if you want to dig into this topic further. There are some sample chapters available on the web as well.
 - Whitt wrote an article that provide several remarks on Erlang B formula via a

Course Web Site: Notes & Slides

- Notes/slides will be posted and updated.
- Everything that I write on my tablet will be uploaded to the course web site. These include comments that are made on pdf files.

Handouts and Course Material

- Slides: [Introduction to ECS455](#).
- Slides from previous year are posted to give you a sneak preview of the up-coming class material

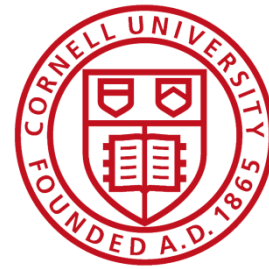
Ch	Handouts & Slides
1	<ul style="list-style-type: none">• Old slides• Notes #1: Fourier Transform and Communication Systems• Slides: 1.1 Mobile Communications & 1.2 Fourier Transform and Communication System

Course Outline

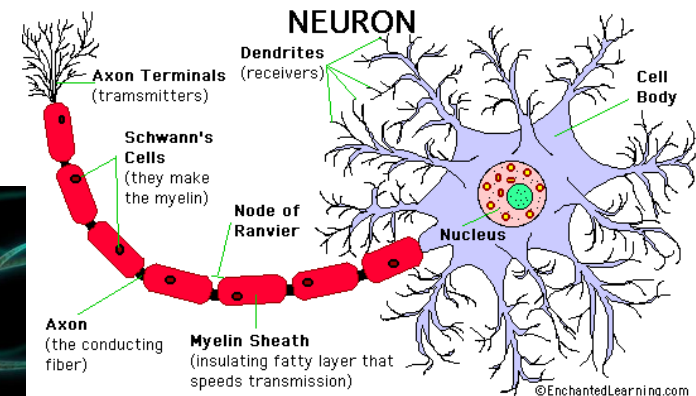
1. Review of Fourier transform, Modulation, and Basic communication systems
2. Cellular communications
3. M/M/m/m Assumption and Derivation of Erlang B formula
4. Duplexing: TDD vs. FDD
5. Multiple Access Schemes
6. Spread Spectrum Communications
7. Multi-carrier and OFDM systems
8. GSM, GPRS, EDGE, UMTS (W-CDMA), WiMAX (OFDMA), LTE (SC-FDMA)

Me?

prapun.com



- PhD from Cornell University
- In Electrical and Computer Engineering
- Minor: Mathematics (Probability Theory)
- Ph.D. Research: Neuro-Information Theory
 - Modeling and analyzing neurons in human brain from communication engineering perspective.
- Current Research: Wireless Communication
 - Mobile, WiFi
- Best Teaching Award, 2009, SIIT



Grading System

- Coursework will be weighted as follows:

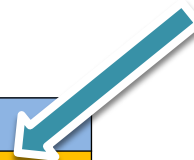
Assignments	5%
Class Participation and Quizzes	15%
Midterm Examination •24 Dec 2010 TIME 09:00 - 12:00	40%
Final Examination (comprehensive) •4 Mar 2011 TIME 09:00 - 12:00	40%

- Mark your calendars now!
- Late HW submission will be rejected.

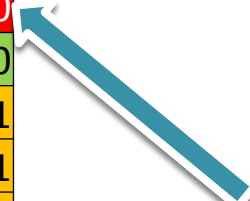
Calendar

M	T	W	R	F
11/8/2010	11/9/2010	11/10/2010	11/11/2010	11/12/2010
11/15/2010	11/16/2010	11/17/2010	11/18/2010	11/19/2010
11/22/2010	11/23/2010	11/24/2010	11/25/2010	11/26/2010
11/29/2010	11/30/2010	12/1/2010	12/2/2010	12/3/2010
12/6/2010	12/7/2010	12/8/2010	12/9/2010	12/10/2010
12/13/2010	12/14/2010	12/15/2010	12/16/2010	12/17/2010
12/20/2010	12/21/2010	12/22/2010	12/23/2010	12/24/2010
12/27/2010	12/28/2010	12/29/2010	12/30/2010	12/31/2010
1/3/2011	1/4/2011	1/5/2011	1/6/2011	1/7/2011
1/10/2011	1/11/2011	1/12/2011	1/13/2011	1/14/2011
1/17/2011	1/18/2011	1/19/2011	1/20/2011	1/21/2011
1/24/2011	1/25/2011	1/26/2011	1/27/2011	1/28/2011
1/31/2011	2/1/2011	2/2/2011	2/3/2011	2/4/2011
2/7/2011	2/8/2011	2/9/2011	2/10/2011	2/11/2011
2/14/2011	2/15/2011	2/16/2011	2/17/2011	2/18/2011
2/21/2011	2/22/2011	2/23/2011	2/24/2011	2/25/2011
2/28/2011	3/1/2011	3/2/2011	3/3/2011	3/4/2011
3/7/2011	3/8/2011	3/9/2011	3/10/2011	3/11/2011

