

# Mobile Communications

ECS 455

**Dr. Prapun Sukksompong**

[prapun@siit.tu.ac.th](mailto:prapun@siit.tu.ac.th)

**Office Hours:**

**BKD 3601-7**

**Wednesday 15:30-16:30**

**Friday 9:30-10:30**

# Mobile Communications

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**Introduction**

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# Course Organization

- **Course Web Site:**

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

- **Lectures:**

- **Tuesday 15:30-17:20 BKD 3510**
- **Thursday 13:30-15:20 BKD 3510**



[prapun.com/ecs455](http://prapun.com/ecs455)

# Getting Info About This Course

- The **syllabus** contains tentative information.
- I will announce **in class** and on the **web site** if there is any change.
- You are responsible for making sure that you obtain this information.
- Come to classes on time and listen carefully for announcement.
- PowerPoint **slides** will be posted on the web soon after class.
- For those who want a preview of the class materials, old slides along with the notes and HWs from earlier years are available on my web site ([prapun.com](http://prapun.com)).

# Marty Cooper: Cellphone Inventor

- 1973
- Motorola DynaTAC prototype
- Weighed nearly **two kilos**
- Cost approximately **\$1 million** for Motorola to produce.
- **20 minutes** battery life



[<http://gizmodo.com>]

*Not a problem* because you could not hold it up for twenty minutes; it was so heavy.



# 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



# Evolution

1970



1965-'70: TV comedy **Get Smart** predicts the future by depicting a mobile phone, the irreverent "shoe phone."



1966-'69: **The Star Trek Communicator**, said to be the inspiration for Martin Cooper's mobile phone, debuts in the late sixties.



Product Development Technologies' team has been at the forefront of many mobile innovations.

Learn more about our work at [PDT.com](http://PDT.com)

1973



1996

1999

1980



HAPPY CHRISTMAS!

✉ SENT

1992: The first text message is sent. It reads "Happy Christmas."



1995: The film **Clueless** features teenage characters on mobile phones, helping to further the youth culture's mobile obsession.

1973: **Martin Cooper** invents the first mobile phone.

1996: The first ever clamshell/flip mobile phone, the **Motorola StarTAC**, is released.



1983: The **Motorola Dynatac 8000X** (the "Zack Morris phone") debuts, weighing nearly two pounds and retailing for almost \$4,000.



1998: **Bluetooth** hits the market, enabling easy hands-free phone use.

