Cheat sheet for Mathematica

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Basic Operation

Matrix Operation

multiplication, dot production, power

Side note : how to generate a matrix :
 "()" and press " ctrl + enter" to increase row entries ; "ctrl +," to increase columns
 Or we can represent a matrix in vector forms

Example 1:Let’s generate a generalized 2 by 2 matrix and then do some basic calculation

```
A = (a11 a12
     a21 a22); (*here we generate a 2 by 2 matrix*)
{{a11 , a12}, {a21 , a22}}
{{a11, a12}, {a21 , a22}} // MatrixForm
B = {{a11, a12}, {a21, a22}} // MatrixForm
A + B  (*This doesn't work since B
 matrix is stored as an image instead of a matrix*)
B1 = {{a11 , a12}, {a21, a22}}
B1 // MatrixForm  (*This works because we first store the
 B matrix in vectors and then transform it ito the matrix form*)
A + B1
A + A (*addition*)
A * A (*this represents the multiplication of individual elements*)
A^2  (*this is equivalent to "A*A"*)
A^2  (*the hotkey is " ctrl+6" and it is the same as "A*A"*)
MatrixPower[A, 2]   (*this is for power operation*)
A.A  // MatrixForm    (*this is identical to the power of any matrix*)
Eigensystem[A](*eigenvalues and their corresponding eignvectors*)
```

Out[∘]= {{a11, a12}, {a21, a22}}

Out[∘]//MatrixForm=

$$\begin{pmatrix} a11 & a12 \\ a21 & a22 \end{pmatrix}$$

Out[∘]//MatrixForm=

$$\begin{pmatrix} a11 & a12 \\ a21 & a22 \end{pmatrix}$$

Out[∘]= $\left\{\left\{a11 + \begin{pmatrix} a11 & a12 \\ a21 & a22 \end{pmatrix}, a12 + \begin{pmatrix} a11 & a12 \\ a21 & a22 \end{pmatrix}\right\}, \left\{a21 + \begin{pmatrix} a11 & a12 \\ a21 & a22 \end{pmatrix}, a22 + \begin{pmatrix} a11 & a12 \\ a21 & a22 \end{pmatrix}\right\}\right\}$

Out[∘]= {{a11, a12}, {a21, a22}}

Out[∘]//MatrixForm=

$$\begin{pmatrix} a11 & a12 \\ a21 & a22 \end{pmatrix}$$

Out[∘]= {{2 a11, 2 a12}, {2 a21, 2 a22}}

Out[∘]= {{2 a11, 2 a12}, {2 a21, 2 a22}}

Out[∘]= $\{\{a11^2, a12^2\}, \{a21^2, a22^2\}\}$

Out[∘]= $\{\{a11^2, a12^2\}, \{a21^2, a22^2\}\}$

Out[∘]= $\{\{a11^2, a12^2\}, \{a21^2, a22^2\}\}$

Out[∘]= $\{\{a11^2 + a12\ a21, a11\ a12 + a12\ a22\}, \{a11\ a21 + a21\ a22, a12\ a21 + a22^2\}\}$

Out[∘]//MatrixForm=

$$\begin{pmatrix} a11^2 + a12\ a21 & a11\ a12 + a12\ a22 \\ a11\ a21 + a21\ a22 & a12\ a21 + a22^2 \end{pmatrix}$$

Out[∘]= $$\left\{\left\{\frac{1}{2}\left(a11 + a22 - \sqrt{a11^2 + 4\ a12\ a21 - 2\ a11\ a22 + a22^2}\right), \frac{1}{2}\left(a11 + a22 + \sqrt{a11^2 + 4\ a12\ a21 - 2\ a11\ a22 + a22^2}\right)\right\}, \left\{\left\{-\frac{-a11 + a22 + \sqrt{a11^2 + 4\ a12\ a21 - 2\ a11\ a22 + a22^2}}{2\ a21}, 1\right\}, \left\{-\frac{-a11 + a22 - \sqrt{a11^2 + 4\ a12\ a21 - 2\ a11\ a22 + a22^2}}{2\ a21}, 1\right\}\right\}\right\}$$

Extracting submatrices

```
Part[A, 2, 1] (*Part command can extract any entry of a matrix*)
A[[2, 1]] (*Double parentheses*)
{A[[2, All]]} // MatrixForm
B2 = {A[[2, All]]}
```

Let’s consider how to extract some specific rows and columns

```
mat = Table[Subscript[m, i, j], {i, 5}, {j, 5}]; (*Subscript is a function*)
mat // MatrixForm
B3 = mat[[1 ;; 3, 2 ;; 3]] // MatrixForm (*";;" refers to "span" command*)
```

