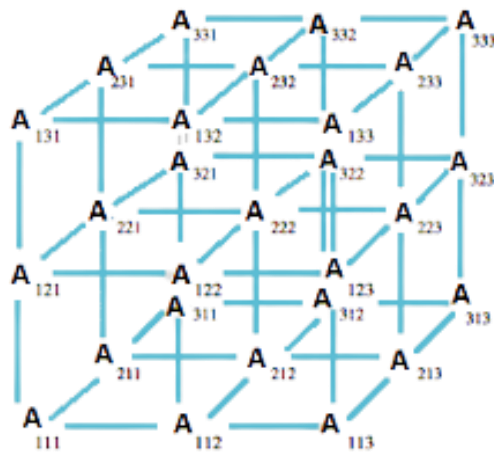


CCS354 – Tensors and Graphs

Lab exercise-02



A.M.Madhu Attanayake

Batch 07

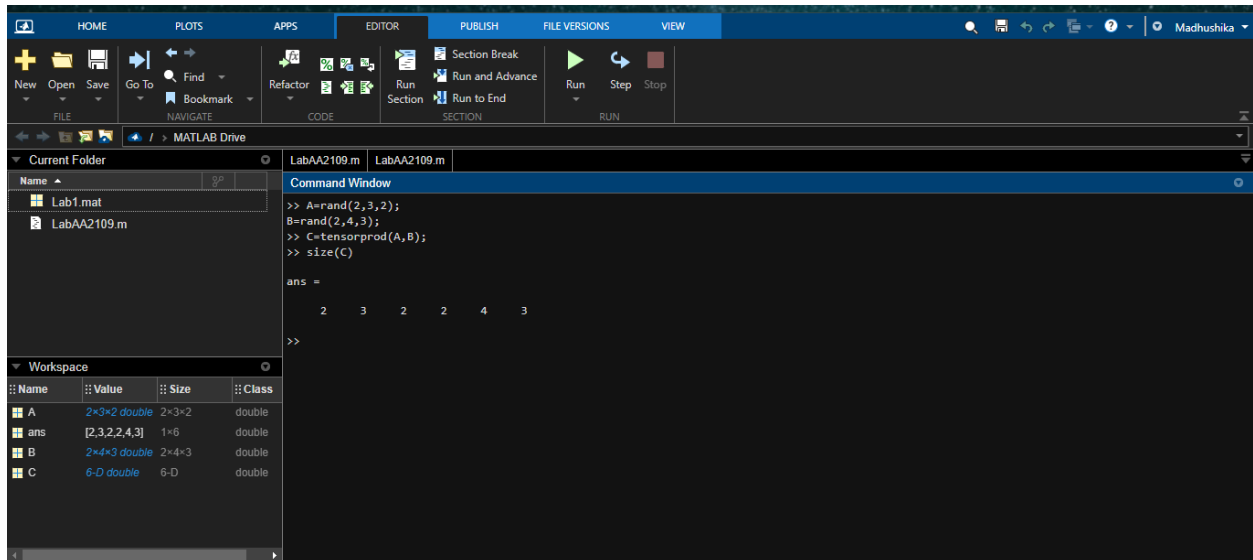
School of Computing & IT

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1. Create two 3-D tensors A (2,3,2) [i, j, k] and B (2,4,3) [k, l, m] with random elements.

a. Calculate the outer product of the two tensors. Check the size of the result.