2000

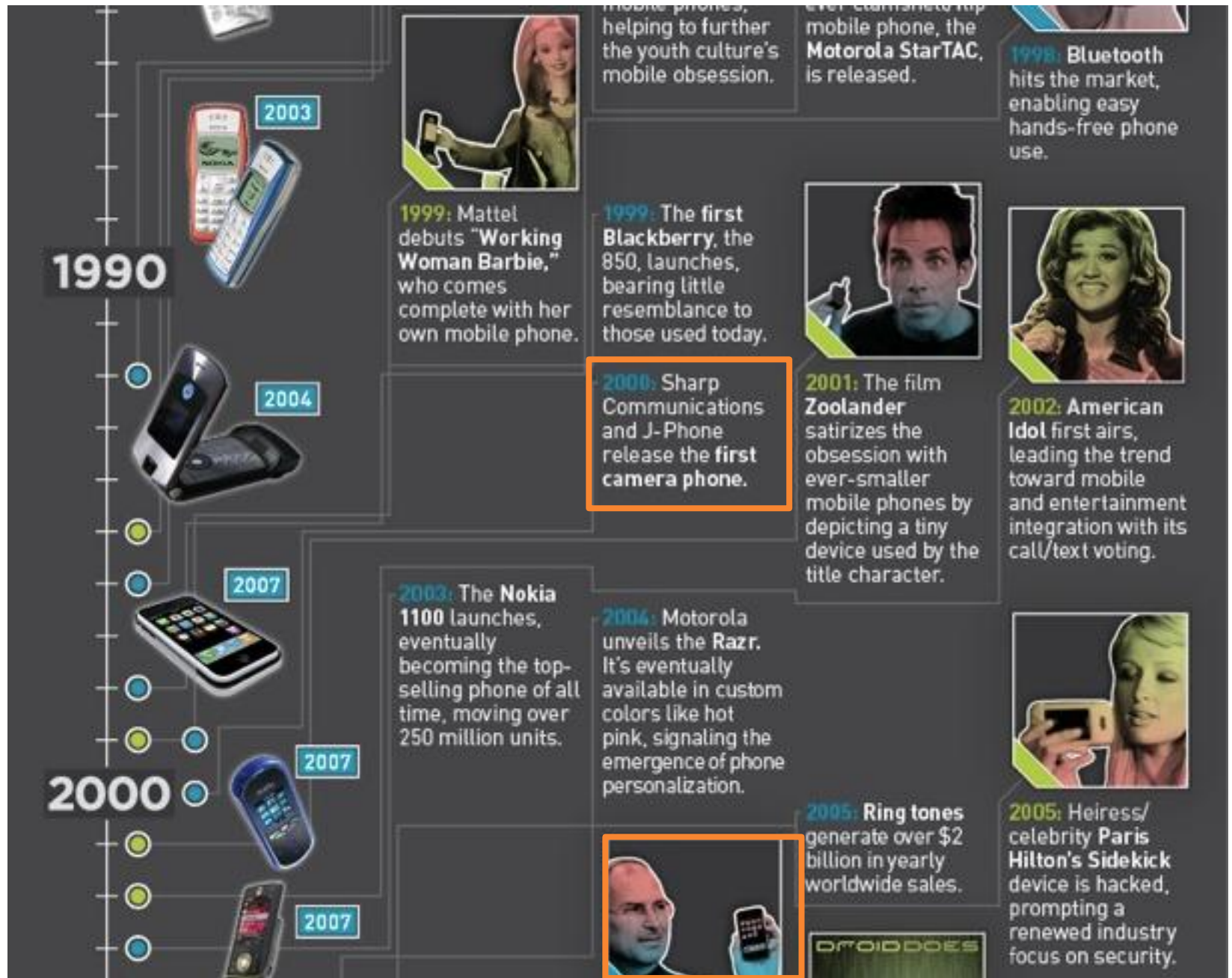


2003





# Evolution (2)



# 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!**



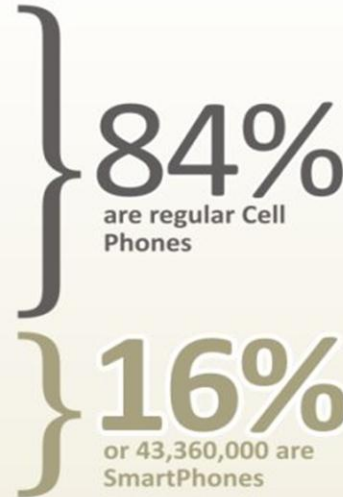
**4,239,956 PEOPLE**  
are having a cell  
phone conversation  
at any given **SECOND**  
in the world

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

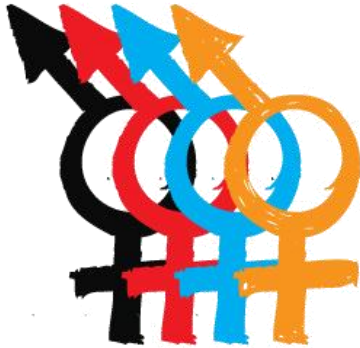
# US Market



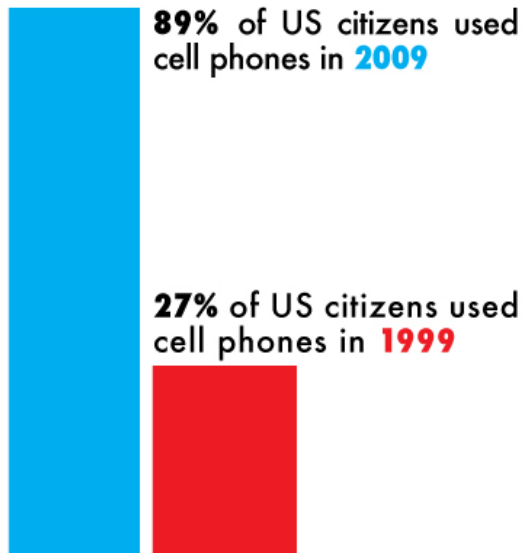
## Cell Phones by the Numbers



# 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.



(con't)

