7.2.1 When Gaussian Elimination Works

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Week 7 due Nov 20, 2023 01:42 IST

7.2.1 When Gaussian Elimination Works

Video

Start of transcript. Skip to the end.

Dr. Robert van de Geijn: Let's start by looking

at what it means when Gaussian elimination, or LU factorization

completes.

So here we have the algorithm for Gaussian elimination,

and notice that the algorithm for LU factorization is identical

0:00 / 0:00

2.0x

Video

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Reading Assignment

0 points possible (ungraded)

Read Unit 7.2.1 of the notes. [LINK]

- [x] Done

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? Question about homework 7.2.1.16

The statement is that there will always be a unique solution. But I am wondering is it possible that there is no solution? 2

Mistake in Homework 7.2.1.5 Answer

Calculator

Question on "only 0 that may or may not have been encountered is the very, very last entry, in the upper triangular matrix" 3
Greetings, Could you mind explaining a bit on the following contents mentioned in your video? "And notice again, we may end up dividing by 0. B...

7.2.1.7 - PictureFLAME (Spoiler - answer given). 2
It is (kind of) possible to get it working in PictureFLAME. For some reason, beta1 can't be used to store intermediate values, but lambda11 can. In...

Variant 2 of Lower Triangular Solve 3
I don't understand how the second variant of the lower triangular solve algorithm works. Are you proceeding from bottom right to top left? How ...

Homework 7.2.1.1

1/1 point (graded)
Let $L \in \mathbb{R}^{1\times 1}$ be a unit lower triangular matrix.

$Lx = b$, where x is the unknown and b is given, has a unique solution.

Always ✔ Answer: Always

Explanation

Answer: Always
Since L is 1×1, it is a scalar:

$$(1)(\chi_0) = (\beta_0).$$

From basic algebra we know that then $\chi_0 = \beta_0$ is the unique solution.

Submit

Answers are displayed within the problem

Homework 7.2.1.2

2/2 points (graded)
Give the solution of $\begin{pmatrix} 1 & 0 \\ 2 & 1 \end{pmatrix} \begin{pmatrix} \chi_0 \\ \chi_1 \end{pmatrix} = \begin{pmatrix} 1 \\ 2 \end{pmatrix}$

1 ✔ Answer: 1

0 ✔ Answer: 0

Answer: The above translates to the system of linear equations

$$\begin{array}{rcrcl} \chi_0 & & & = & 1 \\ 2\chi_0 & + & \chi_1 & = & 2 \end{array}$$

which has the solution

$$\begin{pmatrix} \chi_0 \\ \chi_1 \end{pmatrix} = \begin{pmatrix} 1 \\ 2-(2)(1) \end{pmatrix} = \begin{pmatrix} 1 \\ 0 \end{pmatrix}.$$

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Answers are displayed within the problem

Homework 7.2.1.3

Calculator

3/3 points (graded)

Give the solution of $\begin{pmatrix} 1 & 0 & 0 \\ 2 & 1 & 0 \\ -1 & 2 & 1 \end{pmatrix} \begin{pmatrix} \chi_0 \\ \chi_1 \\ \chi_2 \end{pmatrix} = \begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix}$

1 ✔ Answer: 1

0 ✔ Answer: 0

4 ✔ Answer: 4

Answer: A clever way of solving the above is to slice and dice:

$$\underbrace{\left(\begin{array}{cc|c} 1 & 0 & 0 \\ 2 & 1 & 0 \\ \hline -1 & 2 & 1 \end{array}\right) \left(\begin{array}{c} \chi_0 \\ \chi_1 \\ \hline \chi_2 \end{array}\right)}_{\left(\begin{array}{c} \begin{pmatrix} 1 & 0 \\ 2 & 1 \end{pmatrix} \begin{pmatrix} \chi_0 \\ \chi_1 \end{pmatrix} \\ \hline \begin{pmatrix} -1 & 2 \end{pmatrix} \begin{pmatrix} \chi_0 \\ \chi_1 \end{pmatrix} + \begin{pmatrix} \chi_2 \end{pmatrix} \end{array}\right)} = \underbrace{\begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix}}_{\left(\begin{array}{c} \begin{pmatrix} 1 \\ 2 \end{pmatrix} \\ \hline 3 \end{array}\right)}$$

