Short Tutorial on Using Matlab ODE functions

(10/30/03 by Tomas Co)

1. Suppose we want to simulate the following set of differential equations:

$$\frac{d^2}{dt^2}y + 3\cdot\left(\frac{d}{dt}y\right) + 2\cdot y = 4\cdot\exp(-2\cdot t) - 5$$

subject to the following initial conditions,

$$y(0) = 2$$

$$\frac{d}{dt}y(0) = -1$$

2. You need to convert to state space form. Let $x_1 = y$ and $x_2 = dy/dt$, then we have

$$\frac{d}{dt}x_1 = x_2$$

$$\frac{d^2}{dt^2}x_2 = -3\cdot x_2 - 2\cdot x_1 + 4\cdot\exp(-2\cdot t) - 5$$

$$x_1(0) = 2$$

$$x_2(0) = -1$$

3. Next, you need to create an m-file using either Matlab's editor or just "notepad":

```
function dx = tutorialEqn1(t,x)

    % x is the state vector
    % to minimize parentheses you could put them in other variables

    x1=x(1);
    x2=x(2);

    % write the state equations

    dx1 = x2;
    dx2 = -3*x2 -2*x1 +4*exp(-2*t) - 5;

    % collect the derivatives into a column vector

    dx = [dx1;dx2];
```

save as an m-file, e.g. **`tutorialEqn1.m`**

4. In matlab, you can now invoke the ode solvers. For example, you can use **ode45** command:

```
>> [t,x]=ode45(@tutorialEqn1,[0 10],[2;-1])
```

Remarks:

a) Use the **'@'** symbol followed by the filename (without the file extension)
b) **[0 10]** is the range of time values
c) **[2;-1]** is the initial condition
d) [**t,x]** is the solution. **t** stores the time values while **x** stores the solution where column 1 is x(1), etc.

5. You can now plot the solutions. For instance,

```
>> plot(t,x(:,1))
```

will plot the first column of x.

6. **Additional tips:** you can also pass parameters (either scalar of matrix). For instance, suppose you want to simulate the matrix equation: dx/dt = Ax. The you can use the general function:

```
function    dx = lindiff(t,x,A)

   dx = A*x;
```

Suppose further, we have define matrix A to be

```
>> A = [-3 4 0;0 -1 2;3 3 -6];
```

with intial condition vector

```
>> x0 =[ -1 ; 2 ;0.5 ];
```

then use the following command:

```
>> [t,x]=ode45(@lindiff,[0 100],x0,[],A);
```

Note:
the **'[]'** between **x0** and **A** is required as a placeholder for different options. (See help for other options.)