Welcome to Automotive Vehicle Dynamics!

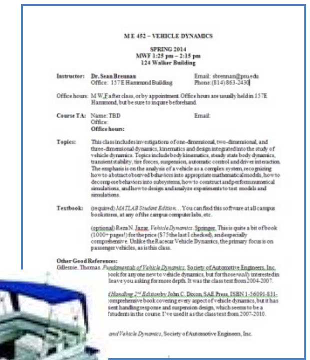
Lecture 01

Sean Brennan, sbrennan@psu.edu
Department of Mechanical Engineering
Penn State University

That's Dr. B doing a demonstration for the Vehicle Dynamics course, Spring 2008!

There are 3 goals of this first lecture

1. Define the course goals and methods
2. Define what vehicles means (to us)
3. Define what dynamics means (to us)



M E 452 – VEHICLE DYNAMICS

SPRING 2014
MWF 1:25 pm – 2:15 pm
124 Walker Building

Instructor: **Dr. Sean Brennan** Email: sbrennan@psu.edu
Office: 157E Hammond Building Phone: (814) 863-2430

Office hours: M,W,F after class, or by appointment. Office hours are usually held in 157E Hammond, but be sure to inquire beforehand.

Course TA: Name: TBD Email:
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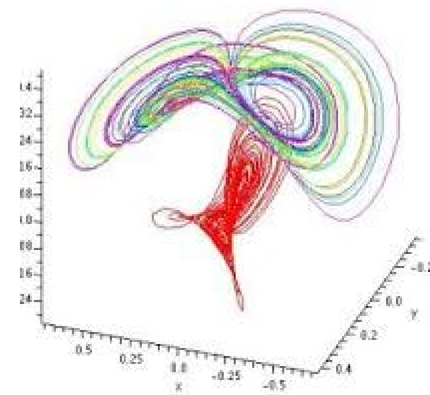
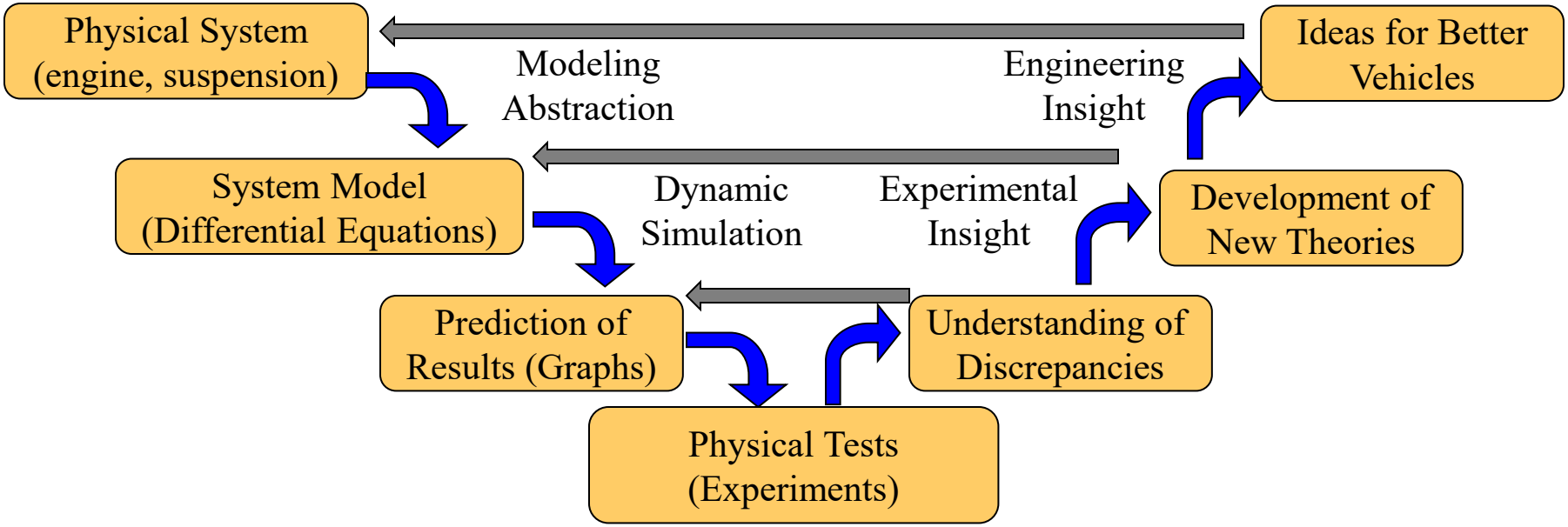


Our main course goal is the modeling, simulation, and analysis of the dynamics of road vehicles

The difference between engineering and technicians: engineers predict, technicians confirm.
Both approaches are necessary!

