1. **Announcements**

TCOM 551 will be meeting in Innovation Hall, room 134, almost every Tuesday, 4:30 – 7:10 p.m., beginning on September 1st, 2009. The current schedule of classes (see section 11) allows for 14 lectures, with the final exam on Tuesday, December 15th, 2009. The exact set of class meeting days is given below in section 11.

2. **Expected Background**

College-level mathematics above Analytical Geometry is not required, although students will be expected to learn, and master, design concepts that require some numerical manipulation. The first lecture will provide most of the mathematical concepts that will form the basis for understanding the design of digital links. Communications concepts learned earlier in TCOM 500 will be re-enforced with a number of numerical examples to explain the concepts in detail.
3. Expected Learning Experience

TCOM 551 is the required class for all students who want to proceed to the wireless communications courses in Satellite Communications (TCOM 607) and Advanced Link Design (TCOM 707). It is suggested that students also take TCOM 551 to help them understand concepts that will be taught in TCOM 552, Mobile Communications. The TCOM 551 course will provide students with a really solid foundation in transmission engineering which, coupled with network classes, will enable students to be comfortable with all forms of design concepts from distributed wireless networks, to WiMAX, to all forms of satellite systems (FSS and VSATs). TCOM 551 students will greatly benefit from the real-world applications taught in the course. These will have an immediate impact on their search for positions in the area of wireless communications (mobile, terrestrial, and satellite).

No single textbook addresses the course completely. Some provide just the theoretical background using higher-level mathematics, which is not appropriate for a program like TCOM. Others teach at too low a level for the required design concepts to be understood. For this reason, the two textbooks used are really supplementary to the material that will be presented over the lecture series in the TCOM 551 course, although the book by Kolimbiris is by far the more extensive in its coverage and explanations of digital communications. However, the Kolimbiris is not called out as a mandatory textbook. The book by Bateman provides a lot of general background material.

The main material for the course will be provided in PowerPoint slides, with the first lecture contained in this web site. Subsequent lectures will be distributed by Email.

NOTE: All lectures and homework assignments and solutions will be distributed to the class through their George Mason University Email accounts. It is therefore essential that students activate their GMU Email accounts. It is a simple matter to have your Email forwarded to a preferred address from the GMU address. However, please remember you will need to clean out your GMU account regularly so as not to have a storage problem and consequently rejected Emails. Also, please do not use hotmail as a forwarding account, since you will probably not be able to receive the Power Point slides due to the size of the file.

4. Required Books and Calculator

A. Mandatory Textbook

1. There is no mandatory textbook for this course as yet
Recommended Supplementary Textbook

2. Textbook Title: *Communications Systems Volume-1 Fundamentals*  
Author: Harold Kolimbiris  
Publisher: Phaeton Press 2008  
ISBN No. 978-0-9782363-0-4

Additional reading

3. Title: *Digital Communications*  
Author: Andy Bateman  
Publisher: Addison Wesley Longman 1999  
ISBN No. 0-201-34301-0

[Note: this is a paperback book with a CD ROM]

B. Calculator

Students should have a calculator, or a PDA (or equivalent) with a calculator option. The calculator shall have the following functions, as a minimum:

(a) LOG  (This key will convert an entered number into its log_{10} value)
(b) 10^x  (This key will convert the log_{10} value back into the original number)
(c) SIN  (This key will convert an angle into the sine of that angle)
(d) COS  (This key will convert an angle into the cosine of that angle)
(e) TAN  (This key will convert an angle into the tangent of that angle)
(f) SIN^{-1}  (This key will convert the sine value of an angle back into the angle; this action is sometimes called ARCSIN rather than SIN^{-1})
(g) COS^{-1}  (This key will convert the cosine value of an angle back into the angle; this action is sometimes called ARCCOS rather than COS^{-1})
(h) TAN^{-1}  (This key will convert the tangent value of an angle back into the angle; this action is sometimes called ARCTAN rather than TAN^{-1})

The calculator should also have the normal +, -, \times, \div arithmetical actions.