Hence, from the last exercise, we conclude that

$$\begin{pmatrix} \chi_0 \\ \chi_1 \end{pmatrix} = \begin{pmatrix} 1 \\ 0 \end{pmatrix}.$$

We can then compute χ_2 by substituting in:

$$\begin{pmatrix} -1 & 2 \end{pmatrix} \begin{pmatrix} \chi_0 \\ \chi_1 \end{pmatrix} + \begin{pmatrix} \chi_2 \end{pmatrix} = 3$$

So that

$$\chi_2 = 3 - \begin{pmatrix} -1 & 2 \end{pmatrix} \begin{pmatrix} 1 \\ 0 \end{pmatrix} = 3 - (-1) = 4.$$

Thus, the solution is the vector

$$\begin{pmatrix} \chi_0 \\ \chi_1 \\ \chi_2 \end{pmatrix} = \begin{pmatrix} 1 \\ 0 \\ 4 \end{pmatrix}.$$

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Answers are displayed within the problem

Homework 7.2.1.4

1/1 point (graded)

Let $L \in \mathbb{R}^{2\times 2}$ be a unit lower triangular matrix.

$Lx = b$, where x is the unknown and b is given, has a unique solution.

Calculator

Always ✔ Answer: Always

Explanation

Answer: Always

Since L is 2×2, the linear system has the form

$$\begin{pmatrix} 1 & 0 \\ \lambda_{1,0} & 1 \end{pmatrix} \begin{pmatrix} \chi_0 \\ \chi_1 \end{pmatrix} = \begin{pmatrix} \beta_0 \\ \beta_1 \end{pmatrix}.$$

But that translates to the system of linear equations

$$\begin{array}{rcl} \chi_0 & & = \beta_0 \\ \lambda_{1,0}\chi_0 & +\chi_1 & = \beta_1 \end{array}$$

which has the unique solution

$$\begin{pmatrix} \chi_0 \\ \chi_1 \end{pmatrix} = \begin{pmatrix} \beta_0 \\ \beta_1 - \lambda_{1,0}\chi_0 \end{pmatrix}.$$

Submit

Answers are displayed within the problem

Homework 7.2.1.5

1/1 point (graded)

Let $L \in \mathbb{R}^{3\times 3}$ be a unit lower triangular matrix.

$Lx = b$, where x is the unknown and b is given, has a unique solution.

Always ✔ Answer: Always

Explanation

Answer: Always

Notice

$$\underbrace{\left(\begin{array}{cc|c} 1 & 0 & 0 \\ \lambda_{1,0} & 1 & 0 \\ \hline \lambda_{2,0} & \lambda_{2,1} & 1 \end{array}\right) \left(\begin{array}{c} \chi_0 \\ \chi_1 \\ \hline \chi_2 \end{array}\right)}_{\left(\begin{array}{c} \begin{pmatrix} 1 & 0 \\ \lambda_{1,0} & 1 \end{pmatrix} \begin{pmatrix} \chi_0 \\ \chi_1 \end{pmatrix} \\ \hline \begin{pmatrix} \lambda_{2,0} & \lambda_{2,1} \end{pmatrix} \begin{pmatrix} \chi_0 \\ \chi_1 \end{pmatrix} + \begin{pmatrix} \chi_2 \end{pmatrix} \end{array}\right)} = \underbrace{\begin{pmatrix} \beta_0 \\ \beta_1 \\ \beta_2 \end{pmatrix}}_{\left(\begin{array}{c} \begin{pmatrix} \beta_0 \\ \beta_1 \end{pmatrix} \\ \hline \beta_2 \end{array}\right)}$$

Hence, from the last exercise, we conclude that the unique solutions for χ_0 and χ_1 are

$$\begin{pmatrix} \chi_0 \\ \chi_1 \end{pmatrix} = \begin{pmatrix} \beta_0 \\ \beta_1 - \lambda_{1,0}\beta_0 \end{pmatrix}.$$

We can then compute χ_2 by substituting in:

Calculator

$$\begin{pmatrix} \lambda_{2,0} & \lambda_{2,1} \end{pmatrix} \begin{pmatrix} \chi_0 \\ \chi_1 \end{pmatrix} + \begin{pmatrix} \chi_2 \end{pmatrix} = \beta_2$$