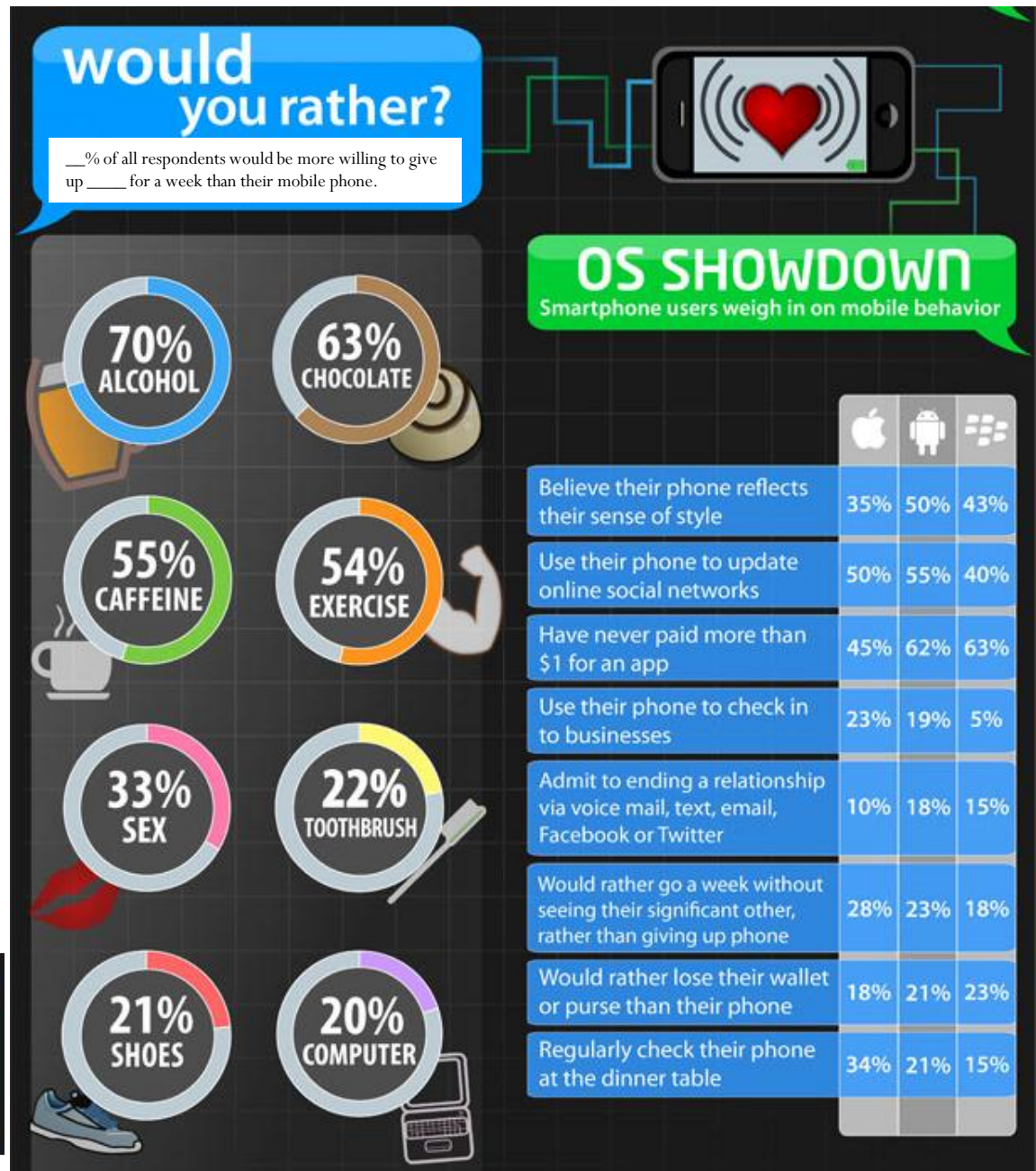
## TeleNav survey examines Americans' attachment to mobile phones

### MORE LOVE STORIES

**66%** of smartphone users said they sleep with their phone next to them

**31%** of smartphone users said they check their phone while at the movies

13



# 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...**

# News: Banning Texting, Cell Phones While Driving (in US)

- The National Transportation Safety Board (NTSB) urged all U.S. states to **ban** drivers from **using electronic devices while driving**, including for text messaging.
- **Distracted driving**, which includes texting and talking on a cell phone, is a major cause of death on the road.
- Nearly two out of every 10 drivers and half of drivers ages 21 to 24 said they are texting while driving.
- A CBS News poll conducted in May found that 94 percent of Americans said they believed texting while driving should be outlawed.



“No call, no text, no update, is worth a human life.”

