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★ Course / Week 4: Matrix-Vector to Matrix-Matrix Multiplication / 4.2 Preparation

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4.2.2 Transposing a Partitioned Matrix

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Week 4 due Oct 24, 2023 19:42 IST

# 4.2.2 Transposing a Partitioned Matrix

## **Important**

Around 1:20 in the below video, the slide that shows the transposed matrix is completely wrong (the indices of the blocks are wrong...) Here is how it should be:

Let  $A \in \mathbb{R}^{m \times n}$  be partitioned as follows:

$$A = \begin{pmatrix} A_{0,0} & A_{0,1} & \cdots & A_{0,N-1} \\ \hline A_{1,0} & A_{1,1} & \cdots & A_{1,N-1} \\ \hline \vdots & \vdots & & \vdots \\ \hline A_{M-1,0} & A_{M-1,1} & \cdots & A_{M-1,N-1} \end{pmatrix},$$

where  $A_{i,j} \in \mathbb{R}^{m_i \times n_j}$ . Then

$$A^{T} = \begin{pmatrix} A_{0,0}^{T} & A_{1,0}^{T} & \cdots & A_{M-1,0}^{T} \\ \hline A_{0,1}^{T} & A_{1,1}^{T} & \cdots & A_{M-1,1}^{T} \\ \hline \vdots & \vdots & & \vdots \\ \hline A_{0,N-1}^{T} & A_{1,N-1}^{T} & \cdots & A_{M-1,N-1}^{T} \end{pmatrix}.$$

Similarly, later, in "special cases",

Each submatrix is a scalar. If

$$A = \begin{pmatrix} \alpha_{0,0} & \alpha_{0,1} & \cdots & \alpha_{0,N-1} \\ \hline \alpha_{1,0} & \alpha_{1,1} & \cdots & \alpha_{1,N-1} \\ \hline \vdots & \vdots & & \vdots \\ \hline \alpha_{M-1,0} & \alpha_{M-1,1} & \cdots & \alpha_{M-1,N-1} \end{pmatrix}$$

then

$$A^{T} = \begin{pmatrix} \alpha_{0,0}^{T} & \alpha_{1,0}^{T} & \cdots & \alpha_{M-1,0}^{T} \\ \hline \alpha_{0,1}^{T} & \alpha_{1,1}^{T} & \cdots & \alpha_{M-1,1}^{T} \\ \hline \vdots & \vdots & & \vdots \\ \hline \alpha_{0,N-1}^{T} & \alpha_{1,N-1}^{T} & \cdots & \alpha_{M-1N-1}^{T} \end{pmatrix} = \begin{pmatrix} \alpha_{0,0} & \alpha_{1,0} & \cdots & \alpha_{M-1,0} \\ \alpha_{0,1} & \alpha_{1,1} & \cdots & \alpha_{M-1,1} \\ \vdots & \vdots & & \vdots \\ \alpha_{0,N-1} & \alpha_{1,N-1} & \cdots & \alpha_{M-1,N-1} \end{pmatrix}.$$

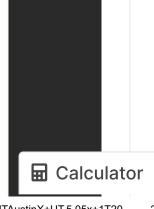
The more I look at it, the more I notice how much I messed up the indices in this particular video... I hate indices...

Best to read the "Related Reading" for this unit...

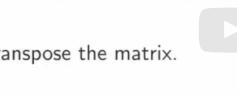


# Summary

Transposing a partitioned matrix:



- View each submatrix as if it is a scalar;
- Transpose the matrix.
- Transpose each submatrix.





4:55 / 4:55

▶ 2.0x

CC

#### **Video**

▲ Download video file

#### **Transcripts**

## Reading Assignment

0 points possible (ungraded) Read Unit 4.2.2 of the notes. [LINK]



Done



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✓ Correct

#### Discussion

**Topic:** Week 4 / 4.2.2

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Problems Reduced to Subproblems

I can't help but comment that this "slicing and dicing" method of parsing a linear transformation is similar in spirit to a divide and conquer approa...