So that

$$\chi_2 = \beta_2 - \begin{pmatrix} \lambda_{2,0} & \lambda_{2,1} \end{pmatrix} \begin{pmatrix} \beta_0 \\ \beta_1 - \lambda_{1,0}\beta_0 \end{pmatrix}$$

Since there is no ambiguity about what χ_2 must equal, the solution is unique:

$$\begin{pmatrix} \chi_0 \\ \chi_1 \\ \chi_2 \end{pmatrix} = \begin{pmatrix} \beta_0 \\ \beta_1 - \lambda_{1,0}\beta_0 \\ \beta_2 - \begin{pmatrix} \lambda_{2,0} & \lambda_{2,1} \end{pmatrix} \begin{pmatrix} \beta_0 \\ \beta_1 - \lambda_{1,0}\beta_0 \end{pmatrix} \end{pmatrix}.$$

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Answers are displayed within the problem

Homework 7.2.1.6

1/1 point (graded)

Let $L \in \mathbb{R}^{n \times n}$ be a unit lower triangular matrix.

$Lx = b$, where x is the unknown and b is given, has a unique solution.

Always ✔ Answer: Always

Explanation

Always

The last exercises were meant to make you notice that this can be proved with a proof by induction on the size, n, of L.

Base case: $n = 1$. In this case $L = (1)$, $x = (\chi_1)$ and $b = (\beta_1)$. The result follows from the fact that $(1)(\chi_1) = (\beta_1)$ has the unique solution $\chi_1 = \beta_1$.

Inductive step: Inductive Hypothesis (I.H.): Assume that $Lx = b$ has a unique solution for all $L \in \mathbb{R}^{n \times n}$ and right-hand side vectors b.

We now want to show that then $Lx = b$ has a unique solution for all $L \in \mathbb{R}^{(n+1)\times(n+1)}$ and right-hand side vectors b.

Partition

$$L \rightarrow \left(\begin{array}{c|c} L_{00} & 0 \\ \hline l_{10}^T & \lambda_{11} \end{array}\right), \quad x \rightarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \end{array}\right) \quad \text{and} \quad b \rightarrow \left(\begin{array}{c} b_0 \\ \hline \beta_1 \end{array}\right),$$

where, importantly, $L_{00} \in \mathbb{R}^{n \times n}$. Then $Lx = b$ becomes

$$\underbrace{\left(\begin{array}{c|c} L_{00} & 0 \\ \hline l_{10}^T & \lambda_{11} \end{array}\right) \left(\begin{array}{c} x_0 \\ \hline \chi_1 \end{array}\right)}_{\left(\begin{array}{c} L_{00}x_0 \\ \hline l_{10}^T x_0 + \lambda_{11}\chi_1 \end{array}\right)} = \left(\begin{array}{c} b_0 \\ \hline \beta_1 \end{array}\right)$$

or

$$L_{00}x_0 = b_0$$

Calculator

$$l_{10}^T x_0 + \lambda_{11}\chi_1 = \beta_1$$

By the Inductive Hypothesis, we know that $L_{00}x_0 = b_0$ has a unique solution. But once x_0 is set, $\lambda_{11}\chi_1 = \beta_1 - l_{10}^T x_0$ uniquely determines χ_1.

By the **Principle of Mathematical Induction**, the result holds.

Submit

Answers are displayed within the problem

Homework 7.2.1.7

1/1 point (graded)

The proof for the last exercise suggests an alternative algorithm (Variant 2) for solving $Lx = b$ when L is unit lower triangular. Use the below partial algorithm to state this alternative algorithm.

Algorithm: $[b] := \text{LTRSV\_UNB\_VAR2}(L, b)$

Partition $L \rightarrow \left(\begin{array}{c|c} L_{TL} & 0 \\ \hline L_{BL} & L_{BR} \end{array}\right)$, $b \rightarrow \left(\begin{array}{c} b_T \\ \hline b_B \end{array}\right)$

where L_{TL} is 0×0, b_T has 0 rows

while $m(L_{TL}) < m(L)$ **do**

Repartition

$$\left(\begin{array}{c|c} L_{TL} & 0 \\ \hline L_{BL} & L_{BR} \end{array}\right) \rightarrow \left(\begin{array}{c|c|c} L_{00} & 0 & 0 \\ \hline l_{10}^T & \lambda_{11} & 0 \\ \hline L_{20} & l_{21} & L_{22} \end{array}\right), \left(\begin{array}{c} b_T \\ \hline b_B \end{array}\right) \rightarrow \left(\begin{array}{c} b_0 \\ \hline \beta_1 \\ \hline b_2 \end{array}\right)$$