[<http://abcnews.go.com/US/ntsb-recommends-banning-texting-cell-phone-calls-driving/story?id=15147547>]

# Hands-free?

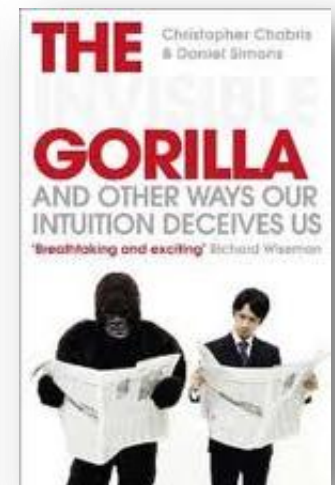
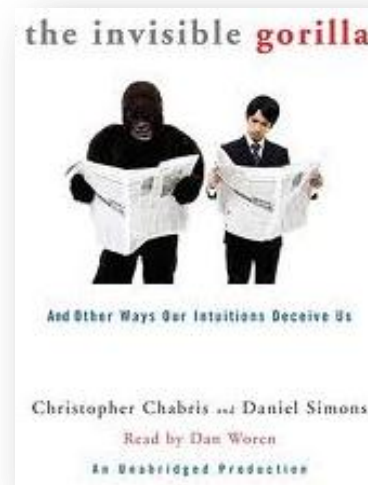
- Current research shows hands-free devices are not that much safer than regular cellphones.
- States that ban cellphones but allow hands-free phones have not seen drops in fatality rates.
- Create “**inattentional blindness**” or “**illusion of attention**”.
  - The mental or cognitive distraction is still there with the hands-free cellphone.
  - When your mind is paying attention to the conversation, you don’t notice what is in front of you.”





