PMATH365 — Differential Geometry

CLASSNOTES FOR WINTER 20019

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List of Definitions

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List of Theorems

Preface

This course is a post-requisite of MATH 235/245 (Linear Algebra II) and AMATH 231 (Calculus IV) or MATH 247 (Advanced Calculus III). In other words, familiarity with vector spaces and calculus is expected.

1 Lecture 1 Jan 7th

1.1 Linear Algebra Review

Definition 1 (Linear Map)

Let V, W be finite dimensional real vector spaces. A map $T: V \to W$ is called **linear** if $\forall a, b \in \mathbb{R}$, $\forall v \in V$ and $\forall w \in W$,

$$T(av + bw) = aT(v) + bT(w).$$

We define L(U, W) to be the set of all linear maps from V to W.

66 Note

- Note that L(U, W) is itself a finite dimensional real vector space.
- The structure of the vector space L(V,W) is such that $\forall T,S \in L(V,W)$, and $\forall a,b \in \mathbb{R}$, we have

$$aT + bS : V \rightarrow W$$

and

$$(aT + bS)(v) = aT(v) + bS(v).$$

• A special case: when W = V, we usually write

$$L(V,W) = L(V),$$

and we call this the space of linear operators on V.

Now suppose $\dim(V) = n$ for some $n \in \mathbb{N}$. This means that there exists a basis $\{e_1, \dots, e_n\}$ of V with n elements.

Definition 2 (Basis)

A basis $\mathcal{B} = \{e_1, \dots, e_n\}$ of an n-dimensional vector space V is a subset of V where

1. \mathcal{B} spans V, i.e. $\forall v \in V$

$$v = \sum_{i=1}^{n} v^{i} e_{i}.$$

2. e_1, \ldots, e_n are linearly independent, i.e.

$$v^i e_i = 0 \implies v^i = 0$$
 for every i .

 1 We shall use a different convention when we write a linear combination. In particular, we use v^{i} to represent the i^{th} coefficient of the linear combination instead of v_{i} . Note that this should not be confused with taking powers, and should be clear from the context of the discussion.

66 Note

We shall abusively write

$$v^i e_i = \sum_i v^i e_i$$
.

Again, this should be clear from the context of the discussion.

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