

## Application Activities - Module S Part 3 - Class Day 14

**Fact 14.1** To compute a basis for the subspace  $\text{span}\{\mathbf{v}_1, \dots, \mathbf{v}_m\}$ , simply remove the vectors corresponding to the non-pivot columns of  $\text{RREF}[\mathbf{v}_1 \dots \mathbf{v}_m]$ .

**Activity 14.2** Find all subsets of  $S = \left\{ \begin{bmatrix} 2 \\ 3 \\ 0 \\ 1 \end{bmatrix}, \begin{bmatrix} 2 \\ 0 \\ 1 \\ -1 \end{bmatrix}, \begin{bmatrix} 2 \\ -3 \\ 2 \\ -3 \end{bmatrix}, \begin{bmatrix} 1 \\ 5 \\ -1 \\ 0 \end{bmatrix} \right\}$  that are a basis for  $\text{span } S$  by changing the order of the vectors in  $S$ .

**Activity 14.3** Assume  $\mathbf{w}_1 \neq \mathbf{w}_2$  are distinct vectors in  $V$ , which has a basis containing a single vector:  $\{\mathbf{v}\}$ . Could  $\{\mathbf{w}_1, \mathbf{w}_2\}$  be a basis?

**Fact 14.4** All bases for a vector space are the same size.

**Definition 14.5** The **dimension** of a vector space is given by the cardinality/size of any basis for the vector space.

**Activity 14.6** Find the dimension of each subspace of  $\mathbb{R}^4$ .

$$\begin{aligned} \text{span} \left\{ \begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 0 \\ 1 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 0 \\ 0 \\ 1 \\ 0 \end{bmatrix}, \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix} \right\} & \quad \text{span} \left\{ \begin{bmatrix} 2 \\ 3 \\ 0 \\ -1 \end{bmatrix}, \begin{bmatrix} 2 \\ 0 \\ 0 \\ 3 \end{bmatrix}, \begin{bmatrix} 4 \\ 3 \\ 0 \\ 2 \end{bmatrix}, \begin{bmatrix} -3 \\ 0 \\ 1 \\ 3 \end{bmatrix} \right\} \\ \text{span} \left\{ \begin{bmatrix} 2 \\ 3 \\ 0 \\ -1 \end{bmatrix}, \begin{bmatrix} 2 \\ 0 \\ 0 \\ 3 \end{bmatrix}, \begin{bmatrix} 3 \\ 13 \\ 7 \\ 16 \end{bmatrix}, \begin{bmatrix} -1 \\ 10 \\ 7 \\ 14 \end{bmatrix}, \begin{bmatrix} 4 \\ 3 \\ 0 \\ 2 \end{bmatrix} \right\} & \quad \text{span} \left\{ \begin{bmatrix} 2 \\ 3 \\ 0 \\ -1 \end{bmatrix}, \begin{bmatrix} 4 \\ 3 \\ 0 \\ 2 \end{bmatrix}, \begin{bmatrix} -3 \\ 0 \\ 1 \\ 3 \end{bmatrix}, \begin{bmatrix} 3 \\ 6 \\ 1 \\ 5 \end{bmatrix} \right\} \\ \text{span} \left\{ \begin{bmatrix} 5 \\ 3 \\ 0 \\ -1 \end{bmatrix}, \begin{bmatrix} -2 \\ 1 \\ 0 \\ 3 \end{bmatrix}, \begin{bmatrix} 4 \\ 5 \\ 1 \\ 3 \end{bmatrix} \right\} & \end{aligned}$$

**Activity 14.7** What is the dimension of the vector space of 7th-degree (or less) polynomials  $\mathcal{P}^7$ ?

- a) 6                                      b) 7                                      c) 8                                      d) infinite

**Activity 14.8** What is the dimension of the vector space of all polynomials  $\mathcal{P}$ ?

a) 6

b) 7

c) 8

d) infinite

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**Observation 14.9** Several interesting vector spaces are infinite-dimensional:

- The space of polynomials  $\mathcal{P}$  (consider the set  $\{1, x, x^2, x^3, \dots\}$ ).
- The space of continuous functions  $C(\mathbb{R})$  (which contains all polynomials, in addition to other functions like  $e^x = 1 + x + x^2/2 + x^3/3 + \dots$ ).
- The space of real number sequences  $\mathbb{R}^\infty$  (consider the set  $\{(1, 0, 0, \dots), (0, 1, 0, \dots), (0, 0, 1, \dots), \dots\}$ ).

**Fact 14.10** Every vector space with finite dimension, that is, every vector space with a basis of the form  $\{\mathbf{v}_1, \mathbf{v}_2, \dots, \mathbf{v}_n\}$  is isomorphic to a Euclidean space  $\mathbb{R}^n$ :

$$c_1 \mathbf{v}_1 + c_2 \mathbf{v}_2 + \dots + c_n \mathbf{v}_n \leftrightarrow \begin{bmatrix} c_1 \\ c_2 \\ \vdots \\ c_n \end{bmatrix}$$