# Video

# More on “Attention”



# ECS455

## Class Organization

**Office Hours:**

**BKD 3601-7**

**Wednesday 15:30-16:30**

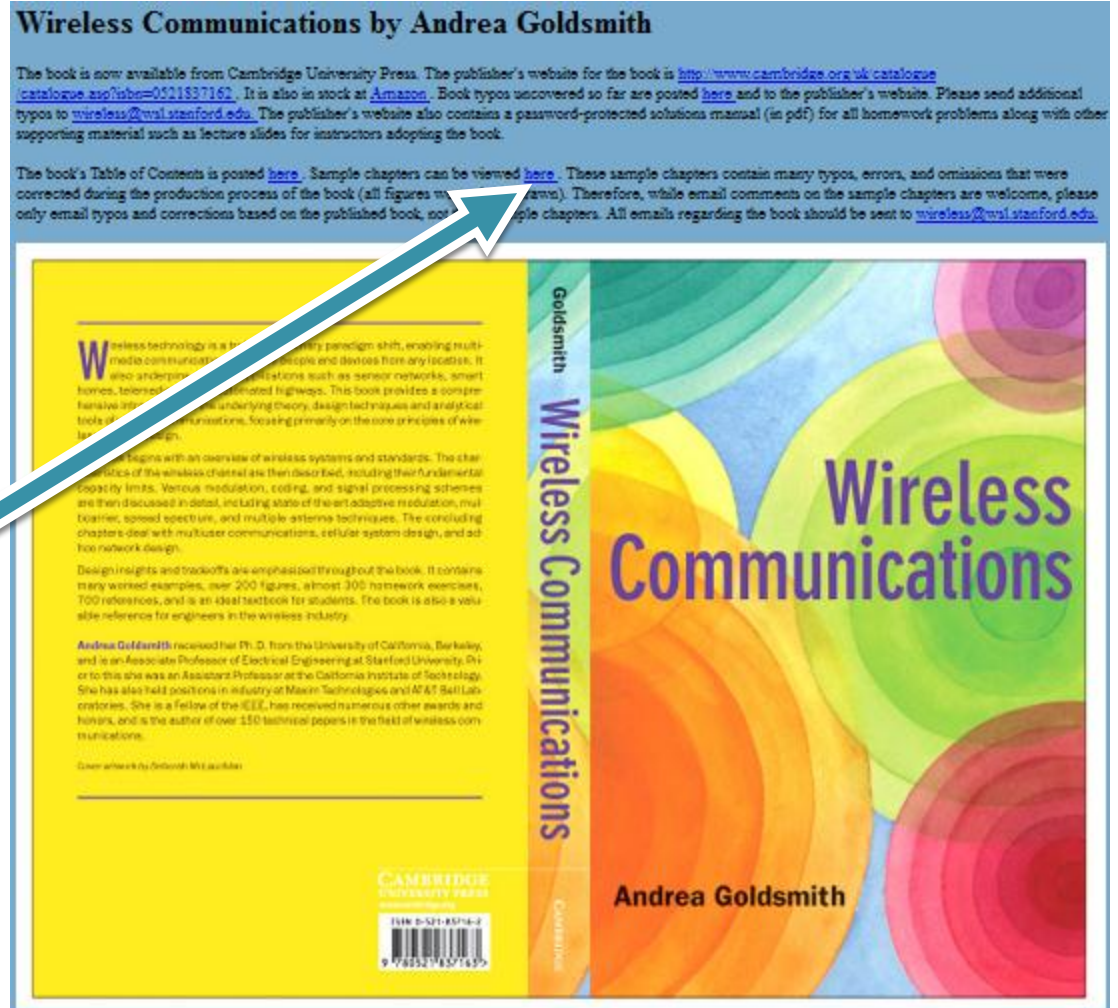
**Friday 9:30-10:30**

# Wireless Communications

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

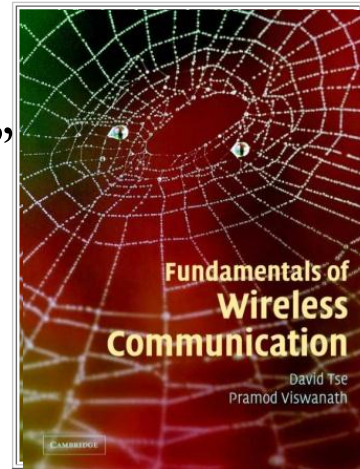


Sample chapters (1, 3, 4,  
6, 10, 12, 14, A, B, C, D)  
of the textbook can be  
downloaded.



# Fundamentals of Wireless Comm.

D. Tse and P. Viswanath,  
“*Wireless Communications*,”  
Cambridge Press, 2005.



## Fundamentals of Wireless Communication

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

[Cambridge University Press](#), 2005

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

[Amazon.com](#)

[BookFinder.com](#)

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

All chapters of the  
textbook can be  
downloaded.



### 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

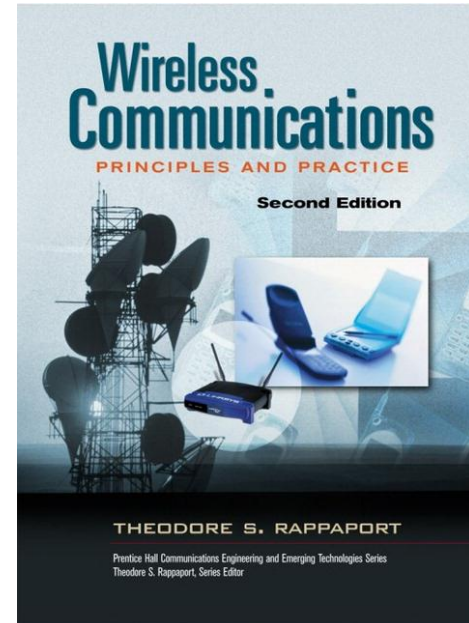
### Book Description

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.

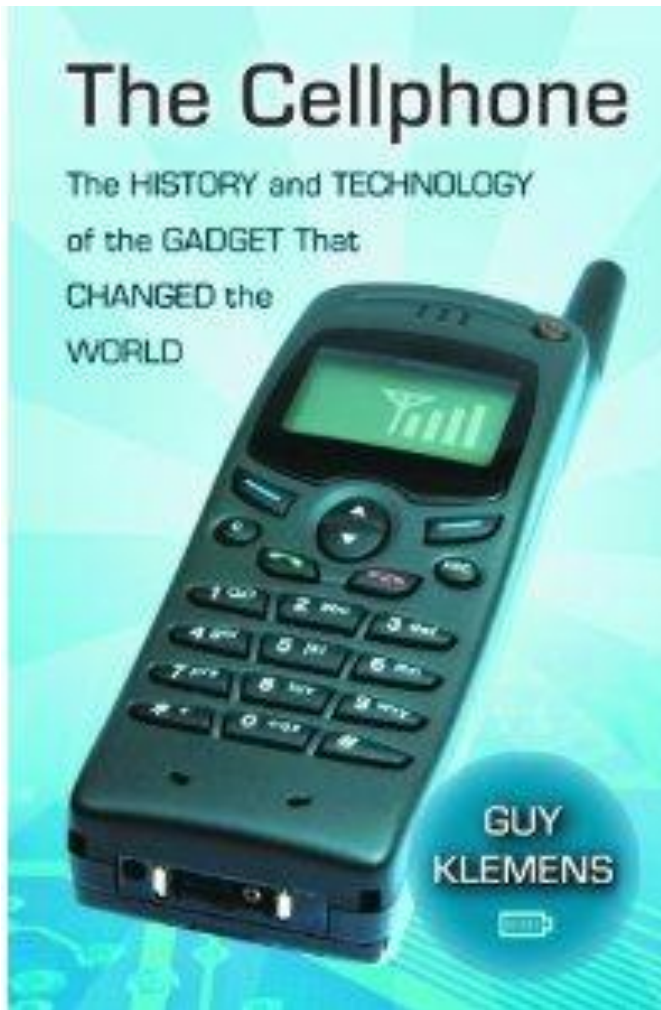
### [Reviews](#)