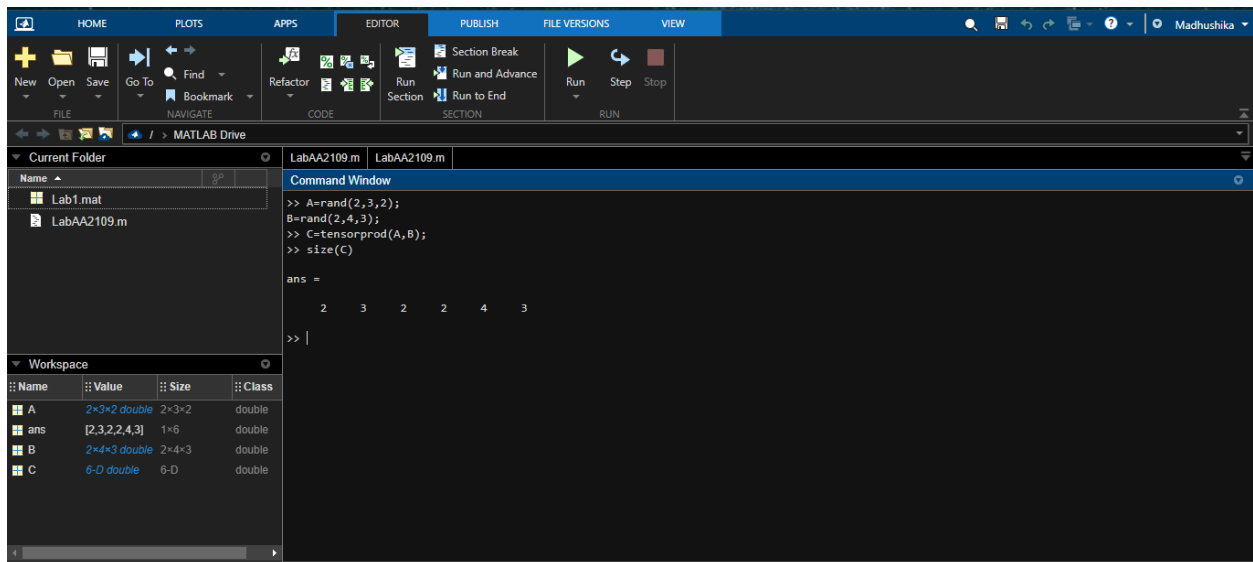


The screenshot shows the MATLAB R2021a interface. The Command Window displays the following code and output:

```
>> A=rand(2,3,2);  
B=rand(2,4,3);  
>> C=tensorprod(A,B);  
>> size(C)  
  
ans =  
  
     2     3     2     2     4     3  
  
>>
```

The Workspace window shows the following variables:

Name	Value	Size	Class
A	2×3×2 double	2×3×2	double
ans	[2,3,2,2,4,3]	1×6	double
B	2×4×3 double	2×4×3	double
C	6-D double	6-D	double



The screenshot shows the MATLAB R2021a interface. The Command Window displays the following code and output:

```
>> A=rand(2,3,2);  
B=rand(2,4,3);  
>> C=tensorprod(A,B);  
>> size(C)  
  
ans =  
  
     2     3     2     2     4     3  
  
>> |
```

The Workspace window shows the following variables:

Name	Value	Size	Class
A	2×3×2 double	2×3×2	double
ans	[2,3,2,2,4,3]	1×6	double
B	2×4×3 double	2×4×3	double
C	6-D double	6-D	double

b. Calculate the tensor product A_{ki} , and $B_{l,mk}$

The MATLAB Editor shows the file LabAA2109.m. The Command Window displays the following code and output:

```
>> A=rand(2,3,2);
B=rand(2,4,3);
>> C=tensorprod(A,B);
>> size(C)

ans =

    2    3    2    2    4    3

>> D=tensorprod(A,B,3,1);
>> size(D)

ans =

    2    3    4    3

>>
```

The Workspace window shows the following variables:

Name	Value	Size	Class
A	2×3×2 double	2×3×2	double
ans	[2,3,4,3]	1×4	double
B	2×4×3 double	2×4×3	double
C	6-D double	6-D	double
D	2×3×4×3 d...	2×3×4×3	double

c. Calculate the tensor product $A_{i,,k}$ and $B_{k,l,m}$.

The MATLAB Editor shows the file LabAA2109.m. The Command Window displays the following code and output:

```
>> E=tensorprod(A,B,3,1);
>> size(E)

ans =

    2    3    4    3

>> |
```

The Workspace window shows the following variables:

Name	Value	Size	Class
A	2×3×2 double	2×3×2	double
ans	[2,3,4,3]	1×4	double
B	2×4×3 double	2×4×3	double
C	6-D double	6-D	double
D	2×3×4×3 d...	2×3×4×3	double
E	2×3×4×3 d...	2×3×4×3	double

d. Discuss the answers in (b) and (c) with screenshots as a proof.

Richard

14/3/2020

AA2109

A.M. Madhu Atanayake

$$A \quad (2, 3, 2) \quad [i, j, k]$$

$$B \quad (2, 4, 3) \quad [k, l, m]$$

(a) To calculate the outer product we use tensorprod function

`tensorprod(A, B)` returns outerproduct of A and B

Size of outerproduct $\rightarrow [\text{size}(A) \quad \text{size}(B)]$

obtained results. $\rightarrow [2 \ 3 \ 2 \ 2 \ 4 \ 3]$

Size A $\rightarrow 2 \times 3 \times 2$

Size B $2 \times 4 \times 3$

(b) Tensor product of A_{k}^{ij} and $B_{l,m}^k$

Here Both A and B contract in same dimension which is k

\therefore the end result may gives $A^{ij} B_{l,m}$ $A B_{l,m}^{ij}$ (4d)

