MATH 601 HOMEWORK (DUE 10/16)

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Contents

1. Jordan Canonical Form

Let k be a field, V a finite dimensional k-vector space, and $T \in \mathrm{End}_k(V)$ a linear transformation.

Exercise. (Problem 1) Show that the set $\{p(x) \in k[x] \mid p(T) = 0 \in \mathrm{End}_k(V)\}$ is an ideal, $I \subset k[x]$. Also, show that $I \neq 0$.

Proof.

- Claim 1: I is nonempty.
  Use Cayley-Hamilton to find a non-trivial element. I'm still trying to understand C-H. One thing I learned today is that the determinant function is independent of the choice of the basis.
- Claim 2: I is closed under subtraction. Let $p(x), q(x) \in I$. Then $p(x) - q(x) \in I$ because $p(T) - q(T) = 0 - 0 = 0$.
- Claim 3: I is closed under multiplication by elements in $k[x]$. Let $p(x) \in I, r(x) \in k[x]$. Then $p(T)r(T) = 0r(T) = 0$, so $r(x)p(x) \in I$.

By Claim 1 and 2, I is a subgroup of $k[x]$ under addition. Then Claim 3 implies that I is an ideal. By Claim 1, $I \neq 0$. □

Exercise. (Problem 2) Let $p(x) \in k[x]$ be a nonzero polynoial such that $p(T) = 0 \in \mathrm{End}_k(V)$. Show that if $p(x) \in k[x]$ is a product of linear polynomials, then there is a k-basis for V with respect to which the matrix for T is in Jordan normal form.

Proof. Solve this.

□