# Wireless Communications

Theodore (Ted) S. Rappaport,  
“Wireless Communications:  
Principles and Practice,”  
2nd Edition, Prentice Hall, 2002.



# The Cellphone



Guy Klemens,  
“The Cellphone: The History and  
Technology of the Gadget That  
Changed the World,”  
McFarland, September 2010

Easy-to-Read yet Related Book

# 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/](http://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 various luxury item to the world's most pervasive consumer electronics product. Even 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 telephone 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-FD-MAC.

**Announcements**

- Welcome to ECS455! Feel free to look around this site.

**General Information**

- **Instructor:** Dr. Prapun Sukkompong (prapun@siit.tu.ac.th)
- **Course Syllabus**
- **Class information**
- **Office Hours**
  - Room: BCD3001-7
  - Time: **TBA**
  - **Please feel free to ask any question or express any concern after class.**
- **Main Textbook:** A. Goldsmith, *Wireless Communications*, Cambridge Press, 2005.
- **References**
  - **Free Textbook:** D. Tse and P. Viswanath, *Fundamentals of Wireless Communication*, Cambridge University Press, 2005.
  - Theodore S. Rappaport, *Wireless Communications: Principles and Practice*, 2nd Edition, Prentice-Hall PTR, 2002. ISBN-11: 078-0130423232. Call No. TK5103.R37 2002
    - There are quite a number of topics in this book. Please go to the [course page](#) to download the pdf file of the pages that have been fixed.
  - M. R. Karim and Mohsen Sarraf, *Wi-CDMA and cdma2000 for 3G Mobile Networks*, McGraw-Hill Professional, 2002.
  - J. S. Lee and L. E. Miller, *CDMA System Engineering Handbook*, Boston, MA: Artech House, Inc., 1996.
  - R.L. Ziemer, *Fundamentals of Spread Spectrum Modulation*, Colorado Springs: Morgan & Claypool Publishers, 2007.
  - A. Bahai, B. R. Saltzberg, 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, 2008.

**Handouts and Course Material**


Ch	Handouts & Slides
1	- Review: Fourier Transform and Basic Communication Systems
2	-
3	-
4	-
5	-
6	-

• Remark: Take a look at the slides from previous year for a sneak preview of the up-coming class material.

**Problem Set**

	Due Date	Remarks/Solutions
HW1		
HW2		
HW3		
Self-Evaluation form (1)		
HW4		
HW5		
Self-Evaluation form (2)		

**Calendar**



**Reading Assignment**

A.

