UTAustinX UT.5.05x
Linear Algebra - Foundations to Frontiers

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🏠 Course / Week 6: Gaussian Elimination / 6.3 Solving Ax = b via LU Factorization

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6.3.1 LU factorization (Gaussian elimination)
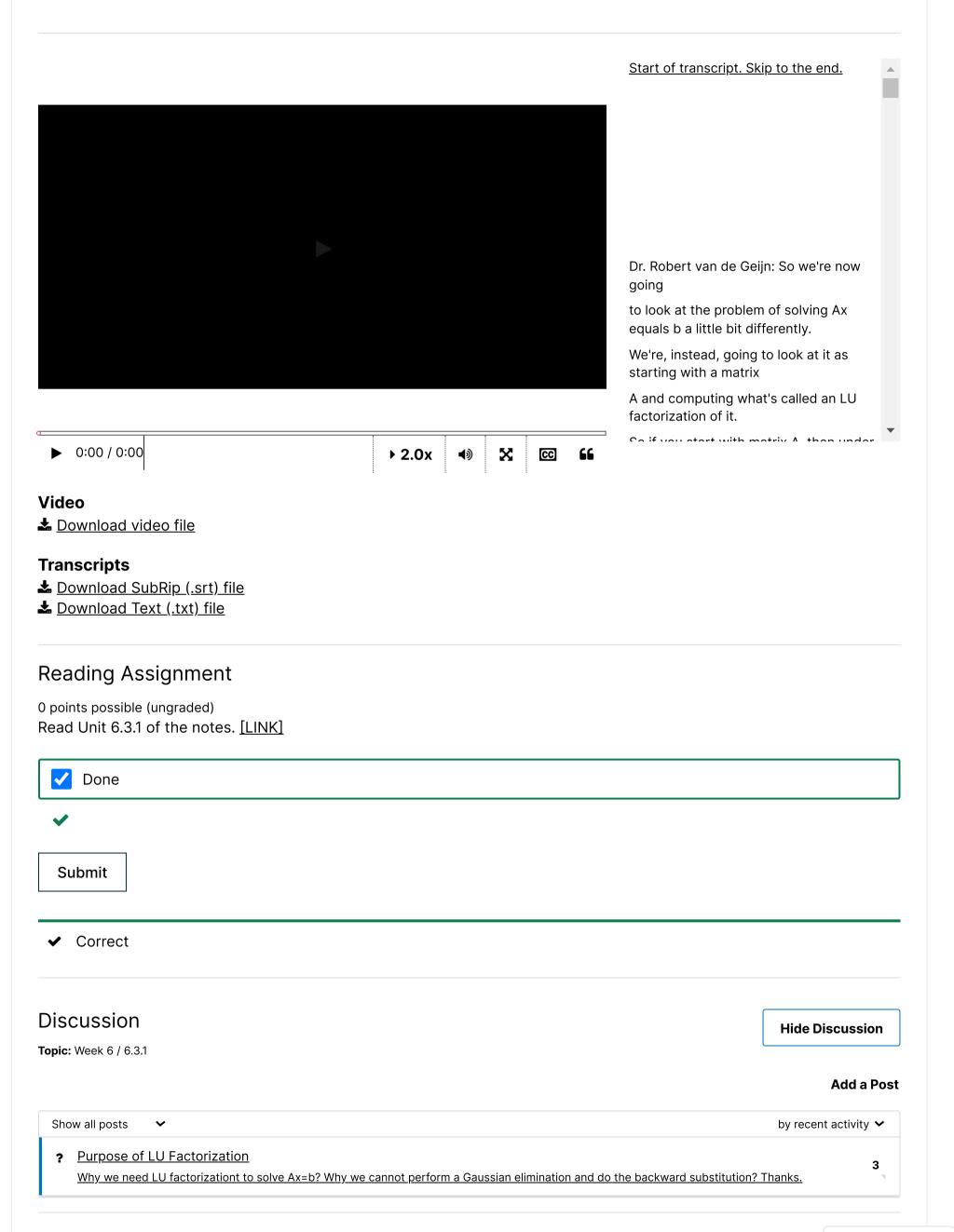
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Week 6 due Nov 13, 2023 12:12 IST

6.3.1 LU factorization (Gaussian elimination)

Dr. Robert van de Geijn: So we're now going

to look at the problem of solving Ax equals b a little bit differently.

