C. HECKMAN 242

Test 3 A

Name: _____

Instructions:

- The exam consists of five (5) problems, some of which may have several parts. It has five (5) pages (including this one); you should make sure that you have all of them before you start.
- Turn off your cell phone or any communications device (if you have one) and put it away, and remove any headphones before beginning the test.
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- Make sure you read the problems and answer everything that is asked. If you are asked to use a particular method, you must use that method to receive full credit. If you are not told to use any particular method, you may use any method mentioned in class.
- No calculators with Qwerty keyboards or ones like the Casio FX-2, TI-89, or TI-92 that do symbolic algebra may be used. If you use your calculator for a calculation, make sure you indicate which expression you are entering into your calculator; do NOT just give a final answer.

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Signature

1. Let $\vec{v}_1 = \begin{bmatrix} -2 \\ 2 \\ 1 \\ 4 \end{bmatrix}$, $\vec{v}_2 = \begin{bmatrix} 4 \\ 1 \\ -2 \\ 2 \end{bmatrix}$, and $\vec{v}_3 = \begin{bmatrix} 1 \\ 4 \\ 2 \\ -2 \end{bmatrix}$. Note that $B = \{\vec{v}_1, \vec{v}_2, \vec{v}_3\}$ is an orthogonal set. Also, let W be the subspace spanned by $\{\vec{v}_1, \vec{v}_2, \vec{v}_3\}$.

   a. [15 points] Find the orthogonal projection of $\begin{bmatrix} -13 \\ 18 \\ 9 \\ 1 \end{bmatrix}$ into W, without inverting any matrices or solving any systems of linear equations.

   b. [10 points] Find an orthonormal basis for W.

2. Let W be the subspace spanned by $\left\{ \begin{bmatrix} 0 \\ -2 \\ -2 \\ -1 \end{bmatrix}, \begin{bmatrix} 0 \\ -3 \\ 0 \\ -3 \end{bmatrix}, \begin{bmatrix} 0 \\ 5 \\ 5 \\ 7 \end{bmatrix} \right\}$. Note that this basis is **not** orthogonal.

a. [15 points] Find the vector in W closest to $\begin{bmatrix} -1 \\ 7 \\ -5 \\ -4 \end{bmatrix}$.

b. [15 points] Find an orthogonal basis for W.

3. Do the following, for the following set of data points: $(-4, -93)$, $(-1, -3)$, $(0, -1)$, $(4, 27)$.

   a. [10 points] Find the parabola $y = ax^2 + bx + c$ which best fits these points.

   b. [10 points] Find the parabola $y = ax^2 + c$ with no linear term which best fits these points.

4. [10 points] Find the Least Squares Solution to the following system of linear equations:

$$\begin{aligned} -x_1 + 5x_2 - 3x_3 &= -2 \\ 2x_1 + 3x_2 - 4x_3 &= 0 \\ 3x_1 + x_2 - 3x_3 &= 2 \\ 3x_1 - 4x_2 + 5x_3 &= -4 \end{aligned}$$

5. [15 points] Find a basis for $W^{\perp}$, the orthogonal complement of W, if W is the subspace spanned by

$$\left\{ \begin{bmatrix} -4 \\ 2 \\ -4 \\ -4 \end{bmatrix} \right\}$$

C. HECKMAN 242

Test 3 B

Name: _____

Instructions:

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Signature

1. Let $\vec{v}_1 = \begin{bmatrix} 1 \\ -2 \\ 0 \\ -2 \end{bmatrix}$, $\vec{v}_2 = \begin{bmatrix} -2 \\ 1 \\ 0 \\ -2 \end{bmatrix}$, and $\vec{v}_3 = \begin{bmatrix} 0 \\ 0 \\ 1 \\ 0 \end{bmatrix}$. Note that $B = \{\vec{v}_1, \vec{v}_2, \vec{v}_3\}$ is an orthogonal set. Also, let W be the subspace spanned by $\{\vec{v}_1, \vec{v}_2, \vec{v}_3\}$.

   a. [15 points] Find the vector in W closest to $\begin{bmatrix} -5 \\ 4 \\ -1 \\ 7 \end{bmatrix}$, without inverting any matrices or solving any systems of linear equations.

   b. [10 points] Find an orthonormal basis for W.

2. Let W be the subspace spanned by $\left\{ \begin{bmatrix} -2 \\ 4 \\ 1 \\ 2 \end{bmatrix}, \begin{bmatrix} 0 \\ 5 \\ 5 \\ 0 \end{bmatrix}, \begin{bmatrix} -5 \\ -5 \\ -15 \\ 0 \end{bmatrix} \right\}$. Note that this basis is **not** orthogonal.

a. [15 points] Find the vector in W closest to $\begin{bmatrix} 6 \\ -12 \\ -8 \\ 9 \end{bmatrix}$.

b. [15 points] Find an orthogonal basis for W.

