Must Know Material for Midterm#1 - M252 - Calculus III - Fall 2022

List of the material that MUST be second nature to you in preparation for MT#1:

- **Chap. 12 Vectors and The Geometry of Space:**
  12.1: Three-Dimensional Coordinate Systems
  12.2: Vectors
  12.3: The Dot Product
  12.4: The Cross Product
  12.5: Equations of Lines and Planes
  12.6: Cylinders and Quadric Surfaces
- **Chap. 13 Vector Functions:**
  13.1: Vector Functions and Space Curves
  13.2: Derivatives and Integrals of Vector Functions
  13.3: Arc Length and Curvature
  13.4: Motion in Space- Velocity and Acceleration

You must be very confident with the following basic and fundamental topics/formulas/techniques:

- If a constant is not defined (like an α or any other symbol), do NOT assign a value for it. It is a fixed scalar (or vector) and you should just leave it as it is.
- Be comfortable with the notation of vectors using coordinates or the main (unit) axis vectors $(\widehat{\mathbf{i}}, \widehat{\mathbf{j}}, \widehat{\boldsymbol{k}})$.
- Remember that a standard basis needs to be a RIGHT-HAND basis.
- In general, equations represent different objects in 2D vs. 3D.
- Remember equation of circles and spheres. Including ones NOT centered about the origin.
- Remember how to complete squares.
- Do NOT need to memorize the table for quadric surfaces. You just need to know how to draw a simple surface (like a plane or a cylinder) and also plot its traces by taking one of the coordinates to be constant.
- Inequalities: the equality is the boundary and then checking the sign on each side.
- A vector does not have an anchor. It is a direction with a length and it can be placed at any point.
- You need to know how to do vector operations: scalar multiplication, dot product, cross product, norm.
- How to project vectors onto other vectors using the dot product.
- Algebra and properties with vectors and scalars. $|a|$ is the absolute value and $|\vec{\boldsymbol{a}}|$ is the norm (magnitude).
- Making a vector unitary: $\widehat{\boldsymbol{a}} = \dfrac{\vec{\boldsymbol{a}}}{|\vec{\boldsymbol{a}}|}$ $\quad\|\quad$ $\vec{\boldsymbol{a}} \cdot \vec{\boldsymbol{b}} = |\vec{\boldsymbol{a}}|\,|\vec{\boldsymbol{b}}|\cos(\theta)$ $\quad\|\quad$ $\vec{\boldsymbol{a}} \cdot \vec{\boldsymbol{b}} = 0 \Leftrightarrow \vec{\boldsymbol{a}} \perp \vec{\boldsymbol{b}}$ $\quad\|\quad$ $\text{proj}_{\vec{\boldsymbol{a}}}(\vec{\boldsymbol{b}}) = \dfrac{\vec{\boldsymbol{a}} \cdot \vec{\boldsymbol{b}}}{|\vec{\boldsymbol{a}}|}\,\widehat{\boldsymbol{a}}$.
- $\vec{\boldsymbol{a}} \times \vec{\boldsymbol{b}} = |3{\times}3 \text{ determinant}|$ (sign $-$ for middle entry!) $\quad\|\quad$ $|\vec{\boldsymbol{a}} \times \vec{\boldsymbol{b}}| = |\vec{\boldsymbol{a}}|\,|\vec{\boldsymbol{b}}|\sin(\theta)$
- $|\vec{\boldsymbol{a}} \times \vec{\boldsymbol{b}}|$ = area of parallelogram (= 2×area of triangle) $\quad\|\quad$ $|\vec{\boldsymbol{a}} \cdot (\vec{\boldsymbol{b}} \times \vec{\boldsymbol{c}})|$ = volume of parallelepiped.
- Equation of line in: (i) vector form, (ii) parametric form, and (iii) symmetric form.
- Equation of plane in: (i) vector form using normal and point and (ii) scalar form.
- Distance between: (i) lines, (ii) // planes, (iii) line and plane, (iv) line and point, and (iv) plane and point.
- Derivatives and integrals of vector functions (just component by component).
- Formulas for tangent, normal and binormal vectors (see cheat sheet).
- Formulas for curvature in 3D, curvature for planar curves (2D) (see cheat sheet).
- Formulas for arclength and arclength function (see cheat sheet).
- $\vec{\boldsymbol{v}}(t) = \int \vec{\boldsymbol{a}}(t) + \vec{\boldsymbol{v}}(0)$ $\quad\|\quad$ $\vec{\boldsymbol{r}}(t) = \int \vec{\boldsymbol{v}}(t) + \vec{\boldsymbol{r}}(0)$ $\quad\|\quad$ $\vec{\boldsymbol{a}}(t) = \vec{\boldsymbol{v}}\,'(t) = \vec{\boldsymbol{r}}\,''(t)$.
- Tangential and normal components of the acceleration (see cheat sheet).
- Make sure that you understand and know how to apply ALL the formulas given in the cheat sheet!