# Level 2 Stars, Workshop 6

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## *1. Convection*

a) What causes convection in stars? Draw cross sections through both a low mass (~1 solar mass) and high mass (~8 solar mass) main-sequence star to highlight the regions where convection is believed to occur in these stars. Why does convection occur in each of these regions?

b) Briefly describe the mixing-length theory of convection.

c) Calculate the radial extent ($\ell$) of the convection cells at the surface of the Sun using the following equation $\ell = \alpha H_P$, where the scale height ($H_p$) satisfies $\frac{1}{H_P} = -\frac{1}{P}\frac{dP}{dr}$ and $\alpha$ is a scaling factor. In your calculation assume that the pressure at the surface of the Sun is $P$=$10^{13}$ N m$^{-2}$ and that the density is equal to the average density of the Sun. State a likely value of $\alpha$ and briefly justify the value you have given.

## *2. Pulsating Stars*

a) What property of Cepheid variables makes them extremely useful in estimating the distances to other galaxies?

b) Using a simple model of constant density and the adiabatic sound speed, show that the period of a radially oscillating star is given by

$$\Pi \approx \sqrt{\frac{3\pi}{2\gamma G\rho}},$$

where $\Pi$ is the period, $\gamma$ is the ratio of specific heats and $\rho$ is the density. State any assumptions you make. You may use the standard integral

$$\int_0^R \frac{dr}{\sqrt{\left(R^2 - r^2\right)}} = \left[\sin^{-1}\left(\frac{r}{R}\right)\right]_0^R.$$

c) A 2 solar mass RR Lyrae variable star has an observed pulsation period of 5.0 hrs, a surface temperature of 7500 K, and $\gamma$=5/3. What is its luminosity?

d) Given, from part b, that $\Pi \approx \sqrt{\frac{3\pi}{2\gamma G\rho}}$, also demonstrate that $\Pi \propto L^{3/4}$.

[$\sigma$=5.67 × $10^{-8}$ W m$^{-2}$ K$^{-4}$; $M_\odot$ = 1.99 x $10^{30}$ kg]