MATH 545
Partial Differential Equations I

Instructor:	Prof. Wolfgang Bangerth Weber 214 bangerth@colostate.edu
Lectures:	Engineering E 206, Mondays/Wednesdays/Fridays, 10-10:50am
Office hours:	Wednesdays, 1-2pm; or by appointment.

Course outline

The syllabus description for this course is pretty short:

> Second order linear PDEs, elliptic and parabolic equations, equations of math physics, separation of variables, Fourier series.

What I care about are essentially the following topics:

1. Where do partial differential equations (PDEs) come from? This is essentially a question of mathematical modeling, i.e., how we can describe the world around us in mathematical terms. It turns out that PDEs commonly appear when we want to mathematically describe things that can be considered continua: how does a fluid flow, how does a solid deform, how is heat transported within a body? This is important in gaining an intuition about PDEs and their solutions because many of the mathematical properties are obviously true if you consider what the PDE describes, even if the proof may not be trivial.

2. How PDEs are classified into elliptic, parabolic, and hyperbolic. While these terms are abstract, they correspond to underlying physical phenomena, and the solutions of PDEs in each of these groups have very different behavior.

3. How PDEs can be solved analytically. Like most practical ODEs, PDEs can in general not be solved on a piece of paper by just deriving a *formula* for the solution. This is particularly true if you want a closed-form formula for the solution, but in reality, in almost all cases, we can not even write the solution as infinite sums that can be evaluated. However, there are important cases where this can be done, either through "separation of variable" approaches, or by Fourier series. We will cover these cases because they give us insight into more general solution approaches (analytic or numeric) and because this is one way to prove properties of solutions (such as smoothness or regularity).

Time permitting, I will also venture into other areas such as hyperbolic equations or nonlinear equations that are commonly found in applications and discuss their properties and relevance. I may also cover other areas based on student interest.
Partial differential equations are an immensely practical part of the applied sciences and underly most areas of engineering, physics, chemistry. As a consequence, a very practical aspect of PDEs is not just their theoretical study, but their actual solution on computers. We teach this in courses such as MATH 561/651/652, but I will also discuss how some of the simpler methods we discuss in this class can be used on computers, and you will be asked to implement these as part of your homework assignments.

Learning objectives

At the end of the semester, this is what you should have learned:

- To categorize a given equation;

- To know qualitative properties of the solutions of PDEs of different categories;
- To know and be able to apply common analytic solution methods for PDEs;
- To have some experience in implementing programs to numerically solve simple cases;
- To have an idea where PDEs come from, and how to translate a word description of a physical phenomenon into a mathematical equation.

Prerequisites

MATH 340 (Introduction to Ordinary Differential Equations) or MATH 345 (Differential Equations) or MATH 530 (Mathematics for Scientists and Engineers).
You should have a little bit of experience in programming in order to write small programs as part of homework.

Literature

I will be losely inspired by the book by Walter A. Strauss: "Partial Differential Equations: An Introduction" (Wiley), but there are many other books about PDEs that cover similar content and that you could consider interchangeably. In any case, I will make the course self-contained and not reference particular parts or exercises in this book or any other: you can just use these books as backup material if you did not understand something or need to read up on material you may have missed.
In other words: You are not required to buy or use any of these books.

Webpage

Homework assignments and other course information will be posted at the course webpage
http://www.math.colostate.edu/~bangerth/teaching.html

Exams and grading

Final grades will be determined based on the following components:

- Biweekly homework and programming assignments: 50%
- Midterm exam, at a date in October still to be determined: 20%
- Final exam, Tuesday December 11, 11:50am–1:50pm: 30%

We may discuss replacing the final exam by a final project as the semester progresses.

Your minimum grade will be A, B, C, or D, for a score of 90%, 80%, 70%, and 60% over the course of the semester, respectively.

You must make arrangements in advance if you expect to miss an exam or quiz. Exam absences due to recognized University-related activities, religious holidays, verifiable illness, and family/medical emergencies will be dealt with on an individual basis. In all cases of absence from exams a written excuse is required. Ignorance of the time and place of an exam will not be accepted as an excuse for absence.

Incompletes: I will consider giving an incomplete if you have successfully completed all but a small portion of the work of the course, and are prevented from completing the course by a severe, unexpected event. Simply being behind work is not a reason for an Incomplete, though; in that case you should consider dropping the course.

S/U grades: If you are registered S/U your grade will be 'S' if your letter grade is C or above, and 'U' otherwise.

Policies *Academic integrity:* Academic integrity is integral to the success of the University and to you as a learner. Academic integrity is conceptualized as doing and taking credit for one's own work. Academic dishonesty undermines the educational experience at Colorado State University. Examples of academic dishonesty include (but are not limited to) cheating, plagiarism, and falsification. Plagiarism includes the copying of language, structure, images, ideas or thoughts of others and is related only to work submitted for credit. Cheating or any form of academic dishonesty will not be tolerated. The use of material from improperly cited or credited sources will be considered plagiarism. You are encouraged to collaborate with your classmates, unless otherwise directed, but all work intended for a grade must clearly be your work as an individual. Ignorance of the rules does not exclude any member of the CSU community from the requirements or the processes meant to ensure academic integrity.

Disabilities: Colorado State University, in compliance with state and federal laws and regulations, does not discriminate on the basis of disability in administration of its education related programs and activities. We have an institutional commitment to provide equal educational opportunities for disabled students who are otherwise qualified. Students with documented disabilities must contact The Office of Resources for Disabled Students (RDS; 970-491-6385) to make arrangements for class accommodations. It is the responsibility of the student to obtain accommodation letters from RDS and to make arrangements for the implementation of accommodations with faculty in advance. Students who believe they have been denied access to services or accommodations required by law should contact RDS (970-491-6385). Students who believe they have been subjected to discrimination on the basis of disability should contact the Office of Equal Opportunity (970-491-5836). For more information regarding disability grievance procedures, visit http://oeo.colostate.edu.