We are going to follow the "design V" methodology

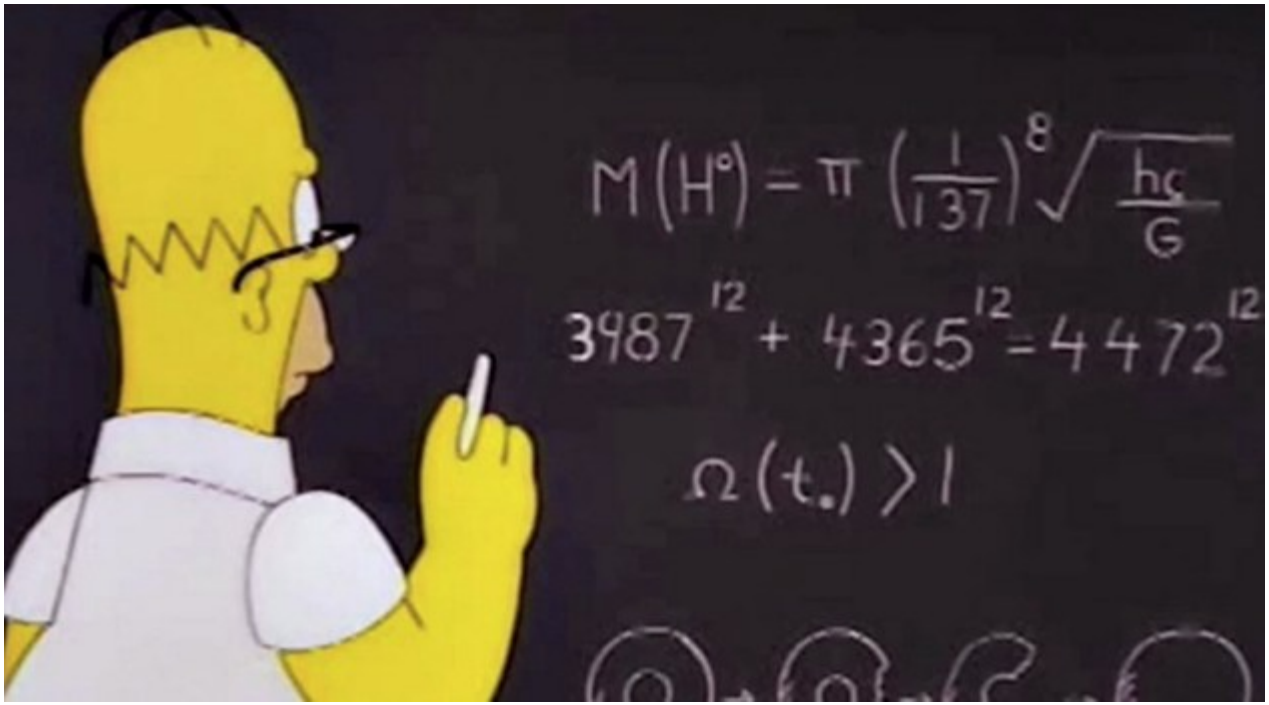


There are some things this class is NOT

- It is NOT a dynamics class:
  This is a great class to solidify your ability to apply standard *System Dynamics* analysis tools, but these are assumed to be familiar to the student
- It is NOT a programming class:
  Programming should be familiar to you now, and if it isn't, it soon will be. We'll use *MATLAB quite a bit.*
- It is NOT a math class:
  The student should be comfortable with the use of *Ordinary Differential Equations, especially eigenvalues*

