

1. The Sun is often modeled using an  $n = 3$  polytrope model. Here, we will compute an interior model for the Sun using an  $n = 3$  polytrope and then compare the results to the output from the Sun-like MESA-Web model you ran a few weeks ago for a previous homework. For all the steps below, recall that Table 19.1 in the handouts gives critical values for the  $n = 3$  polytrope, and that you can divide  $(-z^2 dw/dz)$  by factors of  $z_s$  to compute the necessary derivative terms. You may assume the Sun has  $M = 1.989 \times 10^{33}$  g,  $R = 6.696 \times 10^{10}$  cm, and  $X = 0.7$  and  $Y = 0.3$ .  

15 points

  - (a) Calculate the central pressure at the core of the Sun (in Ba).
  - (b) Calculate the central density at the core of the Sun (in  $\text{g cm}^{-3}$ ).
  - (c) Assuming the Sun is a fully-ionized ideal gas, estimate the central temperature in the Sun's core (in K) using the composition given above.
2. Using *Poly-Web* (<http://user.astro.wisc.edu/~townsend/static.php?ref=poly-web>), create an  $n = 3$  polytrope model using 500 grid points. The output will be a text file with three columns. The three columns are:  $z$ ,  $w(z)$ , and  $dw/dz$ . Using Equation [19.4] and the output from this Poly-Web calculation, create a plot of the Log10 density of the Sun (in  $\text{Log}_{10}[\text{g cm}^{-3}]$ ) as a function of radius  $r$ , where  $r = 1$  corresponds to the Solar surface. Recall that  $z/z_s = r/R$ .  

5 points
3. Use either the Sun-like *MESA-Web* model you created a few weeks ago, or create a new model using the defaults on the *MESA-Web* submission page (<http://user.astro.wisc.edu/~townsend/static.php?ref=mesa-web-submit>). The profile with a model stellar age close to the Sun's 4.5 Gyr should be `profile8.dat`. Read in the columns for radius and  $\log(\rho)$  from this file and overplot them on your polytrope solution above. Submit this combined plot with your homework. Briefly comment on the agreement (or not) of the  $n = 3$  polytrope and the full *MESA* model. Is there a radius where the predicted density of two models diverge? What do you hypothesize is the cause of this divergence?  

5 points