timescales

Before we derive the equations of stellar structure, there are three important timescales which must first be defined. These follow from a consideration of the forces acting in stars and the thermal properties of stars:

1. **dynamical timescale (t_d