Lecture



Exam



Class Participation

- NOT the same as class attendance!
- If you come only to **receive**, you will fall **asleep**.
 - Do not simply sit quietly in the class.
- Need **interaction**.
- **Ask question** when there is something that you don't understand.
 - Don't be shy!
 - It is very likely that your friends don't understand it as well.
- If you already understand what I'm presenting, **SHOW ME!**
 - Point out the errors/typos.
 - I will raise many issues/questions in class. Try to comment on them.
- Don't be shy!

Class Participation (2)

- Record what you have done.
- Submitted before the midterm and before the final.



Sirindhorn International Institute of Technology
Thammasat University at Rangsit
School of Information, Computer and Communication Technology

ECS 455: Self-Evaluation

Instructions

1. The class participation score for this class is judged from how much you actively participate in the class discussion both inside and outside of the classroom.
2. Please honestly answer the following questions. Please provide as much information as possible.
3. Your answer will be read in detail and it may influence the actual score.

Questions

1. How many times have you been absent from the class? Are there any specific reason(s)? Please explain.
2. How many times have you been late (> 3 mins) for the class? Are there any specific reason(s)? Please explain.
3. How many times have you left the class early (> 3 mins)? Are there any specific reason(s)? Please explain.
4. How many times have you participated (provided comments, asked questions, answered questions, etc) in the lectures? Be specific. Provide some short description for each event. (You may put this on another sheet of paper.)

17/06/2010 : I asked question for the example of current source [Op-amp].

24/06/2010 : I answered for the Example 9.2.7. that's $1 \parallel 2 \Omega$ and series with 5Ω .
But it's wrong. The correct answer is "There's no series in that circuit".

01/07/2010 : I asked question "Is participate include with ask question after class".
Answer: Yes


08/07/2010 : I asked about Linear equation "Why $f(x) = 3x+1$ is not a linear equation eventually it is $y = mx+c$ "
Answer: Because it's not satisfy $S(x)+k(S)x$ and $S(x_1+x_2) = S(x_1)+S(x_2)$

15/07/2010 : I asked teacher to give an example of supermesh.
Answer: "We can use only supernode to solve the problems in this class.
You can find more in the textbook for supermesh".

29/07/2010 : I told teacher that we don't have class in static today so we can move this class instead.
I asked: "Is the integrator and differentiator op-amp circuit is the same as in the calculator function" "No for the op-amp it's analog and for calculator is digital".

19/08/2010 : I answered $\frac{d}{dt} \sin \theta = \cos \theta$, $\frac{d}{dt} \cos \theta = -\sin \theta$
I corrected $\frac{d}{dt}$ the unit of voltage from A \rightarrow V.

Policy

- We will start the class **on time** and will finish **on time**.
 - Raise your hand and tell me immediately if I go over the time limit.
 - Does NOT mean that I will leave the room immediately after lecture.
 - I will stay and answer questions.
- Mobile phones *must* be turned off or set in silent mode. 
- We may have some **pop quizzes** (without prior warning or announcement) and in-class activities.
- Attendance and pop quizzes will be taken/given irregularly and randomly.
- Cheating will not be tolerated.

Policy (con't)

- Feel free to stop me when I talk too fast or too slow.
- I will surely make some **mistakes** in lectures / HWs / exams.
 - Some amount of class participation scores will be reserved to reward the **first** student who inform me about each of these mistakes.
- Points on quizzes/ exercises/ exams are generally based on your entire solution, not your final answer.
 - You can get full credit even when you have the wrong final answer.
 - You may get **zero** even when you write down a right answer without justification.

Help and Office Hours

- Get some help!
 - Do not wait until the final exam time or after the grade is out.
 - Right after lecture is always a good time to ask question.
- Office Hours (BKD-3601)
 - T: 3PM to 4PM & F: 2PM to 4PM
 - Appointment can be made.
 - Tutorial session can be arranged.
 - Feel free to come to my office and chat!
 - Don't be shy.

Warning

- This class can be **difficult**.
 - Keep up with the lectures.
 - Make sure that you understand the concepts presented in the lecture before you go home.
- I will **evaluate** your understanding of the course **regularly** through
 - In class problems/activities
 - Quizzes
 - Exams



Concluding remarks

1. Check the course web site regularly
2. Participate actively in class and outside of class
 - Record what you have done.