**Course Outline**

a. Review: Fourier transform and basic communication systems



# Course Website: Notes & Slides

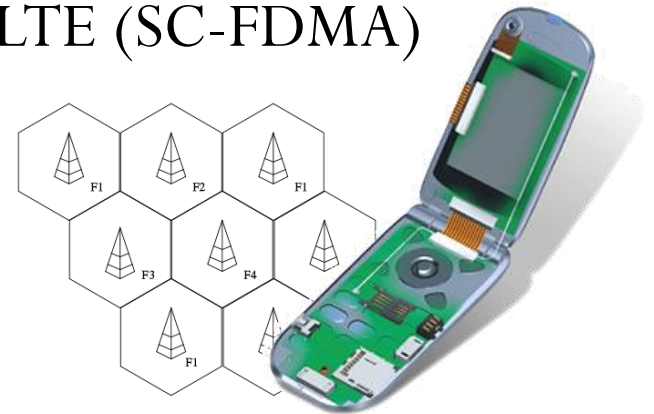
- **Notes** will be posted *before* the corresponding lectures.
  - Hard copies can also be purchased from the **copy center**.
- In lectures...
  - Notes will be highlighted and updated with examples / comments. Some lectures may use slides.
  - **The slides and updated notes will be posted *after* the corresponding lectures.**
  - I also frequently use Microsoft OneNote on my tablet instead of the whiteboard. The files will be exported as pdf and posted *after* the corresponding lectures.
  - Remind me the day after the lecture if the notes/slides from the day before are still not posted on the web.

# Tips

- **Anything** that I have written on my tablet will be saved and posted on the **web** soon after class as well.
  - Sometimes, I write on the whiteboard because I want to walk around. It is also possible that something goes wrong with my tablet. In which case, you (or a good friend of yours) should take a careful note.
- **No need to take detailed lecture notes** (if you don't want to).
  - **Put all of your energy into understanding the material.**
  - Of course, there is always someone who will take good notes anyway and you can (potentially) borrow or make a copy of the notes from them.
- **Have fun** with the materials presented in class.

# ECS455: Topics

1. “Wireless” Communications: Problems and Solutions.
2. “Cellular” Communications: Motivation and Analysis.
3. Multiple Access Schemes: How can many users share communication resources?
4. Spread Spectrum Communications (CDMA)
5. OFDM systems
6. Communication techniques in GSM, GPRS, EDGE, UMTS (W-CDMA), WiMAX (OFDMA), LTE (SC-FDMA)



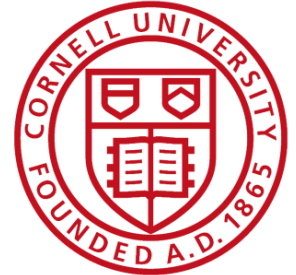
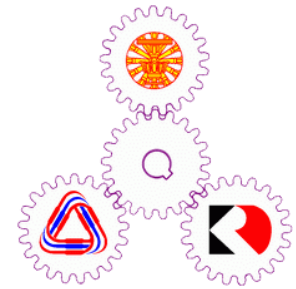
# ECS455: Course Outline

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?