(c) Tensor product of $A_{k,l,m}^{ijk}$ $B_{k,l,m}$

Here if we index

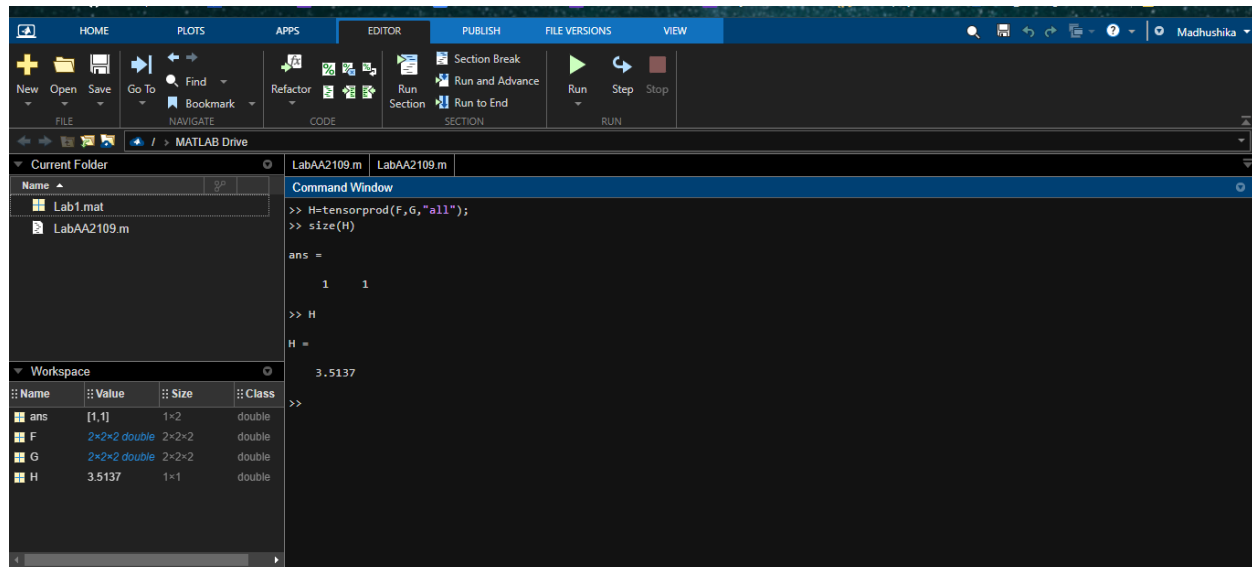
$A \begin{matrix} i & j & k \\ \uparrow & \uparrow & \uparrow \\ \textcircled{1} & \textcircled{2} & \textcircled{3} \end{matrix}$

$B \begin{matrix} k & l & m \\ \uparrow & \uparrow & \uparrow \\ \textcircled{1} & \textcircled{2} & \textcircled{3} \end{matrix}$

* 3rd dimension of A with 1st dimension of B will contract
Hence the result will give us the size of A (uncontracted)
and size of B uncontracted.

2. Create two 3-D tensors A (2,2,2) and B (2,2,2) with random elements

a. Calculate the tensor product A_{ijk} and B_{ijk} (Here, $i = 2, j = 2$ and $k = 2$)



The screenshot shows the MATLAB interface with the following components:

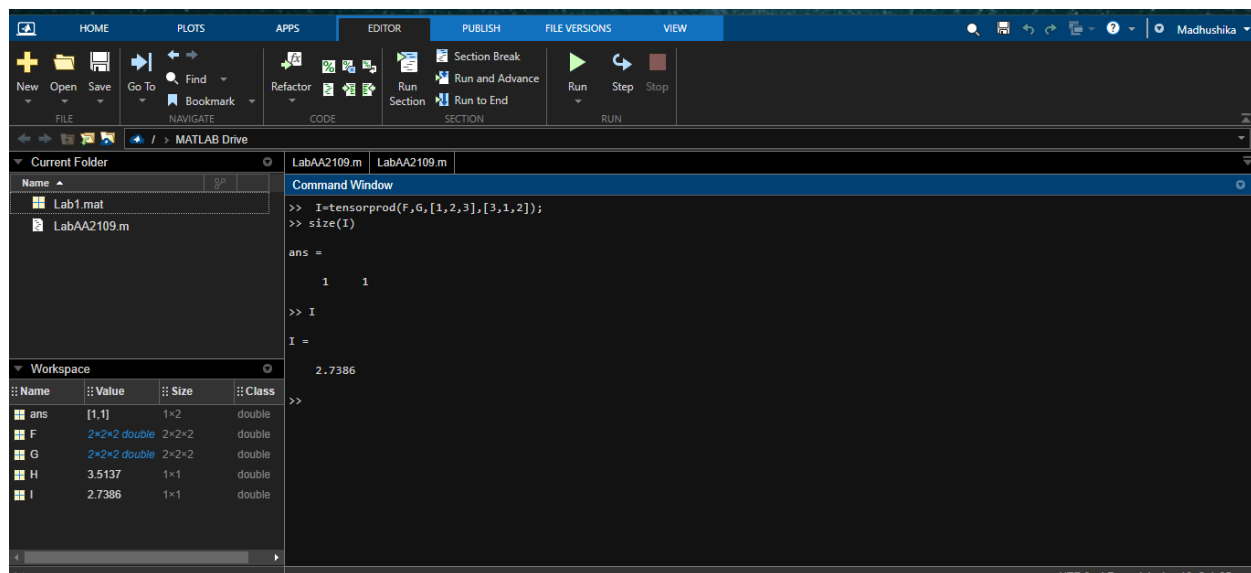
- Current Folder:** Lab1.mat, LabAA2109.m
- Workspace:**

