# Matrix Course Detailed Cheat Sheet

## Day 1: Core and Intermediate Concepts

### Vector Operations

* **Vector Addition**:  
  Formula:  
  + **Commutative**:
  + **Associative**:
* **Scalar Multiplication**:  
  Formula:  
  + **Distributive**:
  + **Associative with Scalars**:
* **Dot Product**:  
  Formula:  
  + **Commutative**:
  + **Distributive**:

### Length and Angle of Vectors

* **Length (Magnitude)**:  
  Formula:
* **Cosine of the Angle Between Vectors**:  
  Formula:
* **Cauchy-Schwartz Inequality**:  
  Formula:
* **Triangle Inequality**:  
  Formula:

### Linear Combinations and Span

* **Linear Combination**:  
  A vector ( ) can be written as a linear combination of other vectors.  
  Formula:
* **Span**:  
  The span of vectors ( \_1, \_2, , \_n ) is the set of all possible linear combinations of those vectors.

### Projections and Orthogonality

* **Projection of ( ) onto ( )**:  
  Formula:
* **Orthogonality**:  
  Two vectors ( ) and ( ) are orthogonal if their dot product is zero:
* **Pythagorean Theorem (in ( ^n ))**:  
  If ( ), then:

### Gaussian Elimination

1. **Forming the Augmented Matrix**:  
   Write the system of linear equations in matrix form.
2. **Row Operations**:
   * **Swap rows**.
   * **Multiply a row by a non-zero scalar**.
   * **Add/subtract multiples of one row to/from another**.
3. **Back Substitution**:
   * Solve the system by simplifying to row echelon form (upper triangular matrix) and using back substitution.

### Matrix Operations

* **Matrix Addition**:
* **Matrix Multiplication**:  
  Formula for the element in the ( i )-th row and ( j )-th column of the product matrix:
* **Transpose of a Matrix**:  
  Formula:

### Key Properties

* **Distributive**:
* **Associative** (Matrix Multiplication):
* **Non-Commutative** (Matrix Multiplication):
* in general.

## Day 2: Advanced Concepts

### Matrix Inverses

* **Matrix Inverse** (for square matrix ( A )):  
  + A matrix ( A ) is invertible if and only if ( (A) ).

### Determinants

* **Determinant of a 2x2 Matrix**:
* **Properties of Determinants**:
  + ( (AB) = (A)(B) )
  + ( (A^T) = (A) )
  + If ( (A) = 0 ), then ( A ) is not invertible.

### Eigenvalues and Eigenvectors

* **Eigenvalue Equation**:  
  + Where ( ) is the eigenvalue, and ( ) is the corresponding eigenvector.
* **Finding Eigenvalues**:  
  Solve ( (A - I) = 0 ) for ( ).
* **Finding Eigenvectors**:  
  Solve ( (A - I) = 0 ) for ( ).

### Diagonalization

* A matrix ( A ) is diagonalizable if there exists an invertible matrix ( P ) such that:  
  + Where ( D ) is a diagonal matrix whose diagonal entries are the eigenvalues of ( A ), and the columns of ( P ) are the corresponding eigenvectors of ( A ).

### Practice Problems

#### Problem 1: Vector Orthogonality

* Let ( ) and ( ) be n-dimensional vectors. Define the vectors:
* Prove that ( h ) is orthogonal to ( ).
* **Solution**: Compute ( h ) and show that it equals zero.

#### Problem 2: Gaussian Elimination

Solve the system of equations using Gaussian Elimination:

#### Problem 3: Determinants and Eigenvalues

Find the determinant and eigenvalues of the matrix:

This cheat sheet now has a **more expanded version**, following the requested format with LaTeX-like syntax that can be used in platforms that