3. Do the following, for the following set of data points: $(-5, -133)$, $(-4, -71)$, $(0, -3)$, $(3, 27)$.

   a. [10 points] Find the parabola $y = ax^2 + bx + c$ which best fits these points.

   b. [10 points] Find the parabola $y = ax^2 + c$ with no linear term which best fits these points.

4. [10 points] Find the Least Squares Solution to the following system of linear equations:

$$\begin{aligned} 4x_1 + 5x_2 &= -3 \\ x_1 + x_2 + x_3 &= 0 \\ -4x_3 &= 2 \\ -3x_1 + 3x_2 + 2x_3 &= -7 \end{aligned}$$

5. [15 points] Find a basis for $W^{\perp}$, the orthogonal complement of W, if W is the subspace spanned by

$$\left\{ \begin{bmatrix} 0 \\ 1 \\ -4 \\ 4 \end{bmatrix} \right\}$$

C. HECKMAN 242

Test 3 C

Name: _____

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Signature

1. Let $\vec{v}_1 = \begin{bmatrix} 0 \\ -2 \\ 1 \\ -2 \end{bmatrix}$, $\vec{v}_2 = \begin{bmatrix} 0 \\ 1 \\ -2 \\ -2 \end{bmatrix}$, and $\vec{v}_3 = \begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \end{bmatrix}$. Note that $B = \{\vec{v}_1, \vec{v}_2, \vec{v}_3\}$ is an orthogonal set. Also, let W be the subspace spanned by $\{\vec{v}_1, \vec{v}_2, \vec{v}_3\}$.

   a. [15 points] Find the vector in W closest to $\begin{bmatrix} 2 \\ 1 \\ -2 \\ -11 \end{bmatrix}$, without inverting any matrices or solving any systems of linear equations.

   b. [10 points] Find an orthonormal basis for W.

2. Let W be the subspace spanned by $\left\{ \begin{bmatrix} 1 \\ 2 \\ -2 \\ 0 \end{bmatrix}, \begin{bmatrix} -3 \\ -1 \\ 2 \\ 2 \end{bmatrix}, \begin{bmatrix} 9 \\ -1 \\ -1 \\ -4 \end{bmatrix} \right\}$. Note that this basis is **not** orthogonal.

a. [15 points] Find the orthogonal projection of $\begin{bmatrix} 1 \\ -4 \\ 1 \\ 3 \end{bmatrix}$ into W.

b. [15 points] Find an orthogonal basis for W.

3. Do the following, for the following set of data points: $(-5, -10)$, $(-4, 12)$, $(0, 0)$, $(2, 18)$.

   a. [10 points] Find the line $y = ax + b$ which best fits these points.

   b. [10 points] Find the parabola $y = ax^2 + c$ with no linear term which best fits these points.

4. [10 points] Find the Least Squares Solution to the following system of linear equations:

$$\begin{aligned} -2x_1 + 2x_2 + 4x_3 &= 5 \\ -x_1 + 4x_2 + 5x_3 &= 0 \\ x_1 + 5x_2 + 3x_3 &= 0 \\ -x_1 + x_2 &= -5 \end{aligned}$$

5. [15 points] Find a basis for $W^{\perp}$, the orthogonal complement of W, if W is the subspace spanned by

$$\left\{ \begin{bmatrix} 2 \\ 2 \\ -2 \\ 1 \end{bmatrix}, \begin{bmatrix} -4 \\ 0 \\ 2 \\ -4 \end{bmatrix}, \begin{bmatrix} -2 \\ 2 \\ -2 \\ 3 \end{bmatrix} \right\}$$

C. HECKMAN 242

Test 3 D

Name: _____

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Signature

1. Let $\vec{v}_1 = \begin{bmatrix} 0 \\ 0 \\ -1 \\ 0 \end{bmatrix}$, $\vec{v}_2 = \begin{bmatrix} 2 \\ -1 \\ 0 \\ 2 \end{bmatrix}$, and $\vec{v}_3 = \begin{bmatrix} 1 \\ -2 \\ 0 \\ -2 \end{bmatrix}$. Note that $B = \{\vec{v}_1, \vec{v}_2, \vec{v}_3\}$ is an orthogonal set. Also, let W be the subspace spanned by $\{\vec{v}_1, \vec{v}_2, \vec{v}_3\}$.

   a. [15 points] Find the orthogonal projection of $\begin{bmatrix} 4 \\ 1 \\ -2 \\ 1 \end{bmatrix}$ into W, without inverting any matrices or solving any systems of linear equations.

   b. [10 points] Find an orthonormal basis for W.

