

**ELEC 3909 ELECTROMAGNETIC WAVES**

**Web site:** Course information and news (including notes) is available at <http://www.doe.carleton.ca/~ngt/3909>.

**Instructor:** N. Garry Tarr ME5160 ngt@doe.carleton.ca

**Marking scheme:** Best of: Final exam 60% *or* Final exam 100%  
Quizzes 40% (best 4 out of 6)

*Notes:* The final exam is exclusively for the purpose of evaluating student performance and will not be returned. Four out of six quizzes must be written (no matter what mark is achieved on them) to pass the course. All requests for religious accommodation in exam scheduling must be made within the first week of term.

**PA sessions:** Problem sets will be assigned every week. The first two hours of each PA will be used to answer your questions and do sample problems. In the last hour there will be a quiz based on the current problem set. PAs and quizzes start May 10.

**TAs:** Hassna Ouassal (HassnaOuassal@cmail.carleton.ca)  
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**Health and Safety:** There are no unusual hazards; see [www.doe.carleton.ca/undergrads/health-and-safety](http://www.doe.carleton.ca/undergrads/health-and-safety) for general information.

**Textbook:** (*not compulsory*)

F.T. Ulaby and U. Ravaioli, *Fundamentals of Applied Electromagnetics* (7<sup>th</sup> ed.), Pearson, 2014

*Other good textbooks:*

U.S. Inan and A.S. Inan, *Electromagnetic Waves*, Prentice Hall 1999

U.S. Inan and A.S. Inan, *Engineering Electromagnetics* Addison-Wesley 1999 (transmission lines and Smith charts)

e-text: Sophocles Orfanidi, *Electromagnetic Waves and Antennas*

**Topics:****1. Plane Wave Solutions of Maxwell's Equations**

Review of Gauss' law, Ampère's law, Faraday's law

Displacement current: generalized Ampère's law

Maxwell's equations

Plane wave solution to Maxwell's equations

Phase velocity: relation between  $c$ ,  $\mu$  and  $\epsilon$ .

The EM spectrum

Propagation of an arbitrary waveform

Relation between  $E$  and  $H$

Generalized equation for plane wave moving in direction  $k$

Polarization: linear, circular, elliptical

Poynting Vector: power flow in an EM wave

**2. EM Wave Propagation in Matter**

Plane waves in a lossless dielectric

Refractive index, characteristic impedance

EM wave propagation in a good conductor; skin depth

Lossy dielectrics

EM wave propagation in a lossy dielectric

**3. EM Wave Reflection at Normal Incidence**

Reflection at a perfect conductor

Standing waves

Reflection at a dielectric interface- normal incidence

Antireflection coatings

Reflection from a real conductor

Standing wave ratio

Stealth aircraft

**4. EM Wave Reflection at Oblique Incidence**

Law of reflection

Snell's Law

Total internal reflection

Fresnel coefficients

Brewster angle

**5. Non-Cartesian Co-ordinate Systems**

Brief review of cylindrical and spherical co-ordinates

**6. Transmission Lines**

EM wave propagation in a coaxial transmission line

Circuit view of transmission line: distributed  $L$  and  $C$

Applications: coax cable, parallel wire line

Voltage and current waves on transmission line

Reflection and transmission

Termination of lines: impedance matching

Smith charts

**7. Guided Waves**

Parallel plate metal waveguide

Waveguide modes

Phase velocity and group velocity; dispersion

Rectangular metal waveguide

Dielectric slab waveguide

Overview of optical fiber communication systems