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Fundamental Subspaces

In this section we want to take a look at some important subspaces that are associated with matrices. In fact they are so important that they are often called the fundamental subspaces of a matrix. We've actually already seen one of the fundamental subspaces, the null space, previously although we will give its definition here again for the sake of completeness.

Before we give the formal definitions of the fundamental subspaces we need to quickly review a concept that we first saw back when we were looking at matrix arithmetic.

Given an $n \times m$ matrix

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1m} \\ a_{21} & a_{22} & \cdots & a_{2m} \\ \vdots & \vdots & & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nm} \end{bmatrix}$$

The **row vectors** (we called them row matrices at the time) are the vectors in R^m formed out of the rows of A. The **column vectors** (again we called them column matrices at the time) are the vectors in R^n that are formed out of the columns of A.

Example 1 Write down the row vectors and column vectors for

$$A = \begin{bmatrix} -1 & 5 \\ 0 & -4 \\ 9 & 2 \\ 3 & -7 \end{bmatrix}$$

Solution

The row vectors are,

$$\vec{r}_1 = \begin{bmatrix} -1 & 5 \end{bmatrix} \qquad \vec{r}_2 = \begin{bmatrix} 0 & -4 \end{bmatrix} \qquad \vec{r}_3 = \begin{bmatrix} 9 & 2 \end{bmatrix} \qquad \vec{r}_4 = \begin{bmatrix} 3 & -7 \end{bmatrix}$$

The column vectors are

$$\vec{c}_1 = \begin{bmatrix} -1 \\ 0 \\ 9 \\ 3 \end{bmatrix} \qquad \vec{c}_2 = \begin{bmatrix} 5 \\ -4 \\ 2 \\ -7 \end{bmatrix}$$

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Paul R. Halmos

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