

## 1 Question 1

### 1.1 Givens

Modes of transport  $\mathbf{v}_1 = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}$   $\mathbf{v}_2 = \begin{bmatrix} 6 \\ 3 \\ 8 \end{bmatrix}$   $\mathbf{v}_3 = \begin{bmatrix} 4 \\ 1 \\ 6 \end{bmatrix}$

### 1.2 Questions

a **Question:** Is there anywhere in  $\mathbb{R}^3$  that old man Gauss can hide?

**Answer:** Maybe, let's do a quick RREF and have a look

$$\left[ \begin{array}{ccc|c} 1 & 6 & 4 & x \\ 0 & 3 & 8 & y \\ 4 & 1 & 6 & z \end{array} \right] \rightarrow \left[ \begin{array}{ccc|c} 1 & 0 & -2 & 0 \\ 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right]$$

We're short a pivot in the bottom row but we do have an entry in the last column. This means that the system is inconsistent and there is no solution. So, there is somewhere in  $\mathbb{R}^3$  that old man Gauss can hide. We can also see that the vectors are linearly dependent.

$$2 \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} + \begin{bmatrix} 4 \\ 1 \\ 6 \end{bmatrix} = \begin{bmatrix} 6 \\ 3 \\ 8 \end{bmatrix} = \mathbf{v}_2$$

## 2 Question 2

### 2.1 Givens

Suppose

$$\mathbf{v}_1 = \begin{bmatrix} 1 \\ -1 \\ 2 \end{bmatrix} \quad \mathbf{v}_2 = \begin{bmatrix} -1 \\ 2 \\ 3 \end{bmatrix} \quad \mathbf{v}_3 = \begin{bmatrix} 2 \\ 3 \\ h \end{bmatrix}$$

### 2.2 Question

**Question:** For what values of  $h$  are the vectors  $\mathbf{v}_1$ ,  $\mathbf{v}_2$ , and  $\mathbf{v}_3$  linearly dependent?

**Answer:** We can do this with the determinant this time around. The system should result in a determinant that is 0.

$$\det \begin{pmatrix} 1 & -1 & 2 \\ -1 & 2 & 3 \\ 2 & 3 & h \end{pmatrix} = 0$$

$$1(2h - 9) + 1(-h - 6) + 2(-3 - 4) = 0$$

$$2h - 9 - h - 6 - 6 - 8 = 0$$

$$h - 29 = 0$$

$$h = 29$$

**Check:** So, given a value of  $h = 29$  we can check our work by calculating

$$\mathbf{v}_1 = \begin{bmatrix} 1 \\ -1 \\ 2 \end{bmatrix} \quad \mathbf{v}_2 = \begin{bmatrix} -1 \\ 2 \\ 3 \end{bmatrix} \quad \mathbf{v}_3 = \begin{bmatrix} 2 \\ 3 \\ 29 \end{bmatrix}$$

$$\left[ \begin{array}{ccc|c} 1 & -1 & 2 & x \\ -1 & 2 & 3 & y \\ 2 & 3 & 29 & z \end{array} \right] \rightarrow \left[ \begin{array}{ccc|c} 1 & 0 & 7 & 0 \\ 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right]$$

As we have a row of all zeros, we can be sure that the vectors are linearly dependent.

### 3 Question 3

#### 3.1 Question

We're asked whether given  $\{\mathbf{x}, \mathbf{y}\}$  as linearly independent. And given  $\{\mathbf{x}, \mathbf{y}, \mathbf{z}\}$  as linearly dependent. Is  $\mathbf{z}$  in the span of  $\{\mathbf{x}, \mathbf{y}\}$ ? If false, give a counterexample.

#### 3.2 Answer

Yes. For  $\{\mathbf{x}, \mathbf{y}, \mathbf{z}\}$  to be linearly dependent, one of the vectors must be a linear combination of the others. That is, we could write  $\mathbf{z}$  as  $\mathbf{z} = a\mathbf{x} + b\mathbf{y}$  for some  $a, b \in \mathbb{R}$ . This is another way of saying that  $\mathbf{z}$  is in the span of  $\{\mathbf{x}, \mathbf{y}\}$ . So, if  $\{\mathbf{x}, \mathbf{y}\}$  is linearly independent and  $\{\mathbf{x}, \mathbf{y}, \mathbf{z}\}$  is linearly dependent, then  $\mathbf{z}$  is in the span of  $\{\mathbf{x}, \mathbf{y}\}$ .

### 4 Question 4

#### 4.1 Remember from class

- If a set contains two vectors that are scalar multiples of one another, then the set is linearly dependent.
- If a set contains at least two vectors that are scalar multiples of one another, then the set is linearly dependent.
- If a set contains  $p$  vectors in  $\mathbb{R}^n$  and  $p > n$  then the set is linearly dependent.
- If a set contains the zero vector then it is linearly dependent.

- e If a set contains exactly one vector, then the set is linearly independent if and only if the vector is non-zero.
- f A set of vectors is linearly dependent if and only if one of the vectors can be expressed as a linear combination of the others.

## 4.2 Question

Choose two and write a reasonable explanation/proof.