Textbooks: 
1) RF Microelectronics (System)  
   by Behzad Razavi  
   Prentice Hall of India

2) The design of CMOS Radio 
   Frequency Integrated Circuits (Acta) 
   by Thomas H. Lee  
   Cambridge University Press

Other ref: 3) VLSI for Wireless Communication 
   by Boris Leung 
   Prentice Hall Electronics & VLSI Series

Course Format: 4 Projects = 40% 
   1 Final Exam = 30% 
   5-6 HW = 10% 
   Journal Paper Seminar = 20% 

* All HW & projects are due at the beginning of class (on the due date) 

Pre-requisites: 1) EE 5390 - Analog IC Design (or similar) 
2) Understanding of MOSFET operation 
3) Understanding of basic signals & systems: Fourier Series, Fourier Transform (i.e. able to think in both time and frequency domains)
**Topics covered in this course:**

- RF basics, Analog & Digital modulation
- S-parameters, resonance, impedance matching
- Inductors, caps, varactors etc.
- Short-channel MOS operation
- Intro to noise & distortion
- RF Tx & Rx architectures
- LNA, mixer, VCO, PA design & operation
- RF layout

**Lecture #1 - Introduction to RF**

**RF = Radio Frequency**

- Any frequency that carries information (wired or wirelessly)
  
  e.g. AM-FM radio, TV, cellular, WiFi...

![Diagram of RF system](image)

**RF systems ⇒**
1) Transceiver architectures
2) Interaction with RFFE
RFICs → 1) Design of LNAs, Mixers etc.  
2) New circuit topologies

Multi-disciplinary!

DC Design → RF Design ← Microwave theory

→ signal propagation

⇒ Transceiver arch.

CAD Tools → Comm. Theory

Comm. Theory → wireless stds.

RF Design Tradeoffs:

Noise ↔ Power

Linarity → Frequency

Supply Voltage ↔ Chaint

Note: CAD tools are indispensable! however: rely on circuit design knowledge
Why CMOS?

CMOS digital gates:
  - require very few devices per gate
  - dissipate power only while switching
  - dimensions of MOS devices can be easily scaled down
  - lower fabrication cost
    (simple mask set etc.)

CMOS for analog:
  - possibility of SoC (system-on-chip)
  - reduce cost

Disadvantages with CMOS:
  - CMOS is no longer cheap!
    + # of masks is large
      + lithography is getting very expensive
    - leakage current -> static power consumption
  - for Analog, MOSFETs were slower & noisier
    than BJTs (gap has shrunk due to scaling)

Moore's Law: # of transistors on an IC doubles every 2 years

\[ \log (\text{# of MOS}) \]
Path loss:

\[ \text{Power loss} \propto d^2 \text{ (theory)} \]

\[ \text{Power loss} \propto d^{4.7} \text{ (empirical)} \]

Multipath Fading:

Diversity: Redundancy in Tx & Rx path

Space/Antenna div. = 2 or more antennas

Frequency div. = 2 or more carrier freq. (frequency hopping)

Time div. = data is sent more than once to overcome short-term fading