Please answer the questions below to the best of your ability either in the space provided. Everything should be scanned or photographed and submitted through gradescope.com. Pictures of your code, simulation or plots would help a lot in giving partial credit on this assignment!

Objective: *I can predict changes in thermal energy and temperature originating from dissipative forces.*

1. When satellites or rockets re-enter the Earth's atmosphere, they must utilize protection to ensure that they don't burn up due to the frictional heating of the atmospheric air drag. Consider a situation where a rocket is located 400 km above the surface of the Earth in the positive x-direction. The 5000 kg rocket has an initial velocity of $\langle 0, 0, 7500 \rangle$ m/s. For convenience sake, you can approximate the shape of the rocket to be spherical with a radius of 5 m, and the Earth has a mass of 5.97×10^{24} kg and a radius of 6371 km.

(6) (a) Spherical objects have a drag coefficient of 0.47. The trickier problem is that the density of the atmosphere decreases as you head up into space. The density can be given as

$$\rho = (1.3\,\text{kg/m}^3) \exp\left(\frac{-y}{10\,000\,\text{m}}\right)$$

where y is the height *above the Earth's surface*. Using this information and a time step of 2 s, determine the final position (x, y, and z) of the rocket when it strikes the surface of the Earth.

(6) (b) This drag force is going to do work on the rocket during its descent that will raise the thermal energy of the rocket. Technically, not *all* of the work will heat just the rocket, much of it will heat the surrounding air itself. Not knowing the exact proportions, say 50% of the work done goes into the heating the rocket itself. Assuming the rocket is made from steel with a specific heat of $4900\,\mathrm{J\,K/kg}$, plot the temperature of the rocket throughout its journey. You can assume the rocket starts at a chilly $-270\,^{\circ}\mathrm{C}$. *(Some Hints: Glowscript has a "dot" function that can take dot products for you. And to get the total work done by a changing force, you just want to add up the work done over each little segment.)*

(1) (c) Look up the approximate melting point of steel. Will the rocket still be solid upon reaching the surface of the Earth?