where λ_{11} is 1×1 , β_1 has 1 row

Continue with

$$\left(\begin{array}{c|c} L_{TL} & 0 \\ \hline L_{BL} & L_{BR} \end{array}\right) \leftarrow \left(\begin{array}{c|c|c} L_{00} & 0 & 0 \\ \hline l_{10}^T & \lambda_{11} & 0 \\ \hline L_{20} & l_{21} & L_{22} \end{array}\right), \left(\begin{array}{c} b_T \\ \hline b_B \end{array}\right) \leftarrow \left(\begin{array}{c} b_0 \\ \hline \beta_1 \\ \hline b_2 \end{array}\right)$$

endwhile

Next, implement it, yielding

- `[ b_out ] = Ltrsv_unb_var2( L, b )`

You can check that they compute the right answers with the script in

- `test_Ltrsv_unb_var2.m`

Unfortunately, PictureFLAME does not work for this problem.

☑ done/skip

✔

Algorithm:

Algorithm: $[b] := \text{LTRSV\_UNB\_VAR2}(L, b)$

Calculator

Partition $L \rightarrow \left(\begin{array}{c|c} L_{TL} & 0 \\ \hline L_{BL} & L_{BR} \end{array}\right)$, $b \rightarrow \left(\begin{array}{c} b_T \\ \hline b_B \end{array}\right)$

where L_{TL} is 0×0, b_T has 0 rows

while $m(L_{TL}) < m(L)$ **do**

Repartition

$$\left(\begin{array}{c|c} L_{TL} & 0 \\ \hline L_{BL} & L_{BR} \end{array}\right) \rightarrow \left(\begin{array}{c|c|c} L_{00} & 0 & 0 \\ \hline l_{10}^T & \lambda_{11} & 0 \\ \hline L_{20} & l_{21} & L_{22} \end{array}\right), \left(\begin{array}{c} b_T \\ \hline b_B \end{array}\right) \rightarrow \left(\begin{array}{c} b_0 \\ \hline \beta_1 \\ \hline b_2 \end{array}\right)$$

where λ_{11} is 1×1, β_1 has 1 row

$\beta_1 := \beta_1 - l_{10}^T b_0$

Continue with

$$\left(\begin{array}{c|c} L_{TL} & 0 \\ \hline L_{BL} & L_{BR} \end{array}\right) \leftarrow \left(\begin{array}{c|c|c} L_{00} & 0 & 0 \\ \hline l_{10}^T & \lambda_{11} & 0 \\ \hline L_{20} & l_{21} & L_{22} \end{array}\right), \left(\begin{array}{c} b_T \\ \hline b_B \end{array}\right) \leftarrow \left(\begin{array}{c} b_0 \\ \hline \beta_1 \\ \hline b_2 \end{array}\right)$$

endwhile

Implementation: `Ltrsv_unb_var2.m`

Submit

Answers are displayed within the problem

Homework 7.2.1.8

1/1 point (graded)

Let $L \in \mathbb{R}^{n \times n}$ be a unit lower triangular matrix.

$Lx = 0$, where 0 is the zero vector of size n, has the unique solution $x = 0$.

Always ✔ Answer: Always

Explanation

Always/Sometimes/Never **Answer:** Always

Obviously $x = 0$ is *a* solution. But a previous exercise showed that when L is a unit lower triangular matrix, $Lx = b$ has a unique solution for *all* b. Hence, it has a unique solution for $b = 0$.

Submit

Answers are displayed within the problem

Homework 7.2.1.9

1/1 point (graded)

Let $U \in \mathbb{R}^{1 \times 1}$ be an upper triangular matrix with no zeroes on its diagonal.

$Ux = b$, where x is the unknown and b is given, has a unique solution.

Calculator

Always ⌄ ✔ Answer: Always

Explanation

Answer: Always

Since U is 1×1, it is a nonzero scalar

$$(\upsilon_{0,0})(\chi_0) = (\beta_0).$$

From basic algebra we know that then $\chi_0 = \beta_0/\upsilon_{0,0}$ is the unique solution.

