**Class 27** – **ODEs Adaptive and Stiff (Chp. 23)**

ChE310\_Sec1\_S2019 / 12.3.19

<http://www.reuelgroup.org/numerical-methods-che-310.html>

Announcements:

* Class project due 12.10 for demo!
* Dec 3 – Recorded Lecture (Reuel flying to Boston)
* Dec 5 – Prof. Roling practice of ODE
* Final is Dec. 19 from 7:30 to 9:30 AM

**Warm Up Group Activity:** (practice)

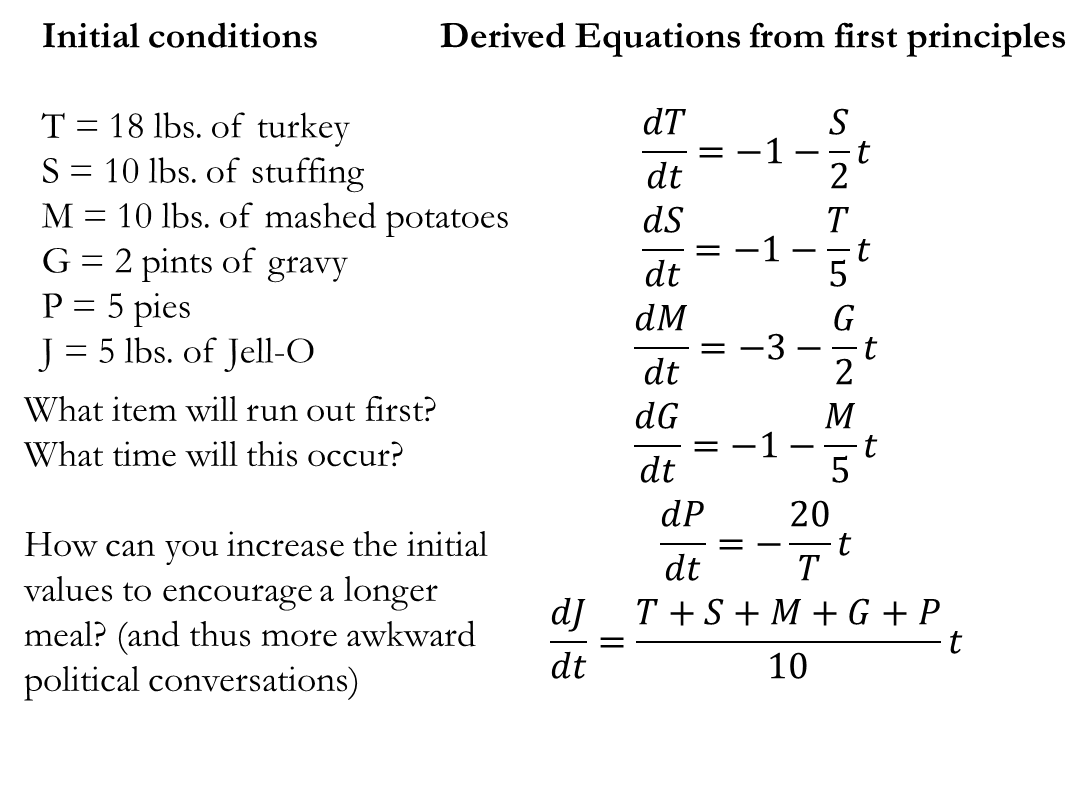
Solve the following ODE and plot solutions with:

1. Analytical method
2. Using a 2nd order RK method of your choice
3. Using the 4th order RK method

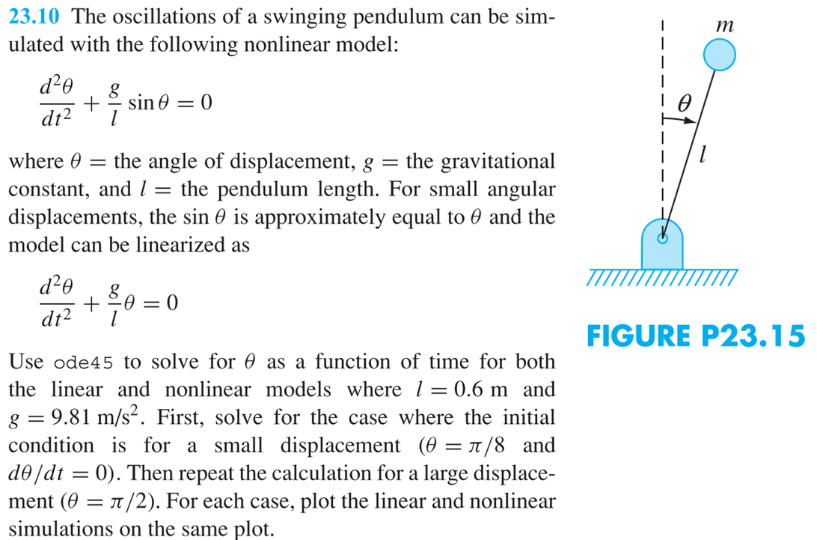
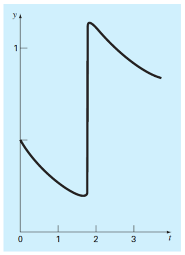
 y(0) = 1

