The final exam will be administered Thursday, March 21st 3:00-6:00pm in **Fowler A103B** (this is **not** our usual classroom). No makeup exams will be given and you must take the final exam to pass the course. The exam is cumulative, covering Chapters 13-15 in the textbook. No electronic devices will be allowed including cell phones, laptops, or calculators, but you may bring a 3×5 inch notecard with notes and/or formulas on the front and back. **You must bring your student ID to the exam**. Scratch paper will be provided.

You should study old homework, worksheets, exams, lecture notes, and these sections of the textbook. You may also find it helpful to do problems in the textbook for each section as well as the Chapter Reviews for Chapters 13, 14, and 15.

Skills List

In general you are expected to know and understand all definitions and theorems covered. The following is a list of skills you will likely need to be able to apply on the exam. This list is meant to be a guide and is not exhaustive. In particular, you should be able to:

- Compute the distance between points in $\mathbb{R}^3$.
- Find the equation of a sphere or complete the square to identify the center and radius of a sphere.
- Perform vector operations including vector addition, subtraction, and scalar multiplication in $\mathbb{R}^2$ and $\mathbb{R}^3$.
- Find and interpret the magnitude of a vector.
- Find and interpret geometrically the dot product of two vectors.
- Compute the angle between two vectors.
- Find and interpret geometrically the cross product of two vectors.
- Find the area of shapes in the plane (parallelogram, triangle) and the volume of a parallelepiped.
- Find the parametric equations and vector equation of a line given some information (two points on the line or a point and a direction vector).
- Find the scalar equation and linear equation of a plane given some information.
- Find the angle between two planes.
- Identify and sketch standard types of quadric surfaces.
- Find the equation for a quadric surface given some information.
- Sketch or identify the graph of a space curve defined by a vector-valued function.
- Find a vector function that represents the intersection of two surfaces.
- Compute and interpret geometrically the derivative of a vector function.
- Find the parametric equations or a vector equation for the tangent line to a vector function.
- Use differentiation rules for vector functions.

- Compute indefinite and definite integrals for vector functions.

- Compute and interpret arc length and curvature for a curve.
- Compute and interpret the Frenet frame, i.e. the $\{\mathbf{T}, \mathbf{N}, \mathbf{B}\}$-frame for a curve.
- Find the osculating plane for a curve at a given point.
- Find and interpret the velocity, acceleration, and speed of a particle given a position function.
- Find the velocity and position functions for a particle given its acceleration, initial velocity, and initial position.
- Find the radial and tangential components of acceleration for a particle.
- Identify the graph and level curves of a function of two variables.
- Identify the domain of a function of multiple variables.
- Find a limit of a function of two variables or show that it does not exist.
- Determine the set of points at which a function of two variables is continuous.
- Compute and interpret first order and higher order partial derivatives.
- Identify signs of first order and higher order partial derivatives from a contour plot.
- Find the equation of the tangent plane to a surface and use it to approximate values of a function.
- Find the total differential and use it to approximate the change in outputs of a function.
- Apply the chain rule in multiple variables to find derivatives and partial derivatives.
- Compute and interpret the directional derivative of a function in a direction $\mathbf{u}$.
- Compute and interpret the gradient of a function of two variables or three variables.
- Find the maximum rate of change of a function and the direction in which it occurs.
- Find the direction of the gradient for a function at a point given a contour plot.
- Use the gradient to find the equation of the tangent plane to a surface.

- Apply the general chain rule in multiple variables to find derivatives and partial derivatives.
- Find and classify critical points (as local maxima, local minima, or saddle points) for a function in several variables.
- Find the absolute maximum and absolute minimum of a function on a closed and bounded domain.
- Use the method of Lagrange multipliers to find the maximum and minimum of a function subject to one or more constraints.