MESA Long Problem #1

This lab concerns the evolution of white dwarfs at "late" times, after they have spent billions of years cooling and have temperatures of 5000 K or less.

1. Use the provided inlist file (`inlist_cool`) to evolve the pre-computed model `0.611_from_2.5_z2m2.mod` in `mesa/data/star_data/white_dwarf_models` down to 10,000 K; Set the atmosphere option to `grey_and_kap`.

   Initially start MESA with diffusion turned on, but around 50,000 K stop the run, turn off diffusion, and restart the run (`re`). Continue evolving down to the target of 10,000 K. Save the final model as `wd_cool.mod`.

2. Restart MESA using the saved model `wd_cool.mod` and evolve it down to $T_{\rm eff} = 2900$ K or as cool as it will go. Save the `star.log` file as `star_grey_and_kap.log`.

3. Now change the atmosphere option to `WD_tau_25_tables` and rerun MESA using the saved model `wd_cool.mod`, again evolving down to cool temperatures. This time save the `star.log` file as `star_atm.log`.

4. Plot $\log t$ (yrs) versus $T_{\rm eff}$ on the same plot. If you want to be super fancy, you can interpolate one curve onto the x values of the other curve so that you can subtract the two y values and plot the difference in ages, as a function of $T_{\rm eff}$?

5. Where do the two curves start to diverge?

6. a) At 5500 K which curve is older?
   b) At 4000 K which curve is older?

7. At this point you can either continue on to the next item and plot the "cooling function" OR choose a different input model from `~/mesa/data/star_data/white_dwarf_models/`. If you choose to evolve a new model, then "randomly" pick from the models matching the pattern `*from*mod`, e.g., `0.927_from_6.0_z2m2.mod`. You will need to turn off diffusion at a different temperature, and you may need to adjust `mesh_delta_coeff` to get it to initially converge. One model I ran needed the value *increased* from 0.75 to 2.0 to run successfully. If, after much troubleshooting, you are unable to get it to run, please let me know the error message you get.

8. If you have time, plot the "cooling function" for the model with the atmosphere tables. That is, plot $\log \Phi \equiv \log |d \log L/dt|^{-1}$ versus $\log L_\star/L_\odot$. The derivative can be calculated just by differencing adjacent models in the `star.log` file.