

ELEC 353 - Basic Electromagnetics and Transmission Line Theory

Course Outline – Winter 2012

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Office Hours: Monday 2:00 to 4:00, EV15.189.
It is best to email for an appointment as I am often not available.

Course Web Site:

www.ece.concordia.ca/~trueman/web_page_353.html

- Course outline
- Formula Sheet
- Course notes
- Assignments
- Practice Problems
- Software: BOUNCE, TRLINE, WAVES, FRIIS.

Text Book: U.S. Inan and A.S. Inan, “Engineering Electromagnetics”, Prentice-Hall, 1999. ISBN 0-8053-4423-3

References

Undergraduate Electromagnetics Textbooks:

1. M.N.O. Sadiku, “Elements of Electromagnetics”, 3rd edition, Oxford University Press, New York, 2001.
2. W.H. Hayt and J.A. Buck, “Engineering Electromagnetics”, 6th edition, McGraw-Hill, New York, 2001.
3. K.R. Demarest, "Engineering Electromagnetics", Prentice-Hall, 1998.
4. J.D. Kraus, "Electromagnetics", 4th edition, McGraw-Hill, 1992.

Books Dealing with High-Speed Logic Circuits:

1. H. Johnson and M. Graham, “High-Speed Digital Design – A Handbook of Black Magic”, Prentice-Hall, 1993.
2. H. Johnson and M. Graham, “High-Speed Signal Propagation, Advanced Black Magic”, Prentice-Hall, 2003.
3. E. Bogatin, “Signal Integrity – Simplified”, Prentice-Hall, 2004.
4. B. Young, “Digital Signal Integrity”, Prentice-Hall, 2001.
5. W.J. Dally and J.W. Poulton, “Digital Systems Engineering”, Cambridge University Press, 1998.

Material Covered in ELEC353 from Inan and Inan

Chapter 1 Introduction: Lumped and distributed circuits.
Chapter 2 Transient Response of Transmission Lines
Chapter 3 Steady-State Waves on Transmission Lines
Chapter 7 Time-Varying Fields and Maxwell’s Equations
Chapter 8 Electromagnetic Waves
Introduction to Antennas (not covered in the textbook).

Grading Scheme

Tutorial Workshops	10	Must be handed in at the end of each tutorial.
Class Test	30	Friday February 17, 2012
Final Examination	60	
Total	100	

- If you do better on the final exam than on the mid-term test, then the final exam will count for 90% of your grade. The tutorial assignments count for the remaining 10%.
- If you are absent for the mid-term test for any reason then the final exam will count for 90%.
- R-grade rules:
 - If you write the final exam but your overall grade is less than 30% in the course, you will receive the grade R.
 - If you do not write the final exam and your tutorial grade is less than 6/10, your grade will be R-DNW. You will not be eligible to write a deferred exam.

Administration

Disclaimer

In the event of extraordinary circumstances beyond the University's control, the content and/or evaluation scheme in this course is subject to change.

Classes

1. It is prudent to attend all of the classes.
2. Taking notes in class will help you to remember what was said about the lecture notes.

Exams

1. The mid-term exam and final exam are multiple-choice tests. The exams are closed book, so no textbook or notes are allowed. A sheet of formulas will be made available during exams. The formula sheet is posted on the course website. Print it out. Use it to solve the tutorial and homework problems. Become familiar with what is on it and what is NOT on it.
2. During exams, possession of a cell phone or other communication device is forbidden by a Senate regulation. Please note that turning the cell phone off is **not** acceptable. You must not have a cell phone in your possession. With communication modes such as text messaging, the exam process can be compromised by the mere presence of these devices. The exams office personnel are going to be very strict and issue an Academic Misconduct Incident Report to any student who is in possession of an unauthorized electronic device in a final exam.
3. The only calculators allowed in ENCS undergraduate mid-term and final exams are the Sharp EL 531 and the Casio FX-300 MS. Your calculator must have an "ENCS" sticker. This policy will be strictly enforced by the exams office. The bookstore and other outlets have these calculators. This policy helps prevent some students from having an advantage over others, based on buying a more expensive and more powerful calculator.

Tutorial Workshop Problems

- In each "tutorial workshop" you will be given problems to solve.
- You will solve the problems during the tutorial and hand in your answers at the end of the tutorial.
- The problems can ONLY be handed in at the end of the tutorial. They cannot be handed in late!
- The problems will count for 10 marks.
- There will be 13 tutorial workshops and 13 tutorial problem sets. Your mark will be found by taking the best 10 of the grades that you earn for the problems.

- **The tutorial workshop problems** are intended to **get you started** doing problems on each topic of the course; so that you can go on to do the homework assignments. The tutorial problems by themselves do not prepare you sufficiently for the final exam. **You must do the homework assignments.**

Homework Assignments

- There are weekly assignments of about three problems each.
- The questions for each assignment are posted on the course web site. Assignments are not handed in and assignments are not graded. The solution to each assignment will be posted on the web site the week after the assignment should be completed. Grade your own assignments using the solutions to check your answers.
- Engineering is learn-by-doing! Learn the course week by week throughout the term. Go to the tutorial and do the tutorial problem to get started with the calculations. Then do the homework problems each week, and check your answers against the solution the following week.
- You *cannot* learn the course material by *reading* the solutions to the assignments. Even if you think that you understand the solutions, you will be unable to answer the final exam questions.

