Possible Prelab Questions.

1) Read the lab manual before lab begins.
2) Watch https://youtu.be/qFjw6Lc6J2g?t=5m (If you are having trouble with the link you can search for: “Youtube Smarter Every Day 131” and all of the video is good, but we are focused on the material from the 5 minute mark onwards.)
3) What does a “hohmann transfer” have to do with the lab we will be doing?

Lab 7
Gravity

Since it is rather difficult to physically play with gravitational forces, we will use a simple gravity simulator provided by the University of Colorado:
http://phet.colorado.edu/sims/my-solar-system/my-solar-system_en.html

The easiest way to get there is to type: phet.colorado.edu into the address bar of your favorite browser.
Click "Play with sims…>"
In the left column click "Physics"
In the left column click "Motion"
Scroll down a bit and in the center of the screen click "My Solar System"
Click "Run Now!"

As you complete each of the tasks assigned invite the instructor to review your results before you move on.

First familiarize yourself with the equipment. Most buttons should be self-explanatory, however**, you may only adjust the mass/position/velocity immediately after hitting the "Reset" button**. You can check the current position and velocity of a planet by pressing the stop button and then placing the mouse on the planet.

Important: The "system centered" box does not force the Center of Mass to be in the center, however it does force the Velocity of the center of mass to be zero. If this does not make sense, create a large "star" and a small planet and give the Large star a velocity and the small planet no velocity and see what happens when it is "System Centered" and not system Centered.

Task 0: The Sun moves?!

When you first start the simulator, you are immediately shown a star and a planet (if you have been playing with the buttons you can return to the setup I am referring to by clicking the drop down menu and selecting "Sun and planet". If you press the Start button the planet will orbit the star and the path of both objects will be traced out. **Why does the Sun move? What is it that the Sun is going around?** (You can make the Sun's motion more apparent by increasing the mass of the "planet." Why does this work?)

Task 1: Units

Under the help button it says that distance mass and velocity are in arbitrary units. To use any of our references from the book we need the value of G in these arbitrary units. I would suggest measuring a change in potential energy and Kinetic Energy might be very helpful.

Our book mentions that the gravitational potential energy associated with Gravity is $U = -\frac{GMm}{r}$.

So create a star and a planet **both at rest** that are separated by some "large" distance (if you want your life to be easier make sure the separation is purely in the x direction OR purely in the y direction). By doing this you can easily calculate everything in the starting potential energy except the big G. Since the two objects are not moving, this starting potential energy is our TOTAL Energy.

Hit "Start" and then hit "Stop" before they collide. If you put the mouse on the large star you can see its position and velocity. Similarly, you can put the mouse on the small mass and see its mass and velocity. Therefore, you can calculate a new potential energy (except G is still unknown) and the kinetic energies for the two masses. If we add the (negative) potential energy to the (positive) Kinetic energies, we must have the same total Energy as when we started. Therefore we can solve for G.
Researcher: explain the formulas used to solve for G.
DA: record the data needed to find the solution.
PI: make sure that you communicate that G is one of the main results of this lab (but this value is only good for this computer simulation. It will not match the value in your textbook).

Task 2: Two body Systems

Set up a situation where a planet is in a significantly elliptical orbit around a star. Compare the motion of the planet at apastron (farthest from the star) to periastron (closest to the star). Why is there a significant speed difference?

Researcher: Explain using either Impulse or Work how the speed of the planet increases as it approaches the star.
DA: record relavent data about the planet and star at apastron and periastron.
PI: Let's assume our "planet" is instead a spaceship that has an orbit of high eccentricity, **how should you fire your thrusters to make the orbit more circular? Does it matter where you are in the orbit? Specifically, what should you do in apastron and periastron?**

Task 3: Moons
Now let's look at something quite different.

From the drop down menu, select “Sun, planet, moon.” Also, please turn OFF the “Show Grid” and “Show Traces” boxes.
Please describe the motion of the moon?

Just for fun, let’s turn “Show traces” back on**. Now, describe the motion of the moon?**

How does the trace of the moon’s path make a difference to its motion? **Or how does the trace of the moon’s path make a difference to our interpretation of its motion?**

Task 4: Many bodies

It turns out that as soon as you have more than two objects in your solar system it become impossible to predict the motion arbitrarily far into the future. In fact, the best you can do is get a strong computer to numerically try to figure out what happens next. However because computers only have a limited amount of memory, they must round their answers, which eventually lead to incorrect results.

Go to the “Select Preset” and start the “Four Star Ballet.” Notice that there is a high degree of symmetry in the initial setting for this four body system. After watching “Four Star Ballet” for 20 seconds or so, hit the reset button and adjust any one initial parameter by just a little bit $\approx 1\%$. How does the resulting motion change?

Thinking about previous “Instability”, will our solar system go spiraling out of control? Play with the simulator, and try to find what conditions allow stable orbit rather than unstable orbits. Why is the “double double” stable but the “four star ballet” is not?

Make sure you look at the “slingshots” and the “double double” Just because they are fun simulations.