2

### Homework 4.2.2.1

1/1 point (graded)

Show, step-by-step, how to transpose:  $\left(egin{array}{cc|c}1&-1&3&2\\\hline2&-2&1&0\\\hline0&-4&3&2\end{array}
ight)$ 

Steps:

$$1. \, \left( egin{array}{c|c|c} 1 & 2 \ -1 & -2 \ 3 & 1 \ \hline \end{array} \, \left( egin{array}{c|c|c} 0 \ -4 \ 3 \ \hline \end{array} \, \left( 2 & 0 \ \end{array} 
ight) = \left( egin{array}{c|c|c} 1 & 2 & 0 \ -1 & -2 & -4 \ \hline 3 & 1 & 3 \ \hline 2 & 0 & 2 \ \end{array} 
ight)$$

■ Calculator

$$2.\left(egin{array}{c|cc|c} \left(egin{array}{c|cc|c} 1 & -1 & 3 \ 2 & -2 & 1 \end{array}
ight) \left(egin{array}{c|cc|c} 2 \ 0 \end{array}
ight)^T \ \hline \left(egin{array}{c|cc|c} 0 & -4 & 3 \end{array}
ight) \left(egin{array}{c|cc|c} 2 \ 0 \end{array}
ight) \end{array}$$

$$3. \left( egin{array}{c|cccc} \left( egin{array}{c|cccc} 1 & -1 & 3 \ 2 & -2 & 1 \end{array} 
ight)^T & \left( 0 & -4 & 3 
ight)^T \ \hline \left( egin{array}{c|cccc} 2 \ 0 \end{array} 
ight)^T & \left( 2 
ight)^T \end{array} 
ight)$$

List the correct order of the steps taken above. (Answer Format: x,x,x where x is a step number)

2,3,1

✓ Answer: 2,3,1 or 2, 3, 1

#### Explanation

• Step 2: 
$$\left(egin{array}{c|c} A_{00} & A_{01} \ \hline A_{10} & A_{11} \end{array}
ight)^T$$

• Step 3: 
$$\left( egin{array}{c|c} A_{00}^T & A_{10}^T \ \hline A_{01}^T & A_{11}^T \end{array} 
ight)$$

• Step 1: Explicitly transpose the individual matrices.

Here

$$egin{array}{c|cccc} A_{00} = egin{pmatrix} 1 & -1 & 3 \ 2 & -2 & 1 \end{pmatrix} & A_{01} = egin{pmatrix} 2 \ 0 \end{pmatrix} \ \hline A_{10} = egin{pmatrix} 0 & -4 & 3 \end{pmatrix} & A_{11} = egin{pmatrix} 2 \end{pmatrix} \end{array}$$

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Answers are displayed within the problem

### Homework 4.2.2.2

6/6 points (graded)

$$\left(\,3\,\right)^{T}=\left(\,3\,\right)$$

TRUE



✓ Answer: TRUE

$$\left(rac{3}{rac{1}{8}}
ight)^T = \left(rac{8}{rac{1}{3}}
ight)$$

FALSE

Answer: FALSE

$$\left(egin{array}{c|c} 3 & 1 & 1 & 8 \end{array}
ight)^T = \left(rac{3}{1\over 1\over 8}
ight)$$

TRUE

✓ Answer: TRUE

$$\left( egin{array}{c|c|c|c|c} 1 & 2 & 3 & 4 \ 5 & 6 & 7 & 8 \ 9 & 10 & 11 & 12 \ \end{array} 
ight)^T = \left( egin{array}{c|c|c} 1 & 2 & 3 & 4 \ \hline 5 & 6 & 7 & 8 \ \hline 9 & 10 & 11 & 12 \ \end{array} 
ight)$$

$$\left(egin{array}{c|c|c} 1 & 5 & 9 \ 2 & 6 & 10 \ 3 & 7 & 11 \ 4 & 8 & 12 \end{array}
ight)^T = \left(rac{1 & 2 & 3 & 4}{5 & 6 & 7 & 8} \ \hline 9 & 10 & 11 & 12 \end{array}
ight)$$

$$\left( \left( egin{array}{c|cccc} 1 & 2 & 3 & 4 \ 5 & 6 & 7 & 8 \ \hline 9 & 10 & 11 & 12 \end{array} 
ight)^T = \left( egin{array}{c|cccc} 1 & 2 & 3 & 4 \ 5 & 6 & 7 & 8 \ \hline 9 & 10 & 11 & 12 \end{array} 
ight)$$

