18.306 Advanced Partial Differential Equations with Applications.

Mon. and Wed. 9:30–11:00 in 2–142

Description:	The focus of the course are the concepts and techniques for solving partial differential equations (P.D.E.) that permeate various scientific disciplines.The emphasis is on nonlinear PDE. Applications include problems from fluid dynamics, electrical and mechanical engineering, materials science, quantum mechanics, etc.
Prerequisites:	Basic theory of one complex variable and ordinary differential equations. No prior knowledge of P.D.E. is assumed.
Textbook:	There is no required textbook. In the lectures the material in a few recommended (but not required) textbooks will be followed.
Instructor:	R. R. Rosales, 2-337, x3-2784, rrr@math.mit.edu. Off. hrs TBA in web page.
TA:	TBA.
Exams:	Two (midterm and last week). Each worth 40% of the grade. **NO FINAL.**
Problem sets:	5 to 8 problem sets (one every 1-2 weeks). **Worth 20% of the grade.**
E-mail:	Make sure that your e-mail address is in the class mailing list. You should receive a test e-mail within a few days. If you do not, contact me at my e-mail address.
WEB page:	http://www-math.mit.edu/18.306/index.html
MatLab:	I **strongly urge you to become proficient in MatLab.** It is a very useful tool, and I may use it from time to time to illustrate points in the course. In addition, the problem sets may require some computations, easily done if you know MatLab. See the course web page for more information about MatLab. If you wish to install MatLab in your own computer (not a bad idea, it is a good investment) you can purchase the **Student version of MatLab.**

Recommended textbooks in Applied Mathematics and applications.

- Whitham, G. B. *Linear and nonlinear waves.* John Wiley, 1999. ISBN: 0471359424.
- Kevorkian, J. *Partial differential equations: analytical solution techniques.* Springer Verlag, 2000, 2nd ed. ISBN: 0387986057.
- Hinch, E. J. *Perturbation methods.* Cambridge University Press, 1991. ISBN: 0521378974.
- Guenther, R. B., and Lee, J. W. *Partial Differential Equations of Mathematical Physics and Integral Equations.* Dover.

Other textbooks at a similar level.

- Debnath, L. *Nonlinear partial differential equations for scientists and engineers.* Birkhauser, 1997. ISBN: 0817639020.
- Carrier, G. F., and C. E. Pearson. *Partial differential equations: theory and technique.* Academic Press, 1988, 2nd ed. ISBN: 0121604519.
- Barenblatt, G. I. *Scaling, self-similarity, and intermediate asymptotics.* Cambridge University Press, 1997. ISBN: 0521435226.

- Levine, H. *Partial differential equations.* Am. Math. Soc.: International Press, 1997. ISBN: 0821807757.
- Drazin, P. G., and R. S. Johnson. *Solitons: An Introduction.* Cambridge University Press, 1989. ISBN: 0521336554.

Books at an advanced level, with emphasis on rigorous theory.

- Evans, L. C. *Partial Differential Equations.* Am. Math. Soc., 1998. ISBN: 0821807722.
- DiBenedetto, E. *Partial Differential Equations.* Birkhauser, 1994. ISBN: 0817637087.
- Garabedian, P. R. *Partial Differential Equations.* Am. Math. Soc., 1998. ISBN: 0821813773.

OUTLINE of the Course: A rough idea follows. Some things may be covered in more detail than this implies, or the reverse. This is just to give you an idea of the "flavor".

- **Introduction.** Terminology; boundary and initial value problems; well- and ill-posed problems.
- **First-order P.D.E.** Complete solutions; characteristics; conservation laws; systems of P.D.E.; introduction to weak solutions: shocks and jump conditions; entropy condition; examples: traffic flow, gas dynamics, etc.
- **Linear P.D.E.** Review and classification; the Laplace, wave and diffusion equations; the Klein-Gordon equation; more on characteristics; standard methods: separation of variables, integral transforms, Green's functions; potential scattering; special topics in conformal mapping; dispersion and diffusion; dimensional analysis and self-similarity; regular and singular perturbation theory; asymptotics for complete solutions; geometrical optics and WKB. eikonal equation; high-frequency expansions; caustics;
- **More on nonlinear P.D.E.** Equations that convert into linear P.D.E.; some exactly solvable cases; Burgers' equation; dimensional analysis and similarity; traveling waves; nonlinear diffusion and dispersion; the KdV, nonlinear Schrdinger and Sine-Gordon equations; reaction-diffusion equations; Fisher's equation; singular perturbations: boundary layers, homogenization, weakly nonlinear geometrical optics, etc.; Solitons; Backlund transformations; Painlevé conjecture.
- **Variational Methods.** First and second variation; Euler-Lagrange equation; constraints.
- **Free-boundary value problems.** Formulation; perturbation theory; more on water waves; method of extended gradient; materials surface evolution; some open problems.