1. Announcements

The class will meet in Innovation Hall, room 215, on Thursdays, 4:30 – 7:10 p.m., with the first class being on Thursday, August 28th, 2008. The exact set of class meeting days is given below in section 11. The course will consist of set lectures and two tests, to be held in week 6 and week 11, and a major class project. The project outline is given in section 8B. Class time (approximately 30 minutes) will be given over each week, starting in the second week, at the start of the class to the setting up of the teams and for the discussion between team members. The Final Exam, which is scheduled for Thursday, December 11th, 2008, from 4:30 – 7:15 p.m., will not consist of a written exam: it will be replaced by presentations by the class of their project work.

NOTE: Graduate students in the ECE program who are in any specialization (including communications) may take TCOM 707 for credit as an out of area course.

2. Expected Background

Students are expected to be very familiar with dB terminology as it applies to link budgets. They should also understand antenna concepts, such as gain and beamwidth; be very familiar with path loss; and be able to develop simple link budgets from information provided to them. While knowledge of satellite communications would be an advantage in this course, it is not a prerequisite. Successfully passing TCOM 551, or an equivalent (or higher-level) course (e.g. ECE 630), should be sufficient background to do well in TCOM 707.

3. Expected Learning Experience

TCOM 707 will develop a student’s understanding of free space transmission concepts over a wide range of frequencies and distances, from S-band to optical wavelengths and from inter-planetary distances to short-range communications. Students will learn about a variety of sensing instruments (e.g. radars) and communications platforms that work in a terrestrial environment, in a space-to-ground or ground-to-space application, or in a space-space application. The concept of directed energy weapons, both microwave and optical, will be investigated.

No textbook addresses the course completely. Four textbooks have been identified as good supplementary texts, but none is mandatory, as the course will be based on lecture notes provided in PowerPoint slides. Homework and the two tests will be based on these notes.

NOTE: The PowerPoint slides will be distributed to the class each week via Email to their GMU
Email addresses. Please do not use hotmail accounts, as you will not be able to receive the PowerPoint slides due to the size of the file (approximately 200k per file). In addition, please make sure you empty your mailboxes regularly to avoid missing lecture slides and informational Emails.

4. Required Books and Calculator

A. Mandatory Textbook

None

B. Supplementary Textbooks and Sources


(e) Web sites for various technologies, e.g.
   Imaging radars (http://southport.jpl.nasa.gov/)
   Optical Communications (http://www.wtec.org/loyola/satcom2/03_06.htm)

B. Calculator

Students should have a calculator, or a PDA (or equivalent) with a calculator option. The calculator shall have logarithmic, anti-log (10^x) and standard trigonometric functions, as a minimum.

NOTE: Calculators will be required in the tests and exams. For this reason, calculators that store equations and other processes will not be permitted. Please make sure you have only a simple calculator for the closed book 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 understanding the processes rather than memorization.

5. Lecture Notes

As noted earlier, Power Point slides for the lectures will be distributed by Email to the class. The set of slides for the first class will be posted on this web site without restriction within two weeks of the start of classes in August. The slides for the first lecture will, in any case, be mailed out a week before the first class to all those who have registered for the course. Subsequent lecture slides will be distributed via Email to all who register for the course.

6. Homework
1. Homework Exercises will be assigned periodically up to test #2 at approximately one per week. They will usually be due the following week at the beginning of the class. No homework will be assigned after test #2 to permit work to be carried out on the project.

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 solution set for that homework has not yet been sent to the class.

   Students are encouraged to study together on homework problems, but they should take care that they submit only their own written work.

   **IMPORTANT NOTE**

   Students are encouraged to find, and use, any and every source they may locate to answer a question or for a research topic. HOWEVER: if elements of a paper or research note 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. No more than 40% of any copied source content may be directly inserted into a document submitted.

7. **Tests**

   Two Tests will be given (in class) during the semester. They will be closed book, closed notes tests of at least an hour each. The first test will cover class work up to and including the lecture prior to the day of the first test (i.e. radar systems). The second test will cover class work from after the first test up to and including the lecture prior to the day of the second test (i.e. advanced satellite systems). 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.

8A. **Final Exam**

    There will be no written final exam. Students will present the results of their project on the day of the final exam (December 11th, 2008). No written report will be required, but a hard and soft copy of the presentation material will be deliverable.