Submit

Answers are displayed within the problem

Homework 7.2.1.10

2/2 points (graded)

Give the solution of $\begin{pmatrix} -1 & 1 \\ 0 & 2 \end{pmatrix} \begin{pmatrix} \chi_0 \\ \chi_1 \end{pmatrix} = \begin{pmatrix} 1 \\ 2 \end{pmatrix}$

0 ✔ Answer: 0

1 ✔ Answer: 1

Answer: The above translates to the system of linear equations

$$\begin{array}{rrcl} -1\chi_0 & +\chi_1 & = & 1 \\ & 2\chi_1 & = & 2 \end{array}$$

which has the solution

$$\begin{pmatrix} \chi_0 \\ \chi_1 \end{pmatrix} = \begin{pmatrix} (1-\chi_1)/(-1) \\ 2/2 \end{pmatrix} = \begin{pmatrix} (1-(1))/(-1) \\ 1 \end{pmatrix} = \begin{pmatrix} 0 \\ 1 \end{pmatrix}.$$

Submit

Answers are displayed within the problem

Homework 7.2.1.11

3/3 points (graded)

Give the solution of $\begin{pmatrix} -2 & 1 & -2 \\ 0 & -1 & 1 \\ 0 & 0 & 2 \end{pmatrix} \begin{pmatrix} \chi_0 \\ \chi_1 \\ \chi_2 \end{pmatrix} = \begin{pmatrix} 0 \\ 1 \\ 2 \end{pmatrix}$

-1 ✔ Answer: -1

0 ✔ Answer: 0

1 ✔ Answer: 1

Calculator

Answer: A clever way of solving the above is to slice and dice:

$$\underbrace{\left(\begin{array}{c|cc} -2 & 1 & -2 \\ \hline 0 & -1 & 1 \\ 0 & 0 & 2 \end{array}\right)\left(\begin{array}{c} \chi_0 \\ \hline \chi_1 \\ \chi_2 \end{array}\right)}_{\left(\begin{array}{c} -2\chi_0 + \left(\begin{array}{cc} 1 & -2 \end{array}\right)\left(\begin{array}{c}\chi_1 \\ \chi_2\end{array}\right) \\ \hline \left(\begin{array}{cc} -1 & 1 \\ 0 & 2\end{array}\right)\left(\begin{array}{c}\chi_1 \\ \chi_2\end{array}\right)\end{array}\right)} = \underbrace{\left(\begin{array}{c} 0 \\ \hline 1 \\ 2 \end{array}\right)}_{\left(\begin{array}{c} 0 \\ \hline \left(\begin{array}{c} 1 \\ 2 \end{array}\right)\end{array}\right)}$$

Hence, from the last exercise, we conclude that

$$\left(\begin{array}{c}\chi_1 \\ \chi_2\end{array}\right) = \left(\begin{array}{c} 0 \\ 1 \end{array}\right).$$

We can then compute χ_0 by substituting in:

$$-2\chi_0 + \left(\begin{array}{cc} 1 & -2 \end{array}\right)\left(\begin{array}{c}\chi_1 \\ \chi_2\end{array}\right) = 0$$

So that

$$-2\chi_2 = 0 - \left(\begin{array}{cc} 1 & -2 \end{array}\right)\left(\begin{array}{c} 0 \\ 1 \end{array}\right) = 0 - (-2) = 2.$$

Thus, the solution is the vector

$$\left(\begin{array}{c}\chi_0 \\ \chi_1 \\ \chi_2\end{array}\right) = \left(\begin{array}{c} -1 \\ 0 \\ 1 \end{array}\right).$$

Submit

Answers are displayed within the problem

Homework 7.2.1.12

1/1 point (graded)

Let $U \in \mathbb{R}^{2\times 2}$ be an upper triangular matrix with no zeroes on its diagonal.

$Ux = b$, where x is the unknown and b is given, has a unique solution.