We will use ODE's to determine dynamic Equations of Motion

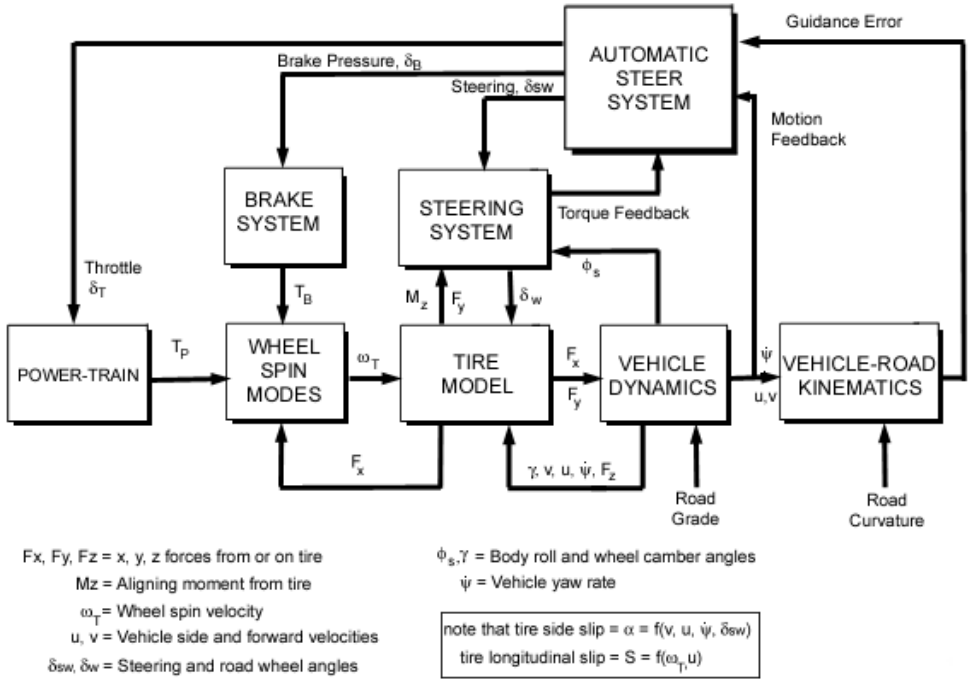
But why use math? Math is hard…



More on why in the next lecture!

Screenshot: Huffington Post/Fox

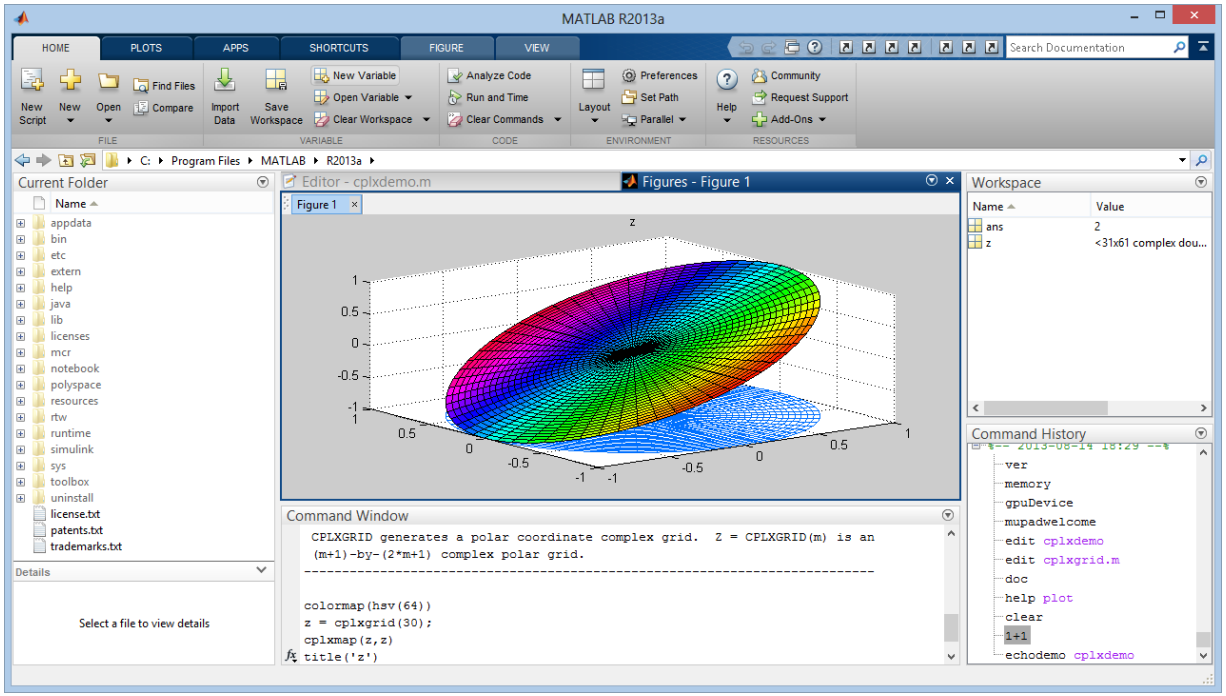
We will focus on module-by-module development