A number of examples in class will require the conversion from normal numerical values into logarithms (i.e. log_{10}), and vice versa, in addition to using the standard geometrical functions sine, cosine, and tangent.

NOTE: Calculators will be required in the tests and exams. For this reason, advanced calculators that store equations and other processes will not be permitted. Please make sure you have only a simple calculator for the closed book, closed notes tests and final exam. Unusual equations, or long equations, will be given to students in exams in the
form of a handout sheet. The key to the exams is being able to understand the processes rather than memorization. A sheet with equations will be available in each test or exam.

5. **Lecture Notes**

As noted earlier, Power Point slides for the lectures will be distributed by Email to the class prior to each lecture. The set of slides for the first class is posted on this web site without restriction.

6. **Homework**

1. Homework Exercises will be assigned periodically (approximately once per week for the first two-thirds of the course) and are due the following week at the beginning of the class.
2. Homework will be collected in hard copy only, unless there is a specific requirement to provide a ‘soft’ copy. Homework will be graded. In most questions, what will carry the greatest number of marks will be the process in which the question has been answered, not the answer itself. Please give all intermediate steps in a question so that partial credit may be given, even though you may not have reached the correct solution. And **PLEASE** put your name and ID number on each sheet of paper and staple the sheets together.
3. Homework will not normally be accepted by Email unless prior permission has been given, e.g. a student is on travel.
4. Late homework will only be accepted
   a. With prior permission, and
   b. If the graded homework has not yet been handed back to the class.
5. To help students with travel commitments, one homework may be dropped from the total number of homeworks set. However, the tests draw most of their material from the homeworks set and so students are encouraged to complete all of the homeworks.
6. Solution sets for the homeworks will be available before the tests on those homeworks.

Students are encouraged to work together on homework problems, but they should **only** submit their own written work.

**TWO IMPORTANT NOTES**

Students are encouraged to find, and use, any and every source they may locate to answer a question or for their term paper. HOWEVER: if elements of their paper have been downloaded from the web or transcribed from another source, STUDENTS MUST WITHOUT FAIL acknowledge the source document. If the elements used are exact copies, those passages must be within quotation marks to note they are not original statements of the student. This includes written sections, diagrams, and pictures. Failure to acknowledge a source used is considered to contravene the copyright act and may also
be subject to honor code proceedings if the student claims the work to be original when it is copied from another person or source.

7. **Intermediate Tests**
   Two Tests will be given (in class) during the semester. They will be closed book, closed notes tests of about two hours each. The first test will cover class work up to and including the lecture prior to the day of the first test (i.e. lectures 1 through 5 and homeworks 1 through 5). The second test will cover class work that has been done after the first test and up to and including the lecture prior to the day of the second test (i.e. lectures 6 through 10 and homeworks 6 and 7). Tests will be closely based on the homework questions set, and again, it will be the process of calculating the answer that is the most important, not the precise answer obtained. An equation sheet will be issued for each test for use by students.

8. **Term Paper**
   Students will be required to submit a term paper on a topic of their choosing that is in the general field of digital communications. The paper should be on the order of 10 pages long (equivalent to about 2,500 words on 11 × 8 paper, plus three or four figures or pictures). Example topics for this paper could be:
   - Which multiple access method is better in certain system applications, and why: TDMA or CDMA?
   - What was the impact of MPEG2 on video communications?
   - What does LD-CELP mean and how has it revolutionized the transmission of voice traffic?
   - In what ways is digital TV better than Analog TV, or vice versa?
   - What is a “smart” antenna and how will it help us in wireless communications?
   - What is the impact of spectrum congestion on new services and existing services?
   - How did Digital Signal Processing affect the introduction of digital communications?
   - How has digital imaging and digital manipulation impacted sports broadcasting and production procedures?
   - What digital technologies are set to impact video film production and distribution?
   - Why did direct broadcast satellite services fail when analog modulation was used but succeed when digital modulation was used?
   - What is UWB?
   - Why is PPM becoming important for long distance optical communications?
   - What are useful measures of spectrum efficiency?
   - What are software-defined radios?
   - Is an optical back-plane a feasible switching option yet?
   - What are the differences between the US GPS system and the European Galileo system?
   - Etc.!!
The term paper is designed to develop the students’ awareness of the multifaceted impact of digital communications technology on our everyday lives. It is also a way of getting students used to writing a technical paper that will almost certainly be required in their work careers. Students may work individually or, with permission, as pairs or trios on a given project. The term paper shall be written with the following basic formatting and fonts:

Double-spaced lines  
Single-sided pages  
Times New Roman font  
Font size 12  
Default MS Word margin spacing.

References cited may be either placed as footnotes on the page where the reference is cited or sequentially in a numbered index at the end. Full references shall be given (all authors, journal name, volume, number, date, pages [start and stop]) and, for web references, the full URL and the date the material was extracted.

The term paper will NOT be allocated any specific marks. However, it will be used as a potential ‘grade-shifter’. If a student submits an excellent paper, then this would be used as a positive influence to move the student up one grade increment if the student is on the borderline between two grades (e.g. B+ and A-). A bad paper will not cause the student to be moved down a grade increment. A soft copy of the term paper will be due the week before the final exam, i.e. on Tuesday, December 8th, 2009, the day of lecture #14. The soft copy may be sent as a Word document attached to an Email. The hard copy must be delivered by noon of the day of the final exam, Tuesday December 15th, 2009.

NOTE

A student who does not hand in a term paper will have the score of his or her final exam cut in half. That is, a final exam score of 90% will become a 45% score in the calculation of the final grade, if the student does not hand in a term paper considered to be adequate.

A hard copy and a soft copy of the term paper will be required.

9. Final Exam
A closed book, closed notes final exam of about two hours will be given in week 16, on Tuesday, December 15th, 2009.
The work covered in the final exam will concentrate on class work after the second test (60%), but it will also include some questions on other parts of the course. The approximate allocation of questions/marks will be 20% lectures 1 through 5 (Test No. 1 topics), 20 % will be lectures 6, 7, 8, 9, and 10 (Test No. 2 topics), and 60% lectures 11, 12, 13 and 14. In view of the fact that there will be no homeworks set after Test No. 2 (to permit the term paper to be completed and studies to begin for the final exam), sample questions will be given to the class that are taken from topics covered in lectures 11 through 14 so that students may test themselves on these topics before the final exam. The sample questions will be available before the appropriate lectures they are drawn from.

10. **Course Grades:**

Final Grades will be determined by a weighted average of the homework (the lowest scoring homework being dropped from this calculation), the two tests, and the final exam in the following manner:
- Regular Homework: 15%
- Test 1: 30%
- Test 2: 30%
- Term Paper has a zero percentage for the final grade, per se, but it may be grade shifter (or final exam reduction). This will be discussed in the first lecture.
- Final Exam: 25%

11. **Course Outline and Book Sections to be Covered**

**Note:** the reference pages for Kolimbiris are for his earlier book

**Digital Communications with Satellite and Fiber Optic Applications**
Author: Harold Kolimbiris
Publisher: Prentice Hall 2000
ISBN No. 0-13-081543-8

Lecture 1: September 1st, 2009
**Lecture 1 notes**
*Introduction to course;* Sine wave review (concepts of phase, frequency, wavelength); logarithm review (need for conversion to log values); why use dB?; review of communications concepts such as C/N, S/N, BER; difference between performance and availability; etc.