Engineers Canada Graduate Attributes

- Concordia's engineering programs are accredited by Engineers Canada. With your Concordia degree you can become a registered professional engineer anywhere in Canada and the United States.
- Engineers Canada lists 12 "graduate attributes" that all engineers must have.
- Each course teaches one or more of the 12 graduate attributes.
- The graduate attribute for ELEC353 is "life-long learning", also called "self learning".
- "Self learning" is important in an engineering career. Self learning keeps your knowledge up to date. Engineers read textbooks, professional magazines and journals. Engineers attend professional conferences and take short courses.
- To practice self learning for ELEC353, please study:
 - AC circuit analysis (review ELEC273)
 - Vector calculus (Inan and Inan Appendix A)
- Read your textbook from ELEC273 on A.C. circuits, phasors and impedance and do the problems at the end of the chapter. AC circuit analysis is very important in ELEC353.
- Read your textbook on vector calculus from ENGR233 and do the problems at the end of the chapter. What is the curl? The divergence? The Laplacian?
- These topics will not be covered in the lectures.
- There will be a question on this material, on both the midterm and final exam.

Academic Code of Conduct

- All Concordia University students must abide by the University's Academic Code of Conduct. The code can be found in the Concordia University Undergraduate Calendar, Section 17.10. Any suspected violation of the Code will be reported to the Dean for investigation. Penalties can be as severe as dismissal from the University.
 - Item 12.b of the Academic Code of Conduct forbids plagiarism. If you copy another student's assignment or lab report you are guilty of plagiarism. You may NOT copy assignments from students who took the course in a previous year, for example.
 - Item 12.c forbids you to provide material for another student to copy. If you allow another student to copy your homework assignment or lab report, you have behaved unethically and committed an offence. If you give another student your homework assignments or lab reports from a course that you took before, and he copies them, then **you** have committed an offence.

- In the Faculty of Engineering and Computer Science you are forbidden from consulting the work of any current or former student. Please read the back of the “Expectations of Originality” form carefully.

ELEC 353 Formula Sheet

Constants

$$\epsilon_0 = 8.854 \times 10^{-12} \text{ F/m}$$

$$\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$$

Maxwell's Equations

$$\nabla \cdot \bar{D} = \rho_v \quad \nabla \times \bar{H} = \bar{J} + \frac{\partial \bar{D}}{\partial t}$$

$$\nabla \cdot \bar{B} = 0 \quad \nabla \times \bar{E} = -\frac{\partial \bar{B}}{\partial t}$$

Time-Domain Transmission Lines

$$\frac{\partial v}{\partial z} = -\ell \frac{\partial i}{\partial t}$$

$$\frac{\partial i}{\partial z} = -c \frac{\partial v}{\partial t}$$

$$R_c = \sqrt{\frac{\ell}{c}}$$

$$u = \frac{1}{\sqrt{\ell c}}$$

Reflection at a load:

$$\Gamma = \frac{R_L - R_c}{R_L + R_c}$$

Transmission from line #1 onto line #2:

$$T_{12} = \frac{2R_{c2}}{R_{c1} + R_{c2}}$$

Sinusoidal Steady State

$$\frac{dV}{dz} = -(r + j\omega\ell)I$$

$$\frac{dI}{dz} = -(g + j\omega c)V$$

$$\gamma = \alpha + j\beta = \sqrt{(r + j\omega\ell)(g + j\omega c)}$$

$$Z_0 = \sqrt{\frac{r + j\omega\ell}{g + j\omega c}}$$

With the generator at $z = 0$ and the load at $z = L$:

$$V(z) = V^+ e^{-j\beta z} + V^- e^{j\beta z}$$

$$V^- = V^+ \Gamma_L e^{-2j\beta L}$$

$$\Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0} = |\Gamma_L| e^{j\phi}$$

$$Z_{in} = Z_0 \frac{Z_L + jZ_0 \tan \beta L}{Z_0 + jZ_L \tan \beta L}$$

Single-Stub Matching Formulas

$$\text{Line length: } L = \frac{\phi - \cos^{-1}(-|\Gamma_L|)}{2\beta}$$

$$\text{Stub length: } L_s = \frac{1}{\beta} \cot^{-1} \left[\frac{\pm 2|\Gamma_L|}{\sqrt{1 - |\Gamma_L|^2}} \right]$$

Time-Harmonic Maxwell's Equations

$$\nabla \cdot \bar{E} = \frac{\rho_v}{\epsilon} \quad \nabla \times \bar{H} = (\sigma + j\omega\epsilon)\bar{E}$$

$$\nabla \cdot \bar{H} = 0 \quad \nabla \times \bar{E} = -j\omega\mu\bar{H}$$

$$E_x(z) = E_x^+ e^{-\gamma z} + E_x^- e^{\gamma z}$$

$$\gamma = \alpha + j\beta = \sqrt{j\omega\mu(\sigma + j\omega\epsilon)}$$

$$\eta = \sqrt{\frac{j\omega\mu}{\sigma + j\omega\epsilon}}$$

Reflection

$$\Gamma = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1}$$

$$\tau = \frac{2\eta_2}{\eta_2 + \eta_1}$$

Transmission through a Wall

$$T = \frac{4\eta_0\eta_w e^{-j\beta_w d}}{(\eta_0 + \eta_w)^2 - (\eta_0 - \eta_w)^2 e^{-2j\beta_w d}}$$

Antennas

$$\text{Hertzian Dipole: } E_\theta = \frac{j\eta_0\beta I_0 \ell}{4\pi} \sin\theta \frac{e^{-j\beta r}}{r}$$

Ideal Dipole of arm length h :

$$E_\theta(\theta) = \frac{jI_0\eta_0}{2\pi} F(\theta) \frac{e^{-j\beta r}}{r}$$

$$F(\theta) = \frac{\cos(\beta h \cos\theta) - \cos(\beta h)}{\sin\theta}$$

Half-wave Dipole Antenna

$$P_{rad} = 36.5 I_0^2$$

Friis Transmission Equation

$$P_R = \left(\frac{\lambda}{4\pi R} \right)^2 G_R G_T P_{in}$$