Ground vehicles are a perfect system to teach you how to decompose a problem.

Image from http://www.systemstech.com/content/view/32/39/ Image added: 10/08

We will utilize numerical simulation tools and techniques to determine the solution to the equation of motion



From
http://en.wikipedia.org/wiki/MATLAB

Make sure you have access to MATLAB, and feel free to bring your laptops to class.

There are lots of ways to break down a vehicle

We will develop dynamic models involving

- Tires
- Suspensions
- Planar Vehicle Motion
- Longitudinal Vehicle Motion
- Your choice (Drivers, Automation, Powertrain)

Now let us decide on what a vehicle means to us (this class)

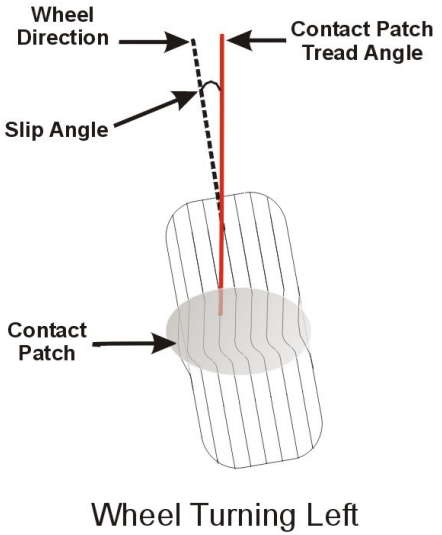
It is sometimes unclear whether something actually is a vehicle!

http://www.ubergizmo.com/2013/04/hyundai-unveils-e4u-concept-personal-vehicle/

I think we'll all agree about some vehicles

But where do we draw the line?

Our definition of a vehicle requires us to define how objects interact with the world



Wheel Turning Left

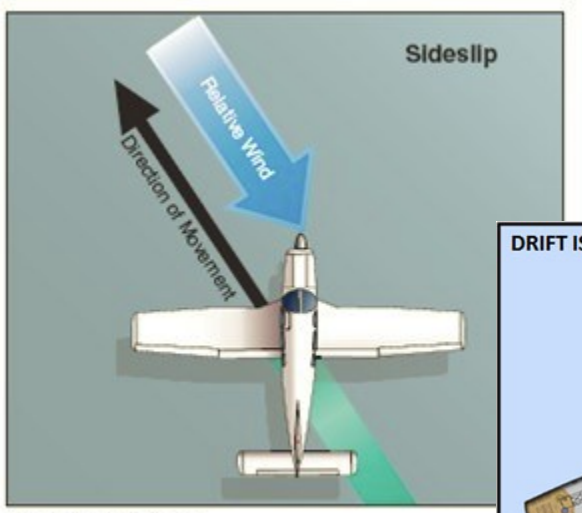
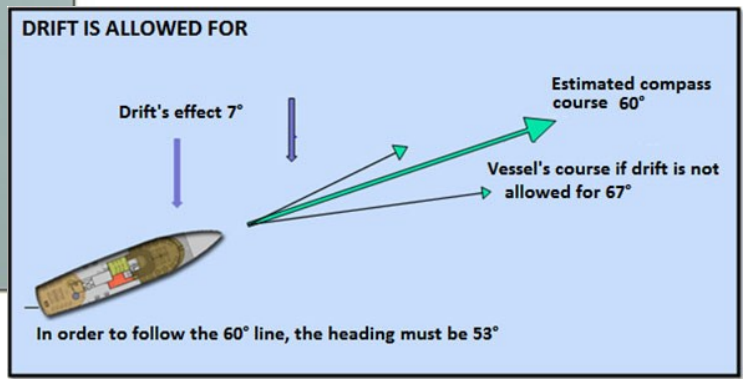


