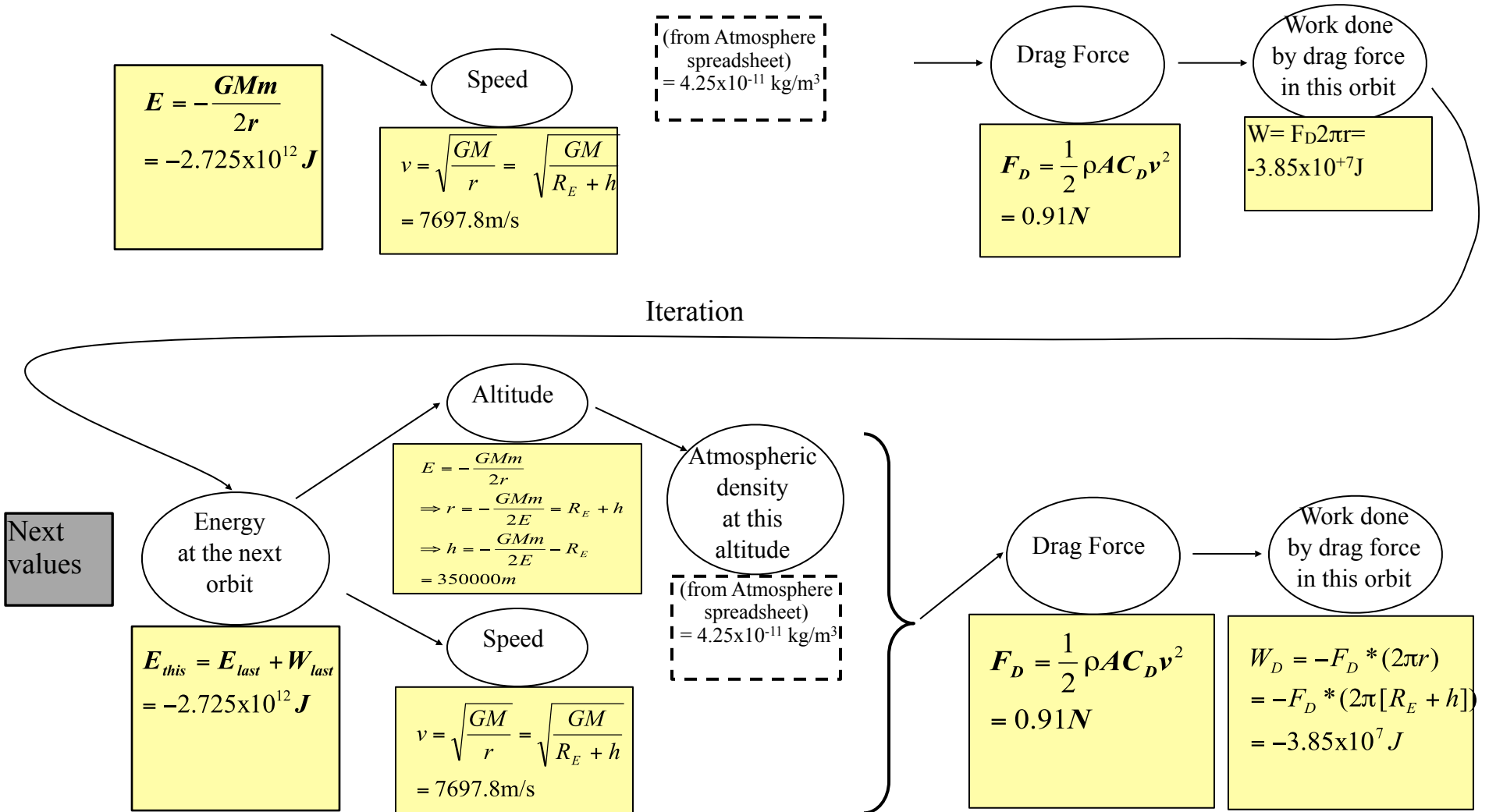


Orbital Drag Laboratory Concept Map Worksheet



ANALYSIS

Values at ~102 hours mission time:

	+0% Temperature	+10% Temperature
Altitude	343.3 km	62.9 km
Velocity	7701.6 m/s	7867.7 m/s
Drag	1.04 N	11,472,162 N (!)
Total Energy	-2.728×10¹² J	-2.847×10¹² J

“The Big Picture” Questions to think about:

1. What are the assumptions which limit the utility of the (simple) Law of Atmospheres? How did we improve on this by using the MSIS model?

- g is assumed to be constant (it actually varies with height)
- T is assumed to be constant (it actually varies with height)
- m is assumed to be constant (it actually varies with height)

The MSIS model allows each of these to vary with height, as they should. This provides much more accurate values for the mass density as a function of altitude (as the graphs show.)

2. What happens to the atmosphere as it heats up?

It expands. At a given altitude, there will be a greater amount of atmospheric ‘stuff’ when there are higher temperatures. (This means the shuttle runs into more atmosphere when the temperature is higher, so loses energy more rapidly under those conditions.)

3. What parameters affect the duration of a shuttle mission?

Atmospheric temperature (which governs the amount of atmospheric ‘stuff’ at a given altitude). Also, the initial altitude, the mass of the shuttle, and the surface area of the shuttle.

4. What happens to the energy (total mechanical, kinetic, and potential) of a satellite as it experiences atmospheric drag?

Drag causes the satellite to LOSE energy. This means its total energy becomes more negative. Because it is lower, it has a lower potential energy (more negative). Because it is closer to the Earth, its speed is greater, so its kinetic energy is greater. (Recall $E = U/2 = -K.$)

5. Why was an iterative technique required in this lab to calculate shuttle altitude?

For each orbit, we calculated the amount of energy the shuttle would lose (because of drag) and from that, calculated the total energy of the shuttle for the next orbit. We had to do this one orbit at a time because the amount of atmospheric ‘stuff’ and speed of the shuttle change with each orbit.

6. What process did you use to model the orbital decay? (Write a summary in a few sentences that outlines the steps.)

The key was finding the orbital energy for each orbit. To obtain each new orbit’s energy, we took the energy at the start of the previous orbit and subtracted the energy lost during that orbit. The amount of energy the shuttle lost (because of drag) was the work done by the drag force, which was just $(\text{force})(\text{distance around one orbit})$. The drag force at a given altitude depended on the atmospheric mass density (which we looked up from the Atmosphere spreadsheet) and the speed of the shuttle at that orbit (which we calculated) and other constants. Each time we found a new orbit’s energy, we found the corresponding altitude for that orbit, and the process continued orbit by orbit.