MATH 5610/6860
PROJECTS

You may work in pairs, or suggest your own project. **Please choose a project by Nov 2** and **notify me** by email or in person that you have done so. The following is expected from you, and both will be equally weighted to get the project grade.

- A report **due Fri 12/11**. This doesn't need to be long (2 pages is OK) and can be handwritten. You should explain with your own words the problem and the method. If your project has a computational part, you should also include some numerical results and the code you used to generate them. You do not need to do proofs for the suggested problems.
- A short (say 10min) presentation **on either 12/3, 12/7 or 12/8**. If you plan to use the projector you can either bring your laptop, or (preferably) bring your presentation on a flash drive. You can also give a presentation on the chalkboard.

1. Some project suggestions

I expect the amount of work for each of these projects to be between one and two homeworks. If you feel the project is taking longer, please come see me as it probably means you are not approaching the problem correctly. If you have doubts about something or would like to know what I am expecting from each project, **please ask!** I have personal copies of the books that are cited, and you can borrow them.

1. Newton's method in n dimensions to solve the system of nonlinear equations $\mathbf{F}(\mathbf{x}) = \mathbf{0}$, where
$$\mathbf{F}(\mathbf{x}) = \begin{bmatrix} f_1(\mathbf{x}) \\ f_2(\mathbf{x}) \\ \vdots \\ f_n(\mathbf{x}) \end{bmatrix}$$
and $\mathbf{x} = (x_1, x_2, \ldots, x_n)^T$. I would expect you to solve a system for $n = 2$ or $n = 3$. Ref: B&F §10.2.
2. Bairstow's method to find the roots of a polynomial. Ref K&C 3.5
3. Laguerre's iteration to find the roots of a polynomial. Ref K&C 3.5
4. Hermite interpolation when $f(x_i)$ and $f'(x_i)$ are specified at all $n+1$ distinct nodes $x_0, x_1, \ldots, x_n$. Ref. B&F 3.3

5. Clamped cubic splines (and comparison to natural cubic splines we saw in class). Ref B&F 3.4
6. Bézier curves. Ref. B&F 3.5
7. Multiple integrals of functions of two variables on regions not necessarily rectangular. Implement Simpson double integral. Ref. B&F 4.8
8. Multiple integrals of functions of two variables on regions not necessarily rectangular. Implement Gaussian double integral. Ref. B&F 4.8
9. Use the Hermite family of orthogonal polynomials to generate Gaussian-Hermite integration formulas to approximate

$$\int_{-\infty}^{\infty} f(x)e^{-x^2}dx.$$

Ref. Abramowitz and Stegun, "Handbook of Mathematical Functions" §25.4.46 p890. This book is public domain and is available online to download.
10. Generate a table with the first 20 Gaussian quadrature nodes and weights on the interval [-1,1], preferably using Jacobi matrices (see §37 in Trefethen and Bau, "Numerical Linear Algebra").