Name	Value	Size	Class
ans	[1,1]	1×2	double
F	2×2×2 double	2×2×2	double
G	2×2×2 double	2×2×2	double
H	3.5137	1×1	double

- Command Window:**

```
>> H=tensorprod(F,G,"all");  
>> size(H)  
  
ans =  
     1     1  
  
>> H  
  
H =  
  
3.5137  
  
>>
```

b. Calculate the tensor product A_{ijk} and B_{jki} . (Here, $i = 2, j = 3$, and $k = 2$).



The screenshot shows the MATLAB interface with the following components:

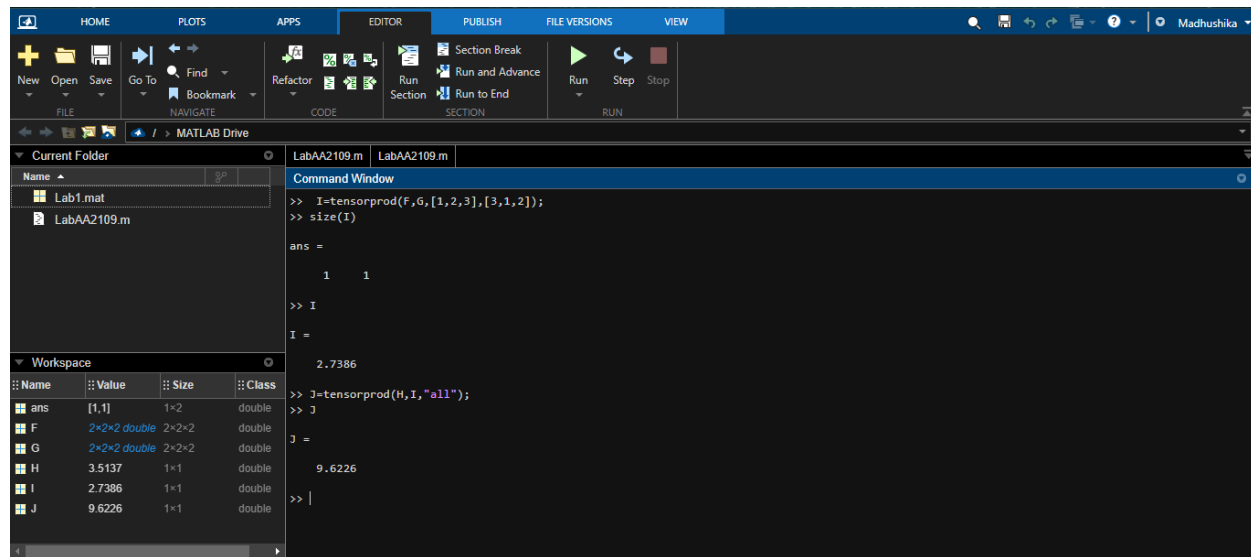
- Current Folder:** Lab1.mat, LabAA2109.m
- Workspace:**

Name	Value	Size	Class
ans	[1,1]	1×2	double
F	2×2×2 double	2×2×2	double
G	2×2×2 double	2×2×2	double
H	3.5137	1×1	double
I	2.7386	1×1	double

- Command Window:**

```
>> I=tensorprod(F,G,[1,2,3],[3,1,2]);  
>> size(I)  
  
ans =  
     1     1  
  
>> I  
  
I =  
  
2.7386  
  
>>
```

c. Calculate the inner product of the tensors in above (a) and (b).



```
>> I=tensorprod(F,G,[1,2,3],[3,1,2]);
>> size(I)

ans =

     1     1

>> I

I =

    2.7386

>> J=tensorprod(H,I,"all");
>> J

J =

    9.6226

>> |
```