2. Let W be the subspace spanned by $\left\{ \begin{bmatrix} 2 \\ 1 \\ 2 \\ 4 \end{bmatrix}, \begin{bmatrix} -7 \\ -1 \\ -2 \\ -14 \end{bmatrix}, \begin{bmatrix} 4 \\ -3 \\ -11 \\ -2 \end{bmatrix} \right\}$. Note that this basis is **not** orthogonal.

a. [15 points] Find the vector in W closest to $\begin{bmatrix} 3 \\ -6 \\ -7 \\ -9 \end{bmatrix}$.

b. [15 points] Find an orthogonal basis for W.

3. Do the following, for the following set of data points: $(-3, 51)$, $(-2, 20)$, $(0, 0)$, $(4, -40)$.

   a. [10 points] Find the line $y = ax + b$ which best fits these points.

   b. [10 points] Find the parabola $y = ax^2 + c$ with no linear term which best fits these points.

4. [10 points] Find the Least Squares Solution to the following system of linear equations:

$$\begin{aligned} 4x_1 - x_2 + 5x_3 &= 7 \\ x_1 + 3x_2 - x_3 &= 5 \\ -x_1 + x_2 - 4x_3 &= 2 \\ -2x_2 - 5x_3 &= -2 \end{aligned}$$

5. [15 points] Find a basis for $W^{\perp}$, the orthogonal complement of W, if W is the subspace spanned by

$$\left\{ \begin{bmatrix} 4 \\ 1 \\ 3 \\ -2 \end{bmatrix}, \begin{bmatrix} -3 \\ 0 \\ 0 \\ -1 \end{bmatrix} \right\}$$

C. HECKMAN 242

Test 3 E

Name: _____

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Signature

1. Let $\vec{v}_1 = \begin{bmatrix} 0 \\ 1 \\ 0 \\ 0 \end{bmatrix}$, $\vec{v}_2 = \begin{bmatrix} 0 \\ 0 \\ 1 \\ 0 \end{bmatrix}$, and $\vec{v}_3 = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix}$. Note that $B = \{\vec{v}_1, \vec{v}_2, \vec{v}_3\}$ is an orthogonal set. Also, let W be the subspace spanned by $\{\vec{v}_1, \vec{v}_2, \vec{v}_3\}$.

   a. [15 points] Find the vector in W closest to $\begin{bmatrix} 1 \\ 2 \\ 3 \\ 0 \end{bmatrix}$, without inverting any matrices or solving any systems of linear equations.

   b. [10 points] Find an orthonormal basis for W.

2. Let W be the subspace spanned by $\left\{ \begin{bmatrix} 0 \\ 2 \\ 2 \\ 1 \end{bmatrix}, \begin{bmatrix} 0 \\ 3 \\ 0 \\ 3 \end{bmatrix}, \begin{bmatrix} 0 \\ 10 \\ 1 \\ 5 \end{bmatrix} \right\}$. Note that this basis is **not** orthogonal.

a. [15 points] Find the orthogonal projection of $\begin{bmatrix} -1 \\ -1 \\ -10 \\ -5 \end{bmatrix}$ into W.

b. [15 points] Find an orthogonal basis for W.

3. Do the following, for the following set of data points: $(-1, 11)$, $(1, 3)$, $(2, 20)$, $(4, 126)$.

   a. [10 points] Find the parabola $y = ax^2 + bx + c$ which best fits these points.

   b. [10 points] Find the parabola $y = ax^2 + bx$ passing through the origin which best fits these points.

4. [10 points] Find the Least Squares Solution to the following system of linear equations:

$$\begin{array}{rcrcrcr} 4x_1 & & & + & 2x_3 & = & 5 \\ -x_1 & + & 5x_2 & & & = & -7 \\ -5x_1 & + & 4x_2 & - & 2x_3 & = & 3 \\ -3x_1 & - & x_2 & & & = & -2 \end{array}$$

5. [15 points] Find a basis for $W^{\perp}$, the orthogonal complement of W, if W is the subspace spanned by

$$\left\{ \begin{bmatrix} 0 \\ -1 \\ -2 \\ 2 \end{bmatrix} \right\}$$

C. HECKMAN 242

Test 3 F

Name: _____

Instructions:

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Signature

1. Let $\vec{v}_1 = \begin{bmatrix} 0 \\ 0 \\ 0 \\ -1 \end{bmatrix}$, $\vec{v}_2 = \begin{bmatrix} 0 \\ 0 \\ 1 \\ 0 \end{bmatrix}$, and $\vec{v}_3 = \begin{bmatrix} -1 \\ 0 \\ 0 \\ 0 \end{bmatrix}$. Note that $B = \{\vec{v}_1, \vec{v}_2, \vec{v}_3\}$ is an orthogonal set. Also, let W be the subspace spanned by $\{\vec{v}_1, \vec{v}_2, \vec{v}_3\}$.

   a. [15 points] Find the orthogonal projection of $\begin{bmatrix} 2 \\ 1 \\ -3 \\ 0 \end{bmatrix}$ into W, without inverting any matrices or solving any systems of linear equations.

   b. [10 points] Find an orthonormal basis for W.