Always ✔ Answer: Always

Explanation

Answer: Always

Since U is 2×2, the linear system has the form

$$\left(\begin{array}{cc} \upsilon_{0,0} & \upsilon_{0,1} \\ 0 & \upsilon_{1,1} \end{array}\right)\left(\begin{array}{c}\chi_0 \\ \chi_1\end{array}\right) = \left(\begin{array}{c}\beta_0 \\ \beta_1\end{array}\right).$$

But that translates rto the system of linear equations

Calculator

$$\begin{array}{rcl} \upsilon_{0,0}\chi_0 \; + \upsilon_{0,1}\chi_1 & = & \beta_0 \\ \upsilon_{1,1}\chi_1 & = & \beta_1 \end{array}$$

which has the unique solution

$$\begin{pmatrix} \chi_0 \\ \chi_1 \end{pmatrix} = \begin{pmatrix} (\beta_0 - \upsilon_{0,1}\chi_1)/\upsilon_{0,0} \\ \beta_1/\upsilon_{1,1} \end{pmatrix}.$$

Submit

Answers are displayed within the problem

Homework 7.2.1.13

1/1 point (graded)

Let $U \in \mathbb{R}^{3\times 3}$ be an upper triangular matrix with no zeroes on its diagonal.

$Ux = b$, where x is the unknown and b is given, has a unique solution.

Always ✔ Answer: Always

Explanation

Answer: Always

Notice

$$\underbrace{\left(\begin{array}{c|cc} \upsilon_{0,0} & \upsilon_{0,1} & \upsilon_{0,2} \\ \hline 0 & \upsilon_{1,1} & \upsilon_{1,2} \\ 0 & 0 & \upsilon_{2,2} \end{array}\right)\begin{pmatrix} \chi_0 \\ \chi_1 \\ \chi_2 \end{pmatrix}}_{\left(\begin{array}{c} \upsilon_{0,0}\chi_0 + \begin{pmatrix} \upsilon_{0,1} & \upsilon_{0,2} \end{pmatrix}\begin{pmatrix} \chi_1 \\ \chi_2 \end{pmatrix} \\ \hline \begin{pmatrix} \upsilon_{1,1} & \upsilon_{1,2} \\ 0 & \upsilon_{2,2} \end{pmatrix}\begin{pmatrix} \chi_1 \\ \chi_2 \end{pmatrix} \end{array}\right)} = \underbrace{\left(\begin{array}{c} \beta_0 \\ \hline \beta_1 \\ \beta_2 \end{array}\right)}_{\left(\begin{array}{c} \beta_0 \\ \hline \begin{pmatrix} \beta_1 \\ \beta_2 \end{pmatrix} \end{array}\right)}$$

Hence, from the last exercise, we conclude that the unique solutions for χ_0 and χ_1 are

$$\begin{pmatrix} \chi_1 \\ \chi_2 \end{pmatrix} = \begin{pmatrix} (\beta_1 - \upsilon_{1,2}\chi_2)/\upsilon_{1,1} \\ \beta_2/\upsilon_{2,2} \end{pmatrix}.$$

We can then compute χ_0 by substituting in:

$$\upsilon_{0,0}\chi_0 + \begin{pmatrix} \upsilon_{0,1} & \upsilon_{0,2} \end{pmatrix}\begin{pmatrix} \chi_1 \\ \chi_2 \end{pmatrix} = \beta_0$$

So that

$$\chi_0 = \left(\beta_0 - \begin{pmatrix} \upsilon_{0,1} & \upsilon_{0,2} \end{pmatrix}\begin{pmatrix} \chi_1 \\ \chi_2 \end{pmatrix}\right)/\upsilon_{0,0}$$

Since there is no ambiguity about what χ_2 must equal, the solution is unique:

$$\begin{pmatrix} \chi_0 \\ \chi_1 \\ \chi_2 \end{pmatrix} = \begin{pmatrix} \left(\beta_0 - \begin{pmatrix} \upsilon_{0,1} & \upsilon_{0,2} \end{pmatrix}\begin{pmatrix} \chi_1 \\ \chi_2 \end{pmatrix}\right)/\upsilon_{0,0} \\ (\beta_1 - \upsilon_{1,2}\chi_2)/\upsilon_{1,1} \\ \beta_2/\upsilon_{2,2} \end{pmatrix}.$$

Submit

Calculator

Answers are displayed within the problem

Homework 7.2.1.14

1/1 point (graded)

Let $U \in \mathbb{R}^{n \times n}$ be an upper triangular matrix with no zeroes on its diagonal.

$Ux = b$, where x is the unknown and b is given, has a unique solution.

Always

Submit

Homework 7.2.1.15

1/1 point (graded)

Let $U \in \mathbb{R}^{n \times n}$ be an upper triangular matrix with no zeroes on its diagonal.

$Ux = 0$, where 0 is the zero vector of size n, has the unique solution $x = 0$.

Always

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