8B. **Class Project**

    A class project will be assigned that tests the students’ ability to design an advanced communications link. Depending on the eventual size of the TCOM 707 class, the project may be a single effort that all of the class
works on or, if there are enough students, possibly two competing teams will be set up to work on the same project. The details of the project will be presented to the class in the first lecture and, over the next two or three weeks, the composition of the team(s) and the sub-assignments will be worked out. The first half-hour of each class, except for the two tests, will be available for the class to meet together to work on their project.

The results of the project will be presented on the formal exam day, replacing the final exam. No written report need be prepared, but the project presentation materials shall be provided as a deliverable in both soft and hard copy.

9. **Course Grades:**

Final Grades will be determined by a weighted average of the homework, the two tests, and the final exam in approximately the following manner:

- Regular Homework - 15%
- Test 1 - 30%
- Test 2 - 30%
- Project presentation and deliverable - 25%

A specific percentage mark will not absolutely correspond to a course grade. Normally, a final percentage score of between 90 and 100% will be some form of A, between 80 and 90% some form of B, and between 70 and 80% some form of B- to C. Usually the median score of the class is around the A-/B+ divide, although this is not necessarily the case for a class of fewer than 20 students.

10. **Course Outline**

**Lecture No. 1** August 28th, 2008
Radar 1 – the basics: *introduction to radar systems: background; time, frequency, and spectrum considerations; range calculations; pulse repetition frequency issues; derivation of the radar equation; radar applications*

**Lecture No. 2** September 4th, 2008
Radar 2 – The radar equation (contd.): *noise temperature; radar system losses; target detection; probability of false alarm; echo integration*

**Lecture No. 3** September 11th, 2008
Radar 3 – radar design trade-offs: other types of radar – CW radar, FM radar, MTI radar, Pulse Doppler radar; tracking techniques and countermeasures; clutter and atmospheric impairments

**Lecture No. 4**, September 18th, 2008
Radar 4 – advanced designs: electronically steerable antennas – passive designs, active designs, single-axis designs; synthetic aperture radars; radar countermeasures; ground radars (ordnance and archeological searches)

**Lecture No. 5**, September 25th, 2008
Radar system design example (first half of lecture); Review of satellite orbits – GEO, MEO, LEO, and HEO VSAT background

**Lecture No. 6**, October 2nd, 2008

Test Number 1 – (Radar Systems)
Advanced satellites 1 – *Review of satellites systems (contd.); multiple access considerations; connectivity issues; on-board switching; on-board processing*

**Lecture No. 7**, October 9th, 2008
Advanced satellites 1 (contd.) – *Link design aspects and terminal design aspects*

**Lecture No. 8**, October 16th, 2008
Advanced satellites 2 – *VSAT system design example – description of system, preliminary calculations, link C/N ratios and power budgets, analysis of inbound and outbound links, system analysis, possible optimization of system*

**Lecture No. 9**, October 23rd, 2008
Advanced satellites 3 – *Propagation countermeasures – atmospheric losses; system considerations; propagation effects – ionospheric effects, clear air effects, rain attenuation, rain depolarization, ice crystal and other impairments*

**Lecture No. 10**, October 30th, 2008
Advanced satellites 4 – *Inter-satellite link design; General requirements for GEO-GEO; GEO-LEO; LEO-LEO; microwave vs. optical; power, mass, and reliability; technology enabling requirements*

**Lecture No. 11**, November 6th, 2008
**Test number 2 (Advanced satellite systems)**
Optical Systems 1 – *some theory and terminology; diffraction limited optics*

**Lecture No. 12**, November 13th, 2008
Optical Systems 1 (contd.) – *optical sources; optical detectors; optical resonators*

**Lecture No. 13**, November 20th, 2008
Optical Systems 2 – *optical communications in the atmosphere; other optical systems*

**November 23rd, 2006 – Thanksgiving Holiday**
No class

**Lecture No. 14**, December 4th, 2008
Directed Energy Weapons – *background; electromagnetic pulse; high power microwave; laser weapons; airborne COIL anti-missile system; plasma weapons*

December 14th, 2006
**Final Exam**
Project Presentations for final exam