2. Let W be the subspace spanned by $\left\{ \begin{bmatrix} -1 \\ 0 \\ 2 \\ -2 \end{bmatrix}, \begin{bmatrix} 2 \\ 0 \\ -10 \\ 7 \end{bmatrix}, \begin{bmatrix} -7 \\ 0 \\ -1 \\ -2 \end{bmatrix} \right\}$. Note that this basis is **not** orthogonal.

a. [15 points] Find the vector in W closest to $\begin{bmatrix} 3 \\ 1 \\ -9 \\ -6 \end{bmatrix}$.

b. [15 points] Find an orthogonal basis for W.

3. Do the following, for the following set of data points: $(-5, 110)$, $(-3, 26)$, $(0, 5)$, $(4, -79)$.

   a. [10 points] Find the parabola $y = ax^2 + bx + c$ which best fits these points.

   b. [10 points] Find the parabola $y = ax^2 + bx$ passing through the origin which best fits these points.

4. [10 points] Find the Least Squares Solution to the following system of linear equations:

$$\begin{aligned} -5x_1 - x_2 - 2x_3 &= 5 \\ 2x_1 + 3x_2 - x_3 &= -7 \\ 5x_1 + 5x_2 - 2x_3 &= -6 \\ -3x_1 - x_2 + 3x_3 &= -6 \end{aligned}$$

5. [15 points] Find a basis for $W^{\perp}$, the orthogonal complement of W, if W is the subspace spanned by

$$\left\{ \begin{bmatrix} -1 \\ 4 \\ 0 \\ 4 \end{bmatrix} \right\}$$

C. HECKMAN 242

Test 3 MAKE-UP

Name: _____

Instructions:

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Signature

1. Let $\vec{v}_1 = \begin{bmatrix} 2 \\ -2 \\ 4 \\ 1 \end{bmatrix}$, $\vec{v}_2 = \begin{bmatrix} -4 \\ -1 \\ 2 \\ -2 \end{bmatrix}$, and $\vec{v}_3 = \begin{bmatrix} -2 \\ 2 \\ 1 \\ 4 \end{bmatrix}$. Note that $B = \{\vec{v}_1, \vec{v}_2, \vec{v}_3\}$ is an orthogonal set. Also, let W be the subspace spanned by $\{\vec{v}_1, \vec{v}_2, \vec{v}_3\}$.

   a. [15 points] Find the vector in W closest to $\begin{bmatrix} -7 \\ -13 \\ 6 \\ -11 \end{bmatrix}$, without inverting any matrices or solving any systems of linear equations.

   b. [10 points] Find an orthonormal basis for W.

2. Let W be the subspace spanned by $\left\{ \begin{bmatrix} 0 \\ 0 \\ -1 \\ 0 \end{bmatrix}, \begin{bmatrix} -2 \\ 1 \\ 1 \\ 2 \end{bmatrix}, \begin{bmatrix} -3 \\ 3 \\ -3 \\ 0 \end{bmatrix} \right\}$. Note that this basis is **not** orthogonal.

a. [15 points] Find the orthogonal projection of $\begin{bmatrix} 6 \\ 0 \\ 1 \\ -3 \end{bmatrix}$ into W.

b. [15 points] Find an orthogonal basis for W.

3. Do the following, for the following set of data points: $(-5, 5)$, $(-2, 17)$, $(-1, 9)$, $(4, 149)$.

   a. [10 points] Find the parabola $y = ax^2 + bx + c$ which best fits these points.

   b. [10 points] Find the parabola $y = ax^2 + c$ with no linear term which best fits these points.

4. [10 points] Find the Least Squares Solution to the following system of linear equations:

$$\begin{aligned} -x_1 + 2x_2 + 2x_3 &= -1 \\ -4x_1 - 2x_2 - 4x_3 &= -3 \\ -2x_1 - 4x_2 - 5x_3 &= 2 \\ -5x_1 - 4x_2 &= 3 \end{aligned}$$

5. [15 points] Find a basis for $W^{\perp}$, the orthogonal complement of W, if W is the subspace spanned by

$$\left\{ \begin{bmatrix} -1 \\ -2 \\ 0 \\ 4 \end{bmatrix}, \begin{bmatrix} -3 \\ -3 \\ -2 \\ 0 \end{bmatrix} \right\}$$