# MESA Workshop 1

**Introduction to Astrophysics**

**February 13, 2015**

This MESA workshop has several goals:

1. To make you familiar with Linux, MESA and python
2. To investigate the mass luminosity relationship (see Fig. 3.2 in the text book), and the relationship between luminosity and temperature, and mass and hydrogen burning time.
3. To investigate the existence of convection in Main Sequence Stars

**Technical details/Instructions:**

1. *Connecting to a computer that can run MESA*

We will run MESA on the computers in the CS lab. Because two CS classes possibly meet in the lab room itself, we will connect to these computers remotely. To do that, download the file mesa.zip from blackboard, unpack it to your k-drive (you should now get a file called mesa.bat) and double click on it. The first time you will get several warnings; just cancel them and you will be able to proceed. The batch script will connect you to the CS lab computer that has the same number as your astrolab computer (so astrolab01 will connect to cslab01). You need to login with your cslab account and your wheaton password.

1. *Setting the Paths and Environment*  
   Before you can do anything, you need to tell your operating system where it can find MESA and other programs that you need. To do this, you want to put something in your .bashrc file in the home directory. Open your .bashrc file with the command nano ~/.bashrc, scroll to the bottom and add the following line:   
   source /cslab/course/phys367/mesa.init to your .bashrc file. To get running now, either log out (and in again) or give the same command on the command line.
2. *Make a working directory for this class*  
   Once you set your environment you want to make a directory for this class. To do that, give the command mkdir phys367. This will make a directory with our class name in your home directory. To enter that directory type cd phys367.

**Instructions for MESA**

MESA is the stellar evolution code that I use for my research and that we will be using in this class to study the structure, evolution and final fate of stars. It is a very versatile code with lots of options to customize models and settings, and we won’t have time to explore all of them (I even haven’t for my research). If you want to know more about MESA go to the MESA website, resource site, or check out the two instrument papers.

* <http://mesa.sourceforge.net/>
* <http://mesastar.org/>
* <http://adsabs.harvard.edu/abs/2011ApJS..192....3P> (Paper I)
* <http://adsabs.harvard.edu/abs/2013ApJS..208....4P> (Paper II)

MESA is installed on all cslab computers and can be run from anywhere on the cslab infrastructure. I would advise, however, to make a dedicated directory for this class (see step 3 above) and do all your work there.

**Running MESA**

1. For every model that you run you have to create a separate directory. To do this give the following commands:  
   cp –r /cslab/class/phys367/work . (this copies a model directory from the main class directory over to your class directory.  
   mv work something\_descriptive (this renames your model directory to a new descriptive name, like 2.5Msun for a 2.5 solar mass model)
2. Enter the newly created directory by typing   
   cd something\_descriptive
3. *A look in our work directory: Important files*To see what is in the directory, type ls (this gives you a listing of files, directories and executables). For our purposes, the most important directory is “LOGS” where all the data from our models are going to be stored. The other important file is inlist\_project where all the parameters for the model are defined (the knobs that tune the model)
4. *Make executable*  
   To make an executable type now ./mk. This will compile the code, link it with the main code in our main class directory and create an executable file named star in our directory.
5. *Set the parameters for the run*  
   There are many parameters that you can set, but for this exercise we will only change the mass of the model. Open the file inlist\_project by giving the command nano inlist\_project. This will open the file so that you can make changes. Move the cursor several lines down until you see the lines:  
   ! starting specifications

initial\_mass = 1 ! in Msun units   
Change the initial\_mass parameter to whatever you want. Save the file with the keystroke Control-O.

1. Run the model  
   Run the model by typing ./rn on the command line. It will show you screen output and also two graphs will pop up with information about the model. The model will only run through the Main Sequence (burning hydrogen into helium) and will terminate when the hydrogen abundance is below 0.001 (see also inlist\_project)

Once your model is finished running, you can inspect it with python.

For instructions on analyzing the model that you just ran, goto the ipython notebook viewer (<http://bit.ly/1vIEva8>)

**Assignment:**

1. Go to the google spreadsheet and claim a mass. (http://bit.ly/1AjFU8Y)
2. Look at your screen output. Take a model where the hydrogen abundance (shown in the column H\_cntr) is still close to 0.7. What is the mass, the luminosity and the temperature of the model? Write these down.
3. Look at the last model of your run. What is the age of the model. Write that down as well.
4. Analyze your model with ipython. What are the locations of the convective boundaries?
5. Go to the google spreadsheet and fill in your numbers.
6. If you have time left over, do the same for a different mass.