We're, instead, going to look at it as starting with a matrix

A and computing what's called an LU factorization of it.

So if you start with matrix A, then under

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Reading Assignment

0 points possible (ungraded)
Read Unit 6.3.1 of the notes. [LINK]

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❓ Purpose of LU Factorization   3
Why we need LU factorizationt to solve Ax=b? Why we cannot perform a Gaussian elimination and do the backward substitution? Thanks.

Homework 6.3.1.1

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1/1 point (graded)

$$\textbf{Algorithm: } A := \text{LU\_UNB\_VAR5}(A)$$

$$\textbf{Partition } A \rightarrow \left(\begin{array}{c|c} A_{TL} & A_{TR} \\ \hline A_{BL} & A_{BR} \end{array} \right)$$

$$\textbf{where } A_{TL} \text{ is } 0 \times 0$$

$$\textbf{while } m(A_{TL}) < m(A) \textbf{ do}$$

$$\textbf{Repartition}$$

$$\left(\begin{array}{c|c} A_{TL} & A_{TR} \\ \hline A_{BL} & A_{BR} \end{array} \right) \rightarrow \left(\begin{array}{c|c|c} A_{00} & a_{01} & A_{02} \\ \hline a_{10}^T & \alpha_{11} & a_{12}^T \\ \hline A_{20} & a_{21} & A_{22} \end{array} \right)$$

$$a_{21} := a_{21}/\alpha_{11} \qquad (= l_{21})$$

$$A_{22} := A_{22} - a_{21}a_{12}^T \qquad (= A_{22} - l_{21}a_{12}^T)$$

$$\textbf{Continue with}$$

$$\left(\begin{array}{c|c} A_{TL} & A_{TR} \\ \hline A_{BL} & A_{BR} \end{array} \right) \leftarrow \left(\begin{array}{c|c|c} A_{00} & a_{01} & A_{02} \\ \hline a_{10}^T & \alpha_{11} & a_{12}^T \\ \hline A_{20} & a_{21} & A_{22} \end{array} \right)$$

$$\textbf{endwhile}$$

Implement the above LU factorization algorithm.

- `[ A_out ] = LU_unb_var5( A )`

You can check that they compute the right answers with the following script:

- `test_LU_unb_var5.m` (In `LAFF-2.0xM/Programming/Week06/`)

Unfortunately, PictureFLAME may not work for this problem, since a zero may be encountered on the diagonal causing a divide by zero.

This script exercises the functions by factoring the matrix

```
A = [
     2     0     1     2
    -2    -1     1    -1
     4    -1     5     4
    -4     1    -3    -8
]
```

by calling

```
LU = LU_unb_var5( A )
```

Next, it extracts the unit lower triangular matrix and upper triangular matrix:

```
L = tril( LU, -1 ) + eye( size( A ) )

U = triu( LU )
```

and checks if the correct factors were computed:

```
A - L * U
```

Calculator

which should yield a 4×4 zero matrix.

> ☑ Done/Skip

✔

Here is our implementations of the function:

- LU_unb_var5.m

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ℹ Answers are displayed within the problem

Homework 6.3.1.2

18/18 points (graded)

What is the LU factorization of $\begin{bmatrix} 1 & -2 & 2 \\ 5 & -15 & 8 \\ -2 & -11 & -11 \end{bmatrix}$?

$L = $

1	✔	0	✔	0	✔
5	✔	1	✔	0	✔
-2	✔	3	✔	1	✔

$U = $

1	✔	-2	✔	2	✔
0	✔	-5	✔	-2	✔
0	✔	0	✔	-1	✔

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