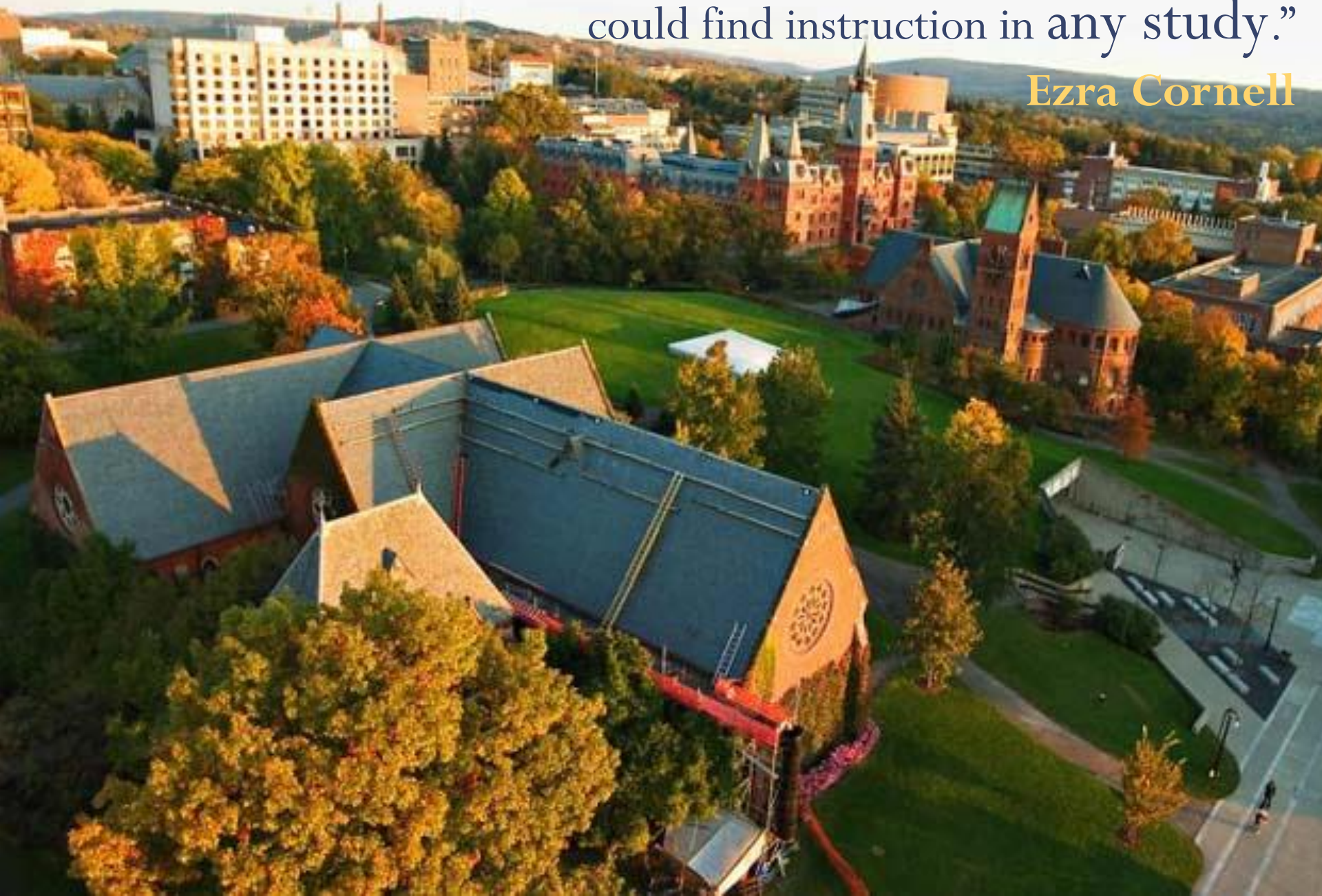
- Ph.D. from **Cornell** University, USA
- In Electrical and Computer Engineering
- Minor: Mathematics (Probability Theory)
- Ph.D. Research: Neuro-Information Theory
  - Modeling and analyzing neurons in human brain from communication engineering perspective.
- Current Research: Wireless Communication
  - Mobile Communications, **WiFi** (802.11)
- Best Teaching Award, 2009, SIIT

[prapun.com](http://prapun.com)



“I would found an institution where any person  
could find instruction in any study.”

Ezra Cornell



On the Ithaca campus alone nearly 20,000 students (13,600 undergrad + 6,000 grad) representing every state and 120 countries choose from among 4,000 courses in 11 undergraduate, graduate, and professional schools.



# Grading System

- Coursework will be weighted as follows:

Assignments	5%
Class Participation and Quizzes	15%
Midterm Examination •21 Feb 2012 TIME 09:00 - 12:00	40%
Final Examination (comprehensive) •3 Apr 2012 TIME 09:00 - 12:00	40%

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



# Calendar (Google)

Today ◀ ▶ January 2012 ▼ Week Month Agenda ▼

Mon	Tue	Wed	Thu	Fri	Sat	Sun
26	27	28	29	30	31	Jan 1
2	3	4 Announcement	5 Registration Period	6 Registration Period	7	8
9 SIIT 2nd Semes	10 3:30pm ECS455 L	11	12 1:30pm ECS455 L	13	14	15
16	17 3:30pm ECS455 L	18	19 1:30pm ECS455 L	20	21	22
23	24 3:30pm ECS455 L	25	26 1:30pm ECS455 L	27	28	29
30	31 3:30pm ECS455 L	Feb 1	2 1:30pm ECS455 L	3	4	5

Events shown in time zone: Bangkok



## ECS455: Mobile Communications

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**Class information**

**Office Hours**

**Room:** BCD3001-7

**Time:** 18A

**Please feel free to ask any question or express any concern after class.**

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Problem Set	Due Date	Remarks/Solutions
HW1		
HW2		
HW3		
Self-Evaluation form (1)		
HW4		
HW5		
Self-Evaluation form (2)		

### Calendar

### Reading Assignment

**Course Outline**

- Review: Fourier transform and basic communication systems

# Calendar

Lecture

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

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** between lecturer and students.
- **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.

# 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 2.2.7. that's  $1 \parallel 2 \Omega$  and series with  $5 \Omega$ .  
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  $s(x)+k(x)$  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".

20/07/2010 : 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)
  - Time:
    - Wednesday: 15:30-16:30
    - Friday: 9:30-10:30
  - 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

