

# Vector Spaces:

Vector space = set of vectors  
(column matrices) + set of scalars ( $\mathbb{R}$ )  
+ closed under vector addition and  
scalar multiplication

## Example of a Vector space:

Set of Vectors: ALL  $3 \times 1$  matrices

Set of scalars: real numbers

$u, v$   $3 \times 1$  matrices

$w = au + bv \Rightarrow w$  is a  $3 \times 1$  matrix

$$a \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} + b \begin{pmatrix} y_1 \\ y_2 \\ y_3 \end{pmatrix} = \begin{pmatrix} ax_1 + by_1 \\ ax_2 + by_2 \\ ax_3 + by_3 \end{pmatrix}$$

Vector spaces associated with matrices:

- null space
- column space
- row space
- left null space