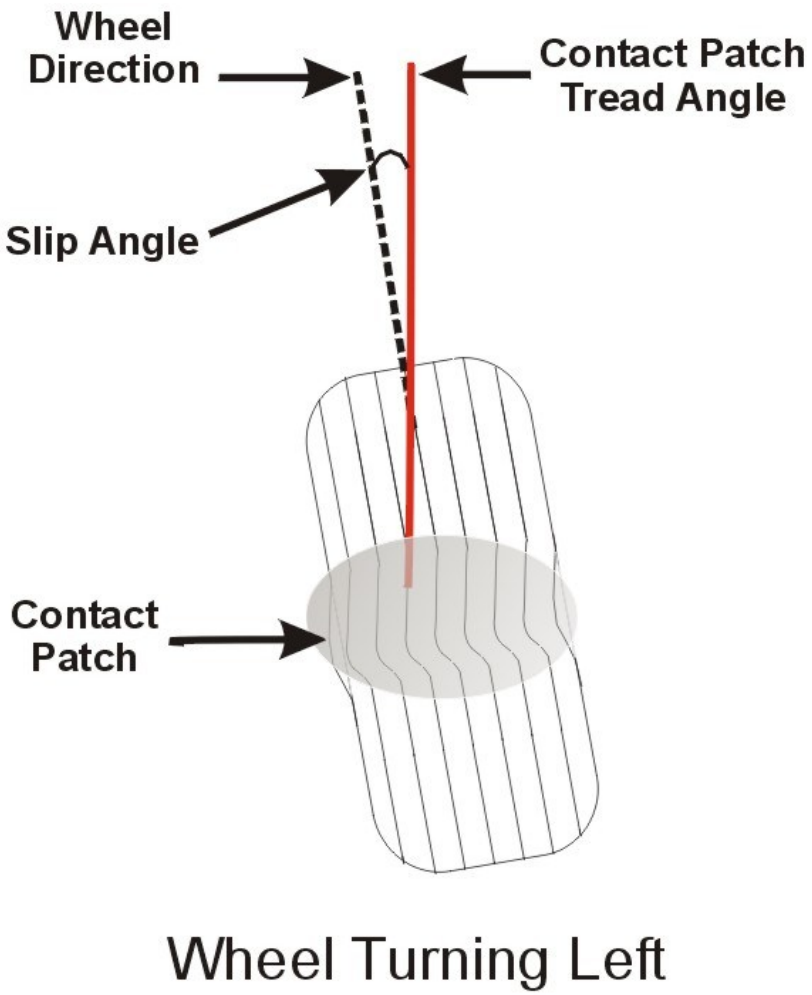
Figure 8-12. Sideslip.



In our class, for something to be a vehicle, SLIP must occur in the vehicle/world interaction.

What is slip?

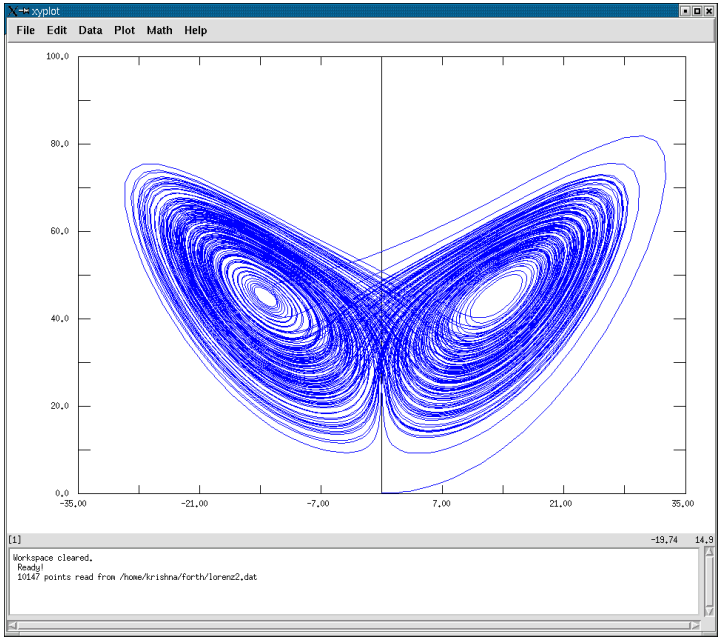
It is when a difference between the orientation of the object to the local velocity vector causes a local force

