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## Chapter 4 Subspaces

### 4.1 Practice Problems

1. (a) Not a subspace. The vector  $0 = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$  is not in the set.

- (b) Let  $S$  be the set of vectors of the form  $\begin{bmatrix} a - b \\ -2a \end{bmatrix}$ . Letting  $a = 0$  and  $b = 0$ , we see that

$0 \in S$ . Suppose  $u$  and  $v$  are in  $S$ , then  $u = \begin{bmatrix} a_1 - b_1 \\ -2a_1 \end{bmatrix}$  and  $v = \begin{bmatrix} a_2 - b_2 \\ -2a_2 \end{bmatrix}$ . Thus  $u + v =$

$$\begin{bmatrix} a_1 - b_1 \\ -2a_1 \end{bmatrix} + \begin{bmatrix} a_2 - b_2 \\ -2a_2 \end{bmatrix} = \begin{bmatrix} (a_1 + a_2) - (b_1 + b_2) \\ -2(a_1 + a_2) \end{bmatrix} \in S. \text{ Let } r \in \mathbb{R} \text{ and } u \in S, \text{ then } ru =$$

$$r \begin{bmatrix} a_1 - b_1 \\ -2a_1 \end{bmatrix} = \begin{bmatrix} (ra_1) - (rb_1) \\ -2(ra_1) \end{bmatrix} \in S, \text{ and we conclude that } S \text{ is a subspace. (Alternatively, we}$$

have  $S = \text{span} \left\{ \begin{bmatrix} 1 \\ -2 \end{bmatrix}, \begin{bmatrix} -1 \\ 0 \end{bmatrix} \right\}$ , and thus  $S$  is a subspace.

2. (a) We row-reduce

$$\begin{bmatrix} 1 & 3 & -2 \\ 3 & 0 & -4 \end{bmatrix} \sim \begin{bmatrix} 1 & 3 & -2 \\ 0 & -9 & 2 \end{bmatrix}.$$

Thus,  $Ax = 0$  has solutions of the form

$$x = s \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} + t \begin{bmatrix} 2 \\ 0 \\ 9 \end{bmatrix}$$

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