Linear Algebra Cheatsheet

Eventual outline

- **Part 1: Vectors**
  - Vectors
  - Plane geometry
  - Generalizing beyond $\mathbf{R}^3$: vector spaces
  - Projections
  - Gram-Schmidt
  - Applications of projections: linear regression least squares

- **Part 2: Matrices**
  - Linear transformations (as matrices)
  - Types of linear transformations (geometric perspective)
  - Matrix multiplication
    - Maybe: application: Markov chain/linear dynamical systems
  - Matrix algebra rules (transpose, various indentities, etc.)
  - Special matrices (symmetric, orthogonal, etc.)
- **Part 3: Linear systems**
  - Matrix inverses
  - Systems of equations as matrices
  - LU and QR decompositions
- **Part 4: Further matrix algebra (or name this eigenvalues)**
  - Eigenvalues and eigenvectors
  - Spectral theorem (diagonolization) and definiteness of symmetric matrices
  - Singular value decomposition
  - The Hessian and the second derivative test
- **Part 5: Matrix calculus and optimization**
  - Aside: Lagrange multipliers (constrained optimization)
  - Calculus with vectors and matrices
    - Gradient, Jacobian, Hessian, chain rule

  - Basics of convex optimization
  - Momentum

- Extra:
    - Gauss-Newton method
    - CS 205L stuff

I. Vectors

Definition 0.1 ($\mathbf{R}^2$, $\mathbf{R}^3$, $\mathbb{R}^n$)**.** The set $\mathbf{R}^2$ is the set of all ordered pairs of real numbers ($\mathbf{R}^2 = \{(x, y) : x, y \in \mathbf{R}\}$). The set itself should be thought of as a plane (i.e. the xy-cartesian plot). The set $\mathbf{R}^3$ is the set of all ordered triples of real numbers ($\mathbf{R}^3 = \{(x, y, z) : x, y, z \in \mathbf{R}\}$). The set itself should be thought of as ordinary space. This generalizes to higher dimensions ($\mathbf{R}^n$).