Out[ ]//MatrixForm=

$$\begin{pmatrix} m_{1,1} & m_{1,2} & m_{1,3} & m_{1,4} & m_{1,5} \\ m_{2,1} & m_{2,2} & m_{2,3} & m_{2,4} & m_{2,5} \\ m_{3,1} & m_{3,2} & m_{3,3} & m_{3,4} & m_{3,5} \\ m_{4,1} & m_{4,2} & m_{4,3} & m_{4,4} & m_{4,5} \\ m_{5,1} & m_{5,2} & m_{5,3} & m_{5,4} & m_{5,5} \end{pmatrix}$$

Out[ ]//MatrixForm=

$$\begin{pmatrix} m_{1,2} & m_{1,3} \\ m_{2,2} & m_{2,3} \\ m_{3,2} & m_{3,3} \end{pmatrix}$$

Concatenation matrix

```
r1 = ( 1  2  3 )
r2 = ( 2  3  4 )
Join[r1, r2] // MatrixForm
(*Vertical concatenation can be achieved by the "Join" command*)
```

$$r3 = \begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix}$$

$$r4 = \begin{pmatrix} 2 \\ 3 \\ 4 \end{pmatrix}$$

```
Join[r3, r4] // MatrixForm (*Note: this is not horizontal concatenation*)
Transpose[Join[Transpose[r3], Transpose[r4]]] // MatrixForm
(*Note: Transpose command only applies to matrix instead of vectors*)
```

$$C1 = \begin{pmatrix} 1 & 0 \\ 0 & 2 \end{pmatrix}$$

$$C2 = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$$

```
ArrayFlatten[{{C1, 0}, {0, C2}}]  // MatrixForm
 (*"ArrayFlatten" can be used to generate diagonal matrices *)
```

Out[∘]= {{1, 2, 3}}

Out[∘]= {{2, 3, 4}}

Out[∘]//MatrixForm=

$$\begin{pmatrix} 1 & 2 & 3 \\ 2 & 3 & 4 \end{pmatrix}$$

Out[∘]= {{1}, {2}, {3}}

Out[∘]= {{2}, {3}, {4}}

Out[∘]//MatrixForm=

$$\begin{pmatrix} 1 \\ 2 \\ 3 \\ 2 \\ 3 \\ 4 \end{pmatrix}$$

Out[∘]//MatrixForm=

$$\begin{pmatrix} 1 & 2 \\ 2 & 3 \\ 3 & 4 \end{pmatrix}$$

Out[∘]= {{1, 0}, {0, 2}}

Out[∘]= {{1, 0}, {0, 1}}

Out[∘]//MatrixForm=

$$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

Out[ ]= {{1, 2, 3}}

Out[ ]= {{2, 3, 4}}

Out[ ]//MatrixForm=

$$\begin{pmatrix} 1 & 2 & 3 \\ 2 & 3 & 4 \end{pmatrix}$$

Out[ ]= {{1}, {2}, {3}}

Out[ ]= {{2}, {3}, {4}}

Out[ ]//MatrixForm=

$$\begin{pmatrix} 1 \\ 2 \\ 3 \\ 2 \\ 3 \\ 4 \end{pmatrix}$$

Out[ ]//MatrixForm=

$$\begin{pmatrix} 1 & 2 \\ 2 & 3 \\ 3 & 4 \end{pmatrix}$$

... Set: Symbol D is Protected.

Out[ ]= {{1, 4}, {5, 2}}

... Set: Symbol ⅇ is Protected.

Out[ ]= {{1, 4}, {7, 5}}

Exercise: IEEE 2020 TPEL

(*Calculate Facc*)

In[ ]:= $F1 = \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix};$

$F2 = \begin{pmatrix} -wa & 0 \\ 0 & -wa \end{pmatrix};$

$$Fd = \begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ \frac{-120}{T^3} & \frac{-60}{T^2} & \frac{-12}{T} \end{pmatrix};$$

$$Fq = \begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ \frac{-120}{T^3} & \frac{-60}{T^2} & \frac{-12}{T} \end{pmatrix};$$

F3 = ArrayFlatten[{{Fd, 0}, {0, Fq}}] ;

$$F4 = \begin{pmatrix} -\frac{R1}{L1} & w1 \\ -w1 & -\frac{R1}{L1} \end{pmatrix};$$

Facc = ArrayFlatten[{{F1, 0, 0, 0}, {0, F2, 0, 0}, {0, 0, F3, 0}, {0, 0, 0, F4}}];

(*calculate Hacc*)

