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# Exercises 10.3

1. Let  $\mathbf{V} = R^3$  with the standard inner product and let

$$\mathbf{S} = \{\boldsymbol{u_1}, \boldsymbol{u_2}, \boldsymbol{u_3}\} = \left\{ \begin{bmatrix} 1\\2\\0 \end{bmatrix}, \begin{bmatrix} 1\\0\\0 \end{bmatrix}, \begin{bmatrix} 1\\0\\1 \end{bmatrix} \right\}.$$

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Use routine **gschmidt** in MATLAB to obtain an orthonormal basis **T** and then find the coordinates of  $\boldsymbol{x} = \begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix}$  relative to **T**. Record the orthonormal basis and the coordinates of  $\boldsymbol{x}$  below.

2. Let  $\mathbf{V} = R^4$  with the standard inner product and let

$$\mathbf{S} = \{ \boldsymbol{u_1}, \boldsymbol{u_2}, \boldsymbol{u_3}, \boldsymbol{u_4} \} = \left\{ \begin{bmatrix} -1\\2\\0\\1 \end{bmatrix}, \begin{bmatrix} 2\\1\\1\\0\\1 \end{bmatrix}, \begin{bmatrix} 0\\1\\1\\0\\1 \end{bmatrix}, \begin{bmatrix} 1\\1\\0\\1 \end{bmatrix}, \begin{bmatrix} 1\\1\\0\\1 \end{bmatrix} \right\}$$

Use routine **gschmidt** in MATLAB to obtain an orthonormal basis **T** and then find the coordinates of  $\boldsymbol{x} = \begin{bmatrix} 4 \\ 0 \\ 2 \\ 1 \end{bmatrix}$  relative to **T**. Record the orthonormal basis and the coordinates of  $\boldsymbol{x}$  below.

3. Let  $\mathbf{V} = R^4$  with the standard inner product and let

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a) Is S an

$$\mathbf{S} = \{\boldsymbol{u_1}, \boldsymbol{u_2}, \boldsymbol{u_3}, \boldsymbol{u_4}\} = \left\{ \begin{bmatrix} .5 \\ .5 \\ .5 \\ .5 \end{bmatrix}, \begin{bmatrix} .5 \\ .5 \\ .5 \\ .-.5 \\ .-.5 \end{bmatrix}, \begin{bmatrix} .5 \\ ..5 \\ ..5 \\ ..5 \end{bmatrix}, \begin{bmatrix} .5 \\ ..5 \\ ..5 \\ ..5 \end{bmatrix}, \begin{bmatrix} .5 \\ ..5 \\ ..5 \\ ..5 \end{bmatrix}, \begin{bmatrix} .5 \\ ..5 \\ ..5 \\ ..5 \end{bmatrix} \right\}.$$
  
Is S an orthonormal basis? Circle one: Yes No  
Explain your answer.

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b) In MATLAB form the matrix T whose columns are the vectors in S. Generate a random vector in  $\mathbb{R}^4$  using command  $\mathbf{x} = \operatorname{rand}(4,1)$  and then compute  $|| \mathbf{x} ||$  and  $|| \mathbf{T} \mathbf{x} ||$ . How are the values of the norms related? Repeat the experiment for another arbitrary vector.

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A' = \_\_\_\_

 $\mathbf{C} = -$ 

4. Let  $v_1 = \begin{bmatrix} 1 \\ 2 \\ 2 \end{bmatrix}$  and  $v_2 = \begin{bmatrix} 1 \\ 3 \\ 1 \end{bmatrix}$ . In MATLAB form the matrix  $\mathbf{A} = [\mathbf{v1} \ \mathbf{v2}]$  and then use command **gschmidt(A)**. Explain the meaning of the display generated.

**5.** Let  $\boldsymbol{A} = \begin{bmatrix} 1 & i & 0 \\ i & 0 & 1 \end{bmatrix}$ .

a) In MATLAB use command A'. Record the result.

- **b)** In MATLAB use command  $\mathbf{C} = \mathbf{A}' * \mathbf{A}$ . Record the result.
- c) What is the relation between C and C'?

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d) Experiment with other complex matrices A to confirm or reject your answer in part c).

Circle one:

confirmed

not confirmed.

YES

NO

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6. A complex matrix A is called Hermitian if it is equal to its conjugate transpose. The command A' gives the conjugate transpose in MATLAB.

a) How can you use MATLAB to determine if the matrix A below is Hermitian?

$$oldsymbol{A}=\left[egin{array}{cc} 2&3-3i\ 3+3i&5 \end{array}
ight]$$

**b)** Compute r = x' \* A \* x for the complex vector below.

 $oldsymbol{x} = \left[ egin{array}{c} i \ 1-i \end{array} 
ight] egin{array}{c} oldsymbol{r} = & & \ \end{array}$ 

Is r a real number? (Circle one:)

c) Experiment with other complex vectors  $\boldsymbol{x}$  to determine whether  $\boldsymbol{x}' \boldsymbol{A} \boldsymbol{x}$  will always be a real number. (Circle one:)

Always a real number for this matrix **A**. Not always a real number.

d) Experiment with another Hermitian matrix A and arbitrary vector x to see if r = x' \* A \* x is always a real number.

(Circle one:) Always a real number. Not always a real number.

7. Let  $\mathbf{V} = R^4$  with the standard inner product and let

$$\boldsymbol{v_1} = \begin{bmatrix} 3\\1\\2\\0 \end{bmatrix}, \quad \boldsymbol{v_2} = \begin{bmatrix} 1\\-1\\-1\\1 \end{bmatrix}, \quad \boldsymbol{v_3} = \begin{bmatrix} 0\\-2\\1\\-1 \end{bmatrix}.$$

a) Find an orthonormal basis for  $R^4$  containing scalar multiples of the vectors  $v_1$  and  $v_2$ . Record your result below.

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b) Find an orthonormal basis for  $R^4$  containing scalar multiples of the vectors  $v_1$ ,  $v_2$ ,  $v_3$ . Record your result below.

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## << NOTES; COMMENTS; IDEAS >>

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