Name	Value	Size	Class
ans	[1,1]	1×2	double
F	2×2×2 double	2×2×2	double
G	2×2×2 double	2×2×2	double
H	3.5137	1×1	double
I	2.7386	1×1	double
J	9.6226	1×1	double

d. Discuss the answers with screenshots as a proof

Date: _____ Page: _____

Person: _____

240 (each tensor is 3x3x3)

$F(2,2,2)$
 $G(2,2,2)$

a. when calculate tensor product of F and G each i, j, k are contracted with each other
 ∴ we can use "all"

$A^{ijk} B_{ijk} \Rightarrow \text{scaler}$

b.

$A \begin{matrix} i & j & k \\ \uparrow & \uparrow & \uparrow \\ ① & ② & ③ \end{matrix}$ $B \begin{matrix} j & k & i \\ \uparrow & \uparrow & \uparrow \\ ① & ② & ③ \end{matrix}$

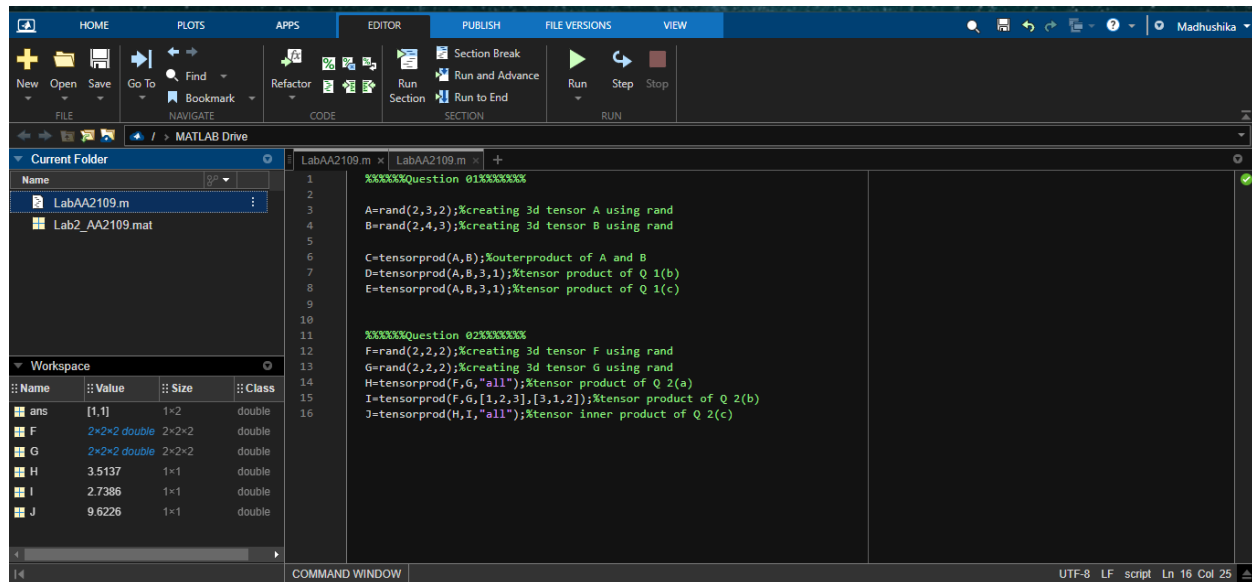
∴ I used contraction as follows

$A(i, j, k) (1, 2, 3)$
 $B(j, k, i) (2, 3, 1)$

∴ result is a scaler = 2.7386

c. For inner product we can use "all" with tensorprod.

Script



Code

%% Question 01

```
A=rand(2,3,2);%creating 3d tensor A using rand  
B=rand(2,4,3);%creating 3d tensor B using rand
```

```
C=tensorprod(A,B);% outerproduct of A and B  
D=tensorprod(A,B,3,1);%tensor product of Q 1(b)  
E=tensorprod(A,B,3,1);%tensor product of Q 1(c)
```

%% Question 02

```
F=rand(2,2,2);%creating 3d tensor F using rand  
G=rand(2,2,2);%creating 3d tensor G using rand  
H=tensorprod(F,G,"all");%tensor product of Q 2(a)  
I=tensorprod(F,G,[1,2,3],[3,1,2]);%tensor product of Q 2(b)  
J=tensorprod(H,I,"all");%tensor inner product of Q 2(c)
```

%I did all codes using matlab online but unable to download the script
%therefore i submit as a 2020 matlab script file, when run the code please use 2022 matlab or
online matlab.

