INTRODUCTION TO MAPLE

Maple is a powerful software system for performing many different symbolic and numerical calculations in mathematics. In previous years students have learnt to use Maple at level one, and level two courses have had various exercises involving Maple. However, most current level two students will have learnt Python instead of Maple. Neither Python nor Maple is essential for the current version of MAS201, but some students may find it helpful to use them. This document will give a brief introduction to Maple. Some notes about linear algebra in Python will be distributed separately. Much more information about Maple is available at

`http://shef.ac.uk/nps/courses/MAS100`

Installing Maple

Maple is available on all open access PCs on campus, but you may need to follow the instructions at

`http://shef.ac.uk/cics/studentcomputing/software`

to install it. You can also install a copy on your own PC by following the instructions at

`http://shef.ac.uk/cics/software/maple`

Using Maple

When you first start Maple, it will offer you a choice between Document Mode and Worksheet Mode. I recommend Worksheet Mode. When Maple has started you can enter `2+2` and press `ENTER`; Maple will print 4 as an answer. Now enter

```
A := <<5|6|7>,<4|3|2>>
B := <<8|9>,<9|8>>
```

Maple will display this as

$$A := \begin{pmatrix} 5 & 6 & 7 \\ 4 & 3 & 2 \end{pmatrix}$$

$$B := \begin{pmatrix} 9 & 5 \\ 5 & 9 \end{pmatrix}$$

(The colon before the equals sign is essential.) You can now enter `B.A` to calculate BA, or `B^2` to calculate B^2, or `B^(-1)` to calculate the inverse of B. If you enter `A.B` then Maple will print an error message explaining that AB is undefined, because A and B do not have compatible shapes.

The 3×3 identity matrix (for example) can be entered as `IdentityMatrix(3)`. To save typing, it is best to enter

```
I3 := IdentityMatrix(3)
```

and then you can just type `I3` after that. You might think of using the symbol `I` instead of `I3`, but Maple will not allow that, because it uses `I` for $\sqrt{-1}$.

To do more complicated things, you need some additional packages that are not loaded by default. I recommend that as soon as you start Maple you enter

```
with(LinearAlgebra):
with(Student[LinearAlgebra]):
```

This will load up everything that you need. (Here and elsewhere in Maple, you need to use capital letters exactly as specified; it will not work to enter `With(linearalgebra)`.)

In particular, after you have done the above you can enter

```
Transpose(A)
Determinant(B)
```

to calculate A^T and $\det(B)$. You can extract rows and columns from a matrix using syntax like

```
Row(A,2)
Column(B,1)
```

You can refer to the bottom right hand entry of A as `A[2,3]`.

In many places, it is convenient to give names to the columns of a matrix. For example, we might take u_1, u_2 and u_3 to be the columns of the matrix A above. To do this in Maple you can type

```
u[1] := Column(A,1)
u[2] := Column(A,1)
u[3] := Column(A,1)
```

or

```
for i from 1 to 3 do u[i] := Column(A,i) od
```

(Here `od` is `do` backwards, and marks the end of the `do` statement. You can type `end do` instead of `od` if you prefer.)

To find the RREF of A, you can enter

```
ReducedRowEchelonForm(A)
```

That is quite a lot of typing, so I suggest that after loading the `LinearAlgebra` and `Student[LinearAlgebra]` packages you immediately enter

```
RREF := RowReducedEchelonForm
GJET := GaussJordanEliminationTutor
```

You can then type `RREF(A)` to find the RREF of A immediately, or `GJET`to open a new window that leads you through the process step by step.

If you are going to use the RREF of A in further calculations, then you probably want to give it a name, like this:

```
A1 := RREF(A)
```

Again, the colon before the equals sign is necessary.

To find and factor the characteristic polynomial of B you can enter

```
p := CharacteristicPolynomial(B,t)
factor(p)
```

This works as written for square matrices like B that have an even number of rows. However, Maple defines the characteristic polynomial of M to be $\det(M - tI)$, whereas the notes use $\det(tI - M)$. (Both of these conventions are common in the literature.) Thus, for square matrices of odd size you need to multiply Maple's characteristic polynomial by -1 to get the characteristic polynomial as defined in the notes.

To find the eigenvalues and eigenvectors of B, enter `Eigenvectors(B)`. The result consists of a vector and a matrix, like this:

$$\begin{pmatrix} 4 \\ 14 \end{pmatrix} \begin{pmatrix} -1 & 1 \\ 1 & 1 \end{pmatrix}$$

The eigenvalues are 4 and 14, which appear as the entries in the vector above. The corresponding eigenvectors are $\begin{pmatrix} -1 \\ 1 \end{pmatrix}$ and $\begin{pmatrix} 1 \\ 1 \end{pmatrix}$, which appear as the columns of the matrix above. In cases where the matrix has repeated eigenvalues the result will need a bit more interpretation, but that will be discussed later.