$H1 = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix};$

$H2 = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix};$

$$H3 = \begin{pmatrix} 0 & 0 \\ 0 & 0 \\ 1 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 1 \end{pmatrix};$$

$$H4 = \begin{pmatrix} -\frac{1}{L1} & 0 \\ 0 & -\frac{1}{L1} \end{pmatrix};$$

```
Hacc = ArrayFlatten[{{H1, 0, 0, 0}, {0, H2, 0, 0}, {0, 0, H3, 0}, {0, 0, 0, H4}}];
(*calculate Jacc*)
```

$$J1 = \begin{pmatrix} kic & 0 \\ 0 & kic \end{pmatrix};$$

$$J2 = \begin{pmatrix} -ka * wa & 0 \\ 0 & -ka * wa \end{pmatrix};$$

$$J3 = \begin{pmatrix} \frac{240}{T^3} & 0 & \frac{24}{T} & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{240}{T^3} & 0 & \frac{24}{T} \end{pmatrix};$$

$$J4 = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix};$$

```
Jacc = ArrayFlatten[{{J1, 0, 0, 0}, {0, J2, 0, 0}, {0, 0, J3, 0}, {0, 0, 0, J4}}];
(*calculate Kacc*)
```

$$K1 = \begin{pmatrix} kpc & 0 \\ 0 & kpc \end{pmatrix};$$

$$K2 = \begin{pmatrix} -ka & 0 \\ 0 & -ka \end{pmatrix};$$

$$K3 = \begin{pmatrix} -1 & 0 \\ 0 & -1 \end{pmatrix};$$

$$K4 = \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix};$$

```
Kacc = ArrayFlatten[{{K1, 0, 0, 0}, {0, K2, 0, 0}, {0, 0, K3, 0}, {0, 0, 0, K4}}];
(*define L matrices*)
```

$$Lacc1 = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \end{pmatrix};$$

$$Lacc2 = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix};$$

$$Lacc3 = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix};$$

$$Lacc4 = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix};$$

```
(*Define Identify matrix*)
I1 = IdentityMatrix[8];
M1 = Inverse[I1 - Kacc.Lacc1] ;
(*calculate Aacc, Bacc Cacc Dacc*)
Aacc = Facc + Hacc.Lacc1.M1.Jacc;
Bacc = Hacc.Lacc1.M1.Kacc.Lacc2 + Hacc.Lacc2;
```

```
Cacc = Lacc3.M1.Jacc ;
Dacc = Lacc3.M1.Kacc.Lacc2 + Lacc4;
(*generate Fvsc Hvsc Jvsc Kvsc*)
(*Fvsc*)
```

$$\text{Fpll} = \begin{pmatrix} 0 & 0 \\ \text{kip} & 0 \end{pmatrix};$$

$$\text{Fdvc} = \begin{pmatrix} 0 \end{pmatrix};$$

```
Favc = (-wac);
```

$$\text{Fapb} = \begin{pmatrix} 0 \end{pmatrix};$$

```
Fvsc = ArrayFlatten[{{Aacc, 0, 0, 0, 0}, {0, Fpll, 0, 0, 0},
    {0, 0, Fdvc, 0, 0}, {0, 0, 0, Favc, 0}, {0, 0, 0, 0, Fapb}}];
(*Hvsc*)
```

$$\text{Hpll} = \begin{pmatrix} 1 \\ \text{kpp} \end{pmatrix};$$

$$\text{Hdvc} = \begin{pmatrix} 1 \end{pmatrix};$$

$$\text{Havc} = \begin{pmatrix} \text{kpa} * \text{wac} \end{pmatrix};$$

$$\text{Hapb} = \begin{pmatrix} \frac{\text{Id1}}{\text{Cdc}*\text{Vdc0}} & \frac{\text{Iq1}}{\text{Cdc}*\text{Vdc0}} & \frac{\text{V1}}{\text{Cdc}*\text{Vdc0}} & 0 \end{pmatrix};$$

```
Hvsc = ArrayFlatten[{{Hacc, 0, 0, 0, 0}, {0, Hpll, 0, 0, 0},
    {0, 0, Hdvc, 0, 0}, {0, 0, 0, Havc, 0}, {0, 0, 0, 0, Hapb}}];
(*Jvsc*)
Jpll = ( 0  1 );
```

$$\text{Jdvc} = \begin{pmatrix} \frac{\text{Kid} * \text{Vdc0}}{\text{V1}} \end{pmatrix};$$

$$\text{Javc} = \begin{pmatrix} 1 \end{pmatrix};$$

$$\text{Japb} = \begin{pmatrix} -1 \end{pmatrix};$$

```
Jvsc = ArrayFlatten[{{Jacc, 0, 0, 0, 0}, {0, Jpll, 0, 0, 0},
    {0, 0, Jdvc, 0, 0}, {0, 0, 0, Javc, 0}, {0, 0, 0, 0, Japb}}];
(*Kvsc*)
```

$$\text{Kpll} = \begin{pmatrix} 0 \end{pmatrix};$$

$$\text{Kdvc} = \begin{pmatrix} \frac{\text{Kpd} * \text{Vdc0}}{\text{V1}} \end{pmatrix};$$

