Outline/Study Sheet

Chapters 1 and 2

Vector Basics

- Know the **geometric** definition (magnitude and direction) versus the **algebraic** definition of a vector (e.g., written using Cartesian components): Sec. 1.1.
- Know how to **add, subtract**, and find the **magnitude** of vectors: Sec. 1.1.
- Know the geometric and algebraic definitions of the **dot product**: Sec. 1.2.
- Know the geometric and algebraic definitions of the **cross product**: Sec. 1.3.
- Know how to **parameterize** lines and planes using vectors, where the vector can be either the **tangent** or **normal** to the line or plane: Secs. 1.2, 1.3.
- Know the geometric and algebraic definitions of the **triple scalar product**: Sec. 1.4.
- Know how to prove simple vector identities, if required. Know how to use them, if required: Sec. 1.5

Derivatives

- Time derivatives: Sec. 1.2.
- Spatial derivatives:
  - **Gradient**, ∇f : Sec. 1.5.
    - Know the direction of the gradient, and know the geometric interpretation of the gradient.
    - Understand the meaning of the equation $df = \nabla f \cdot d\vec{r}$.
    - Understand the integral definition, Eq. (1.112).
  - **Divergence**, $\nabla \cdot \vec{V}$: Secs. 1.6, 1.9, 1.10, 1.13.
    - Know intuitively (geometrically) the relationship between divergence and flux integrals
    - Understand the integral definition, Eq. (1.113).
    - Understand the connection to Gauss's Theorem
  - **Curl**, $\nabla \times \vec{V}$: Secs. 1.7, 1.9, 1.11, 1.12.
    - Know intuitively (geometrically) the relationship between curl and line integrals
    - Understand the integral definition, Eq. (1.114).
    - Understand the connection to Stoke's Theorem
    - Understand the connection to work and potential in physics
- Combinations of div, curl, gradient, e.g., the **Laplacian**: Sec. 1.8.

Types of Integrals

- **Line integrals**. Know how to setup a path $d\vec{r}$ in Cartesian, cylindrical, and spherical coordinates. Be willing to evaluate simple line integrals of the form:
  - $\int_C f d\vec{r}$,
  - $\int_C \vec{A} \cdot d\vec{r}$,
  - $\int_C \vec{A} \times d\vec{r}$.
- **Surface integrals**. Know how to setup an oriented surface $d\vec{\sigma} = \hat{n} d\sigma$ in Cartesian, cylindrical, and spherical coordinates. Be willing to evaluate simple surface integrals of the form:
  - $\int_S f d\vec{\sigma}$,
  - $\int_S f d\vec{\sigma}$,
  - $\int_S \vec{A} \cdot d\vec{\sigma}$,
  - $\int_S \vec{A} \times d\vec{\sigma}$.
- **Volume Integrals**. Know how to setup a volume dV in Cartesian, cylindrical, and spherical coordinates. Be willing to evaluate simple volume integrals of the form:
  - $\int_V f dV$,
  - $\int_V \vec{A} dV$.
- Also should know how to calculate:
  - **Arc length**: $(ds)^2 = d\vec{r} \cdot d\vec{r}$.
  - Simple surface or volume integrals, e.g., the volume under a plane or the area cut out of a plane by a cylinder.

Useful Theorems

- Gauss's Theorem: See inside front cover of book.
- Stoke's Theorem: See inside front cover of book.
- Area as a line integral: p. 73.

Curved Coordinate Systems

Secs. 2.1 through 2.5.

- Know how to work with the formulas found on the inside front cover of your book.

- For **spherical** and **cylindrical**, know the unit vectors in terms of the Cartesian unit vectors.
- Know how to write the **position** $\vec{r}$ in terms of cylindrical and spherical coordinates.
- Know how to write $d\vec{r}$ in terms of cylindrical and spherical coordinates.
- Understand qualitatively the origin of scale factors in $d\vec{r} = h_1 dq_1 \hat{q}_1 + h_2 dq_2 \hat{q}_2 + h_3 dq_3 \hat{q}_3$. What does orthogonal mean for coordinate systems?
- Be willing to work with the abstract form of vector equations, as found on the inside front cover of the book.