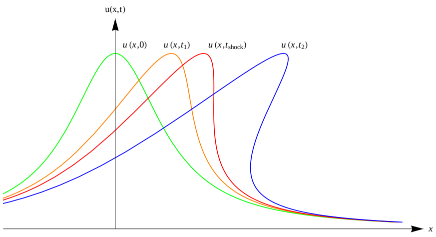
Course Description

Vv454 Partial Differential Equations and Boundary Value Problems

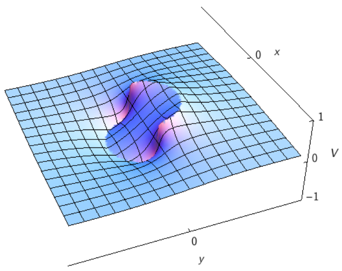
Spring Term 2016

Prerequisites: Vv256 or Vv286 and the preceding calculus courses.

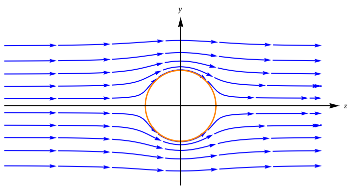
Course website: http://umji.sjtu.edu.cn/~horst/teaching/vv454.html

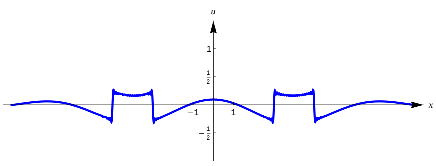


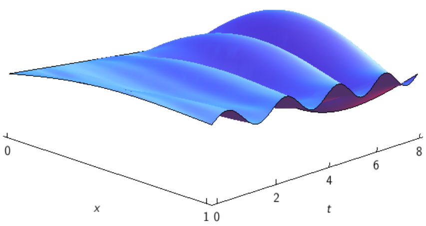
Shock waves



Electrostatic potentials


Fluid flow


Signal transmission



Vibrations and Resonance

Intended Audience: ME and ECE undergraduate and graduate students. The course is accessible to sophomore students; no additional background is required. Graduate students wishing to take Vv557 in the summer term are strongly encouraged to take Vv454 first.

Description: This course gives an introduction to classical methods for solving partial differential equations (PDEs). PDEs lie at the heart of all analytical problems of engineering and physics. They occur in the modelling of such diverse subjects as traffic jams, transmission of signals through telegraph lines, electromagnetic problems, fluid flow, heat transfer, bending and buckling of beams and mechanical vibrations of any kind.

The focus of this course is on learning new methods and adapting methods from the solution of ordinary differential equations (ODEs) to the solution of PDEs. A recurring theme is the reduction of PDEs to ODEs, e.g., using the Laplace or Fourier transforms, separation of variables or analysis of the solution curves (method of characteristics). Therefore, close familiarity with the material of Vv256 or Vv286 will be very helpful. As the course focuses on methods and not proofs, it is very much application-oriented. (The figures to the left of this text accompany actual examples in the course.)

Keywords: Conservation laws and the derivation of PDEs from physical models; quasilinear first-order PDEs and the method of characteristics; Burgers's equation and weak solutions; shock waves; the eikonal equation and other nonlinear first-order PDEs; classification of quasilinear second-order PDEs and their transformation into normal form; boundary value problems of various kinds; the wave equation on an infinite string and d'Alembert's method; the heat equation in a finite bar and its solution through separation of variables; Fourier-Euler series and their convergence; spaces of weighted square-integrable functions and the problem of best approximation; Sturm-Liouville boundary value problems; separation of variables for nonhomogeneous one-dimensional evolution equations; problems on infinite and semi-infinite bars and the Fourier transform; dispersive solutions; analysis of the telegraph equation; separation of variables in higher dimensions; Bessel functions and Legendre polynomials; multipole expansions in electromagnetics. If time permits: the Poisson equation and properties of harmonic functions.

Textbooks:

- Pinchover, Y. and Rubinstein, J., *An Introduction to Partial Differential Equations*, Cambridge University Press 2005.

Syllabus:

Lecture	Lecture Subject	Textbook Sections
1	Introduction	1.1 - 1.3
2	Semilinear Equations	2.1 - 2.6
3	Quasilinear Equations	2.1 - 2.6
4	The Cauchy Problem	2.1 - 2.6
5	Burgers's Equation	2.7
6	The Eikonal Equation	2.8
7	Nonlinear PDEs	2.9
8	Classification of 2nd order PDEs	3
9	Classical PDEs of Physics and Engineering	1.4 - 1.6, 5.6.1
10	Classical PDEs of Physics and Engineering	1.4 - 1.6, 5.6.1
11	**First Midterm Exam**	1-3
12	The Wave Equation for an Infinite String	4
13	Separation of Variables	5
14	Square Integrable Functions	—
15	Fourier Series	5
16	Sturm-Liouville Problems	6
17	The Wave and Heat Equations	5
18	The Laplace Equation	7.7
19	The Fourier Transform	Evans excerpt
20	The Fourier Transform	Evans excerpt
21	The Eigenvalue Problem for the Laplacian	9.5
22	**Second Midterm Exam**	4-6; 7.7
23	The Eigenvalue Problem for the Laplacian	9.5
24	Bessel Functions and the Problem for a Disk	9.6-9.8
25	Legendre polynomials and the Problem for a Sphere	9.6-9.8
26	Legendre polynomials and the Problem for a Sphere	9.6-9.8
27	Elliptic Equations	7
28	Elliptic Equations	7
29	Elliptic Equations	7
30	**Final Exam**	7, 9.5-9.8, Evans

- The exact location of the exam classes may vary according to the term schedule.
- This term, minor changes may be made to the acheduling of certain topics.

Course Grade Components: Attendance of 2/3 of all classes is mandatory. Students who miss 11 or more out of the 30 lecture classes without the instructor's permission will receive an F for the course, regardless of exam and course work grades.

- First midterm exam: 25%
- Second midterm exam: 25%
- Final exam: 25%
- Course work: 25%

Honor Code Policy:

The rules for observing the Honor Code in this course are quite simple: you must never show any other student your written work. You are not allowed to write down formulas for another student, or to let them see hour homework, or to demonstrate something to them on a blackboard or use any other type of written communication.

You are allowed to talk about the course work (the weekly assignments), but may not communicate in writing. For example, it is OK to tell another student "I solved this differential equation by substituting as for a homogeneous equation." It is not OK to actually show another student the written calculations of how you did this.

Of course, during exams, no communication of any kind (verbal or written) is allowed!
In this course, the following actions are examples of violations of the Honor Code:

- Showing another student your written solution to a problem.
- Sending a screenshot of your solution via QQ, email or other means to another student.
- Showing another student the written solution of a third student; distributing some student's solution to other students.
- Viewing another student's written solution.
- Copying your solution in electronic form (LaTeX source, PDF, JPG image etc.) to the computer hardware (flash drive, hard disk etc.) of another student. Having another student's solution in electronic form on your computer hardware.

The above ist is of course not exhaustive. If you have any questions regarding the application of the Honor Code, please contact me or any of the TAs.