### Explanation

1. 
$$\left(\begin{array}{c}3\end{array}\right) \left(\begin{array}{c}3\end{array}\right)^T = \left(\begin{array}{c}3^T\end{array}\right) \left(\begin{array}{c}3\end{array}\right)$$

$$2. \left(\frac{3}{\frac{1}{8}}\right) \quad \left(\frac{3}{\frac{1}{8}}\right)^{T} = \left( \begin{array}{c} 3\\ \frac{1}{1} \end{array} \right)^{T} \left| \begin{pmatrix} 1 \end{pmatrix}^{T} \right| \left( 8 \right)^{T} \right) = \left( 3 \quad 1 \mid 1 \mid 8 \right)$$

3. 
$$\begin{pmatrix} 3 & 1 & 1 & | & 8 \end{pmatrix}$$
  $\begin{pmatrix} \frac{\begin{pmatrix} 3 & 1 \end{pmatrix}^T}{\begin{pmatrix} 1^T \end{pmatrix}} \\ \hline \begin{pmatrix} 8^T \end{pmatrix} \end{pmatrix} = \begin{pmatrix} \frac{3}{1} \\ \frac{1}{8} \end{pmatrix}$ 

$$4. \left(\begin{array}{c|c|c} 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \\ 9 & 10 & 11 & 12 \end{array}\right) \quad \left(\begin{array}{c|c} 1 & 5 & 9 \\ \hline 2 & 6 & 10 \\ \hline \hline 3 & 7 & 11 \\ \hline 4 & 8 & 12 \end{array}\right)$$

5. 
$$\begin{pmatrix} 1 & 5 & 9 \\ 2 & 6 & 10 \\ 3 & 7 & 11 \\ 4 & 8 & 12 \end{pmatrix} \quad \begin{pmatrix} 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \\ 9 & 10 & 11 & 12 \end{pmatrix}$$

$$6. \left(\begin{array}{c|c|c} 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \\ \hline 9 & 10 & 11 & 12 \end{array}\right) \quad \left(\begin{array}{c|c|c} 1 & 2 \\ \hline 5 & 6 \end{array}\right)^T \quad \left(\begin{array}{c|c} 3 & 4 \\ 7 & 8 \end{array}\right)^T \\ \hline \left(\begin{array}{c|c|c} 9 & 10\end{array}\right)^T \quad \left(\begin{array}{c|c} 1 & 5 & 9 \\ \hline 2 & 6 & 10 \\ \hline \end{array}\right) = \left(\begin{array}{c|c} 1 & 5 & 9 \\ \hline 2 & 6 & 10 \\ \hline \hline 3 & 7 & 11 \\ \hline 4 & 8 & 12 \end{array}\right)$$

$$//1 \quad 2 \quad 3 \quad 4 \quad 1 \quad 1 \quad 1 \quad 2 \quad 3 \quad 4 \quad 1$$

$$7. \left( \begin{array}{c|cccc} 1 & 2 & 3 & 1 \\ \hline 5 & 6 & 7 & 8 \\ \hline 9 & 10 & 11 & 12 \end{array} \right)$$

7.  $\left(\begin{array}{c|c|c|c} 5 & 6 & 7 & 8 \\ \hline 9 & 10 & 11 & 12 \end{array}\right)$   $\left(\begin{array}{c|c|c|c} 5 & 6 & 7 & 8 \\ \hline 9 & 10 & 11 & 12 \end{array}\right)$  (You are transposing twice...)

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**1** Answers are displayed within the problem

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