$$\text{Kavc} = \begin{pmatrix} 0 \end{pmatrix};$$

$$\text{Kapb} = \begin{pmatrix} 0 & 0 & -\frac{\text{L1}*\text{Id1}}{\text{Cdc}*\text{Vdc0}} & -\frac{\text{L1}*\text{Iq11}}{\text{Cdc}*\text{Vdc0}} \end{pmatrix};$$

```
Kvsc = ArrayFlatten[{{Kacc, 0, 0, 0, 0}, {0, Kpll, 0, 0, 0},
    {0, 0, Kdvc, 0, 0}, {0, 0, 0, Kavc, 0}, {0, 0, 0, 0, Kapb}}];
(*define Lvsc matrices*)
```

$$\text{Lvsc1} = \begin{pmatrix} 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\text{V1} & 0 & 0 & 0 \\ 0 & 0 & -\text{V1} & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & -\text{Iq1} & 0 & 0 & 0 \\ 0 & 1 & \text{Id1} & 0 & 0 & 0 \end{pmatrix};$$

```
Lvsc2 = (0 0
         0 0
         1 0
         0 1
         0 1
         0 0
         1 0
         1 0
         0 1
         0 0
         0 0);

Lvsc3 = (1 0 -Iq1 0 0 0
         0 1  Id1 0 0 0);
Lvsc4 = (0 0
         0 0);
(*Define Identify matrix*)
I2 = IdentityMatrix[11];
M1 = Inverse[I1 - Kvsc.Lvsc1]  // MatrixForm
```

… Dot: Tensors
{{0, 0, 0, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0, 0, 0}, {kpc, 0, −ka, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0, 0, 0}, {0, kpc, 0, −ka, 0, 0, 0, 0}, $\left\{\frac{\text{kpc}}{\text{L1}}, 0, -\frac{\text{ka}}{\text{L1}}, 0, \frac{1}{\text{L1}}, 0, 0, 0\right\}$, $\left\{0, \frac{\text{kpc}}{\text{L1}}, 0, -\frac{\text{ka}}{\text{L1}}, 0, \frac{1}{\text{L1}}, 0, 0\right\}$} and
{{1, 0, 0, 0}, {0, 1, 0, 0}, {0, 0, 1, 0}, {0, 0, 0, 1}, {0, 0, 0, 0}, {0, 0, −1, 0}, {0, 0, 0, −1}} have incompatible shapes.

… Dot: Tensors
{{1, 0, 0, 0, 0, 0, 0, 0}, {0, 1, 0, 0, 0, 0, 0, 0}, {0, 0, 1, 0, 0, 0, 0, 0}, {0, 0, 0, 1, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 1, 0, 0, 0}, {0, 0, 0, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 1, 0, 0}, $\left\{0, 0, 0, 0, 0, 0, -\frac{1}{\text{L1}}, 0\right\}$, $\left\{0, 0, 0, 0, 0, 0, 0, -\frac{1}{\text{L1}}\right\}$} and {{1, 0, 0, 0}, {0, 1, 0, 0}, {0, 0, 1, 0}, {0, 0, 0, 1}, {0, 0, 0, 0}, {0, 0, −1, 0}, {0, 0, 0, −1}} have incompatible shapes.

… Dot: Tensors {{0, 0, 0, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0, 0, 0}} and
{{1, 0, 0, 0}, {0, 1, 0, 0}, {0, 0, 1, 0}, {0, 0, 0, 1}, {0, 0, 0, 0}, {0, 0, −1, 0}, {0, 0, 0, −1}} have incompatible shapes.

… Dot: Tensors
{{kpc, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0}, {0, kpc, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0}, {0, 0, −ka, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0}, {0, 0, 0, −ka, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0}, {0, 0, 0, 0, −1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, −1, 0, 0, 0, 0, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0}, $\left\{0, 0, 0, 0, 0, 0, 0, 0, 0, \frac{\text{Kpd Vdc0}}{\text{V1}}, 0, 0, 0, 0, 0\right\}$, {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0}, $\left\{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -\frac{\text{Id1 L1}}{\text{Cdc Vdc0}}, -\frac{\text{Iq11 L1}}{\text{Cdc Vdc0}}\right\}$} and
{{0, 0, 0, 1, 0, 0}, {0, 0, 0, 0, 1, 0}, {0, 0, 0, 0, 0, 0}, {0, 0, −V1, 0, 0, 0}, {0, 0, −V1, 0, 0, 0}, {0, 1, 0, 0, 0, 1}, {0, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0}, {1, 0, −Iq1, 0, 0, 0}, {0, 1, Id1, 0, 0, 0}} have incompatible shapes.

Out[ ]//MatrixForm=

$\left(\cdots 1 \cdots \right)$

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