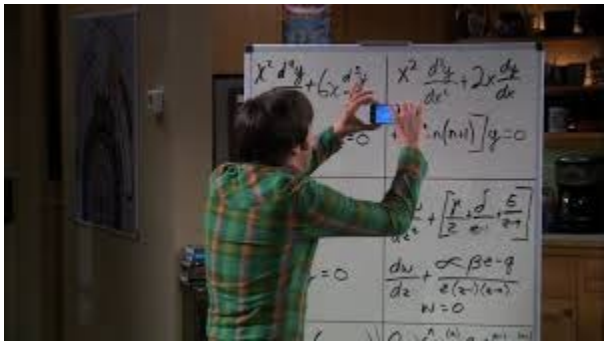


That last slide was important, so let's do a quick review!

Which of the following are vehicles according to this class?

So what are dynamics? (to us)





$$\frac{d^2y}{dt^2} + 2\frac{dy}{dt} + 7y = 4u$$

Dynamics are often presented as scary equations or plots, but they are really just a fancy way of saying "memory" – something in the past that affects the present.

If you don't believe dynamics (e.g. derivatives) equals memory…

Recall how a derivative is defined

Assume $\frac{\mathrm{d}y}{\mathrm{d}t} = f(t, y)$

Integrate both sides $y(t_{k+1}) - y(t_k) = \int_{t_k}^{t_{k+1}} f(t, y(t))\,\mathrm{d}t.$

Assuming the dt interval is small enough that f(t) is approximately constant, we get:

$$y(t_{k+1}) - y(t_k) \approx h f(t_{k+1}, y(t_{k+1})).$$

So which one of these terms is "memory" relative to behavior predictions at time k+1?

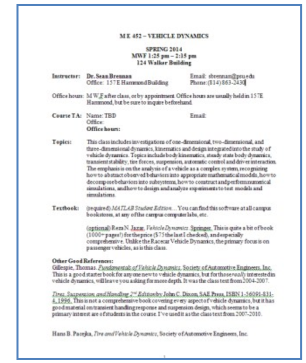
Let's do a demo to show you that more dynamics = more memory

More derivatives in a differential equation mean more dynamics, and thus more memory. We call the level of memory the "order" of the system.

To show this, let's simulate the unit step response of the following system for different values of n, for 10 seconds of simulation:

$$\frac{Y(s)}{U(s)} = \frac{1}{(s+1)^n}$$

In summary



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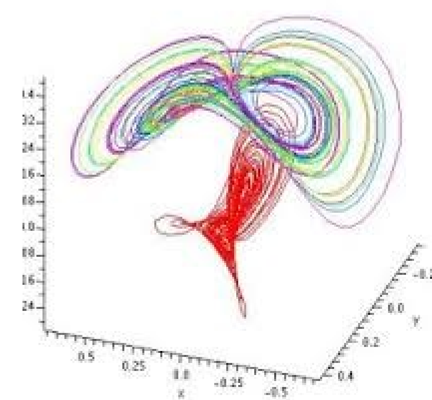
   be engineers, not techs

2. Define what vehicles means –
   they mean slip

3. Define what dynamics means –

   dynamics = memory



Upcoming homework (#2):

Do the simulations yourself in Simulink to show the plots of :

$$\frac{Y(s)}{U(s)} = \frac{1}{(s+1)^n}$$

Plot the results for n = 1, n = 2, n=3, on the same plot, with a legend that is your first, middle, and last name respectively. Turn in this plot with your Simulink diagram. So that I know the diagram is yours, put a comment in the diagram that has your name in it, and your favorite joke! (bonus for good vehicle jokes)

Thanks!

Dr. B with his dad, Christmas 2014

Sean Brennan
Department of Mechanical and Nuclear Engineering
Penn State University
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