Lecture 2: September 8th, 2009
*Concept of Noise and Bandwidth,* and their impact on communications systems; Boltzmann’s constant = k; System Noise Temperature = T_{sys}; Noise Power = k T_{sys} B watts, where B = bandwidth; concept of baseband and passband signals.
Lecture 3: September 15th, 2009
The Building Blocks of a Communications System; Transmission side: source, source coding, information signal, channel coding, modulation, multiplexing, IF, mixer, RF, transmitter, antenna; Receiving side: antenna, low noise amplifier, mixer (RF to IF), amplifier, demodulation, demultiplexing, decoding, sink.
Kolimbiris Chapter 3; Bateman Pages 25-28, 162, 172; Class Notes

Lecture 4: September 22nd, 2009
The Building Blocks of Networks – Digital Multiplexing: FDM and TDM concepts; multiplexing hierarchies; statistical multiplexing and Digital Speech Interpolation; Kolimbiris elements of Chapter 4; Bateman Pages 16-24; Class Notes

Lecture 5: September 29th, 2009
Digitization: conversion of an analog signal into a digital signal; sampling theorem, quantization noise, aliasing, digitization (quantization, bits per sample, line codes, etc.), compression laws.
Kolimbiris Chapter 2; Bateman 24-25, 67-70, 91-93, 163-168; Class Notes

Lecture 6: October 6th, 2009
Test No.1
RF Design Concepts: line of sight microwave radio links; flux density; antenna design concepts, gain, beamwidth; EIRP and calculation of overall System Noise Temperature; Frénel zone; path loss; development of link budget, part 1.
Kolimbiris Chapter 4 and elements of Chapter 6; Bateman Pages 94-102; Class Notes

October 13th Class Does Not Meet

Lecture 7: October 20th, 2009
Link Budget II – Amplifiers; linearity, saturation, output back-off, and input back-off; examples of other digital systems (optical fibers, satellites) Link budget examples
Kolimbiris Chapter 4 and elements of Chapters 8, 9, & 10; Bateman Pages 78-88; Class Notes

Lecture 8: October 27th, 2009
Filtering and Interference Issues; root raised cosine filters; baseband bandwidth and pass band bandwidth; filter roll off; Inter Symbol Interference; Nyquist filtering; Sinc functions \( \frac{(\sin x)}{x} \); effect of coding on bandwidth required
Bateman Pages 8-11, 50-59, 61-65; Class Notes

Lecture 9: November 3rd, 2009
Digital Filters: Filter & Interference Issues; Pulse spectra; Inter Symbol Interference (ISI); Shaped pulses (Nyquist filtering); Square root raised cosine filter; Bandwidth occupancy; Baseband and pass band; Different calculation procedures for Noise bandwidth and Signal bandwidth
Kolimbiris elements of Chapter 3; Bateman Pages 36-46, 104-135, 136-138; Class Notes

Lecture 10: November 10th, 2009
Digital Modulation: the concept of modulation; amplitude modulation, frequency shift keying, phase shift keying; bits per symbol; modulation index; higher order modulations; advanced modulation concepts; PPM, PWM, trellis code modulation; QAM; synchronization aspects; frequency locking; phase locking;
Kolimbiris elements of Chapter 3; Bateman Pages 36-46, 59-61, 142-159, 183-184; 78-88; Class Notes

Test No.2

Multiple Access I: FDMA, ALOHA, TDMA, and CDMA
Kolimbiris elements of Chapter 7; Bateman Pages 188-202; Class Notes

Lecture 12: November 24th, 2009
Multiple Access II: FDMA, ALOHA, TDMA, and CDMA (contd.)
Kolimbiris elements of Chapter 7; Bateman Pages 188-202; Class Notes

Lecture 13: December 1st, 2009
Channel Coding: FEC, block codes, Hamming codes, Hamming distance, convolutional codes, hard decision/soft decision decoding
Bateman Pages 173-182; Class Notes

Lecture 14: December 8th, 2009
Propagation Effects: line-of sight phenomena – multipath, rain attenuation, rain depolarization, scintillation; non-line of sight phenomena – diffraction, over-the-horizon effects; impact of atmospheric particles’ (e.g. rain drops) absorption effects on system noise temperature
Kolimbiris elements of Chapter 4; Bateman Pages 94-98; Class Notes

Final Exam:
December 15th, 2009