Learning Objectives

> This review session has one objective, and that is to *Work in groups to identify course objectives that you are not comfortable with.*

1. The following sentences have errors or are missing something. Correct them or add the missing details.

   (a) A transformation $f : \mathbb{R}^n \to \mathbb{R}^m$ is linear if it sends sums to sums, $f(\vec{0}) = \vec{0}$, and $f(\alpha\vec{x}) = \alpha f(\vec{x})$.

   (b) An $n \times m$ matrix corresponds to a linear transformation from $\mathbb{R}^n$ to $\mathbb{R}^m$.

   (c) A basis for the subspace V is a set S such that $\dim S = \dim V$ and $\operatorname{span}(S) = V$.

   (d) $\vec{w}$ is a convex combination of u and v if:

   $$\vec{w} = \left\{ \vec{w} : \vec{w} = a\vec{u} + b\vec{v} \text{ for all } a, b \in [0,1] \right\}$$

   (e) If $\vec{a}$, $\vec{b}$, and $\vec{c}$ are pairwise orthogonal vectors in $\mathbb{R}^3$, then $\det\left[\vec{a}|\vec{b}|\vec{c}\right] = 1$.

2. A transformation $T : \mathbb{R}^n \to \mathbb{R}^m$ is called *almost linear* if for all $x, y \in \mathbb{R}^n$, we have $\|T(x+y)\| \leq \|T(x)+T(y)\|$, and for all $\alpha \geq 0$ and $x \in \mathbb{R}^n$, we have $\|T(\alpha x)\| \leq \alpha\|T(x)\|$.

   - Write down a clear and concise explanation of what one must do in order to show that a transformation is almost linear.
   - Show that the transformation $f : \mathbb{R} \to \mathbb{R}$ defined by $f(x) = x^2$ is not almost linear.
   - Show that any linear transformation in almost linear.

3. Mohammed has partially row-reduced the matrix A using the following steps. Use his work to write A as a product of elementary matrices. Use this to compute $\det A$.

$$A = \begin{bmatrix} 0 & 0 & 0 & 2 \\ 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 1 & 0 & 3 & 0 \end{bmatrix} \xrightarrow{r_1 \leftrightarrow r_3} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 2 \\ 1 & 0 & 3 & 0 \end{bmatrix} \xrightarrow{r_4 \to r_4 - r_1} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 2 \\ 0 & 0 & 3 & 0 \end{bmatrix} \xrightarrow{r_4 \leftrightarrow r_3} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 3 & 0 \\ 0 & 0 & 0 & 2 \end{bmatrix}$$

4. For which values of a is the matrix A invertible? Compute the inverse of A when it exists (your answer may depend on a).

$$A = \begin{bmatrix} 0 & 3 & 2 \\ a & 0 & 0 \\ 8 & 2 & 0 \end{bmatrix}$$

5. Let $T : \mathbb{R}^2 \to \mathbb{R}^2$ be the transformation which projects vectors onto the subspace $V = \operatorname{span}\{\vec{v}\}$, where $\vec{v} = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$.

   (a) Show that T is linear.

   (b) What are the eigenvectors of T? Is T diagonalizable?

   (c) How do the eigenvectors of T relate to V and $V^{\perp}$?