**Outline for Class 27 Lecture**

1. Review of ODEs – what are they? Why do we care?
2. Review on systems of ODEs



1. Example with 2nd Order ODE – Problem 23.10



1. Adaptive Methods

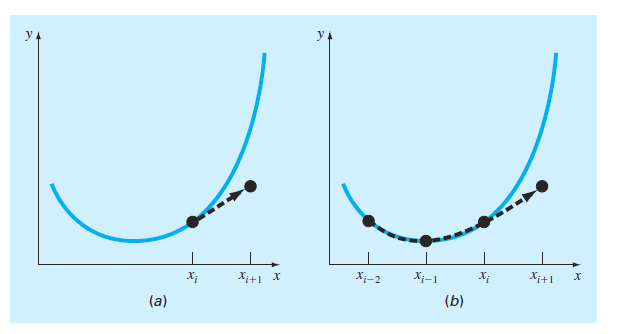
Useful when the rate equations have abrupt changes.

This can be done in two ways:

1. *Step-Halving –* evaluate at full step and at half the step distance. Evaluate difference. If significant adjust step size.
2. *Embedded Methods (a.k.a. Fehlberg methods)* – error estimated from full step size evaluated at two different order RK methods

Example: BS23 algorithm (Bogacki and Shampine)

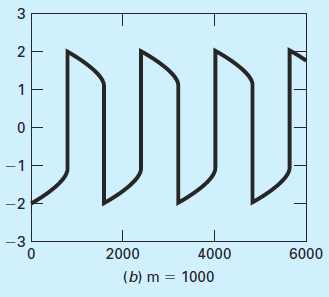
1. Multistep methods - Retain information from previously solved points and use to inform on curvature to make better prediction of next points. There is a built in ODE function from matlab that is multistep (**ode113**)



1. Stiff Problems

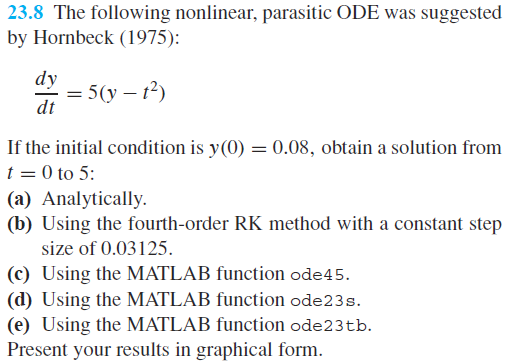
“A stiff system is one involving rapidly changing components together with slowly changing ones. In some cases, the rapidly varying components are ephemeral transients that die away quickly, after which the solution becomes dominated by the slowly varying components.” – Chapra

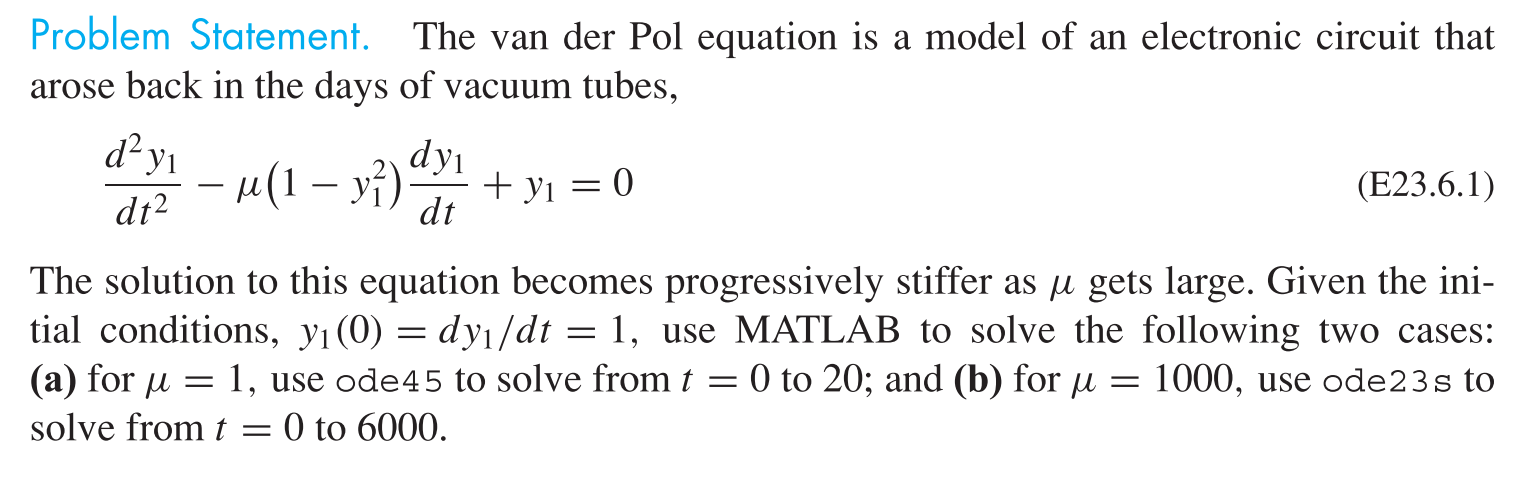
* They can be a single equation or a system of eqns.
* Apparent when there are sharp transitions when plotting the dependent variables. Solve with implicit (backward step) methods.
* Matlab built in functions – **ode15s** and **ode23s**



Order to attempt: **ode45** 🡪 **ode15s** 🡪 **rk4sys** 🡪 **ode113**

1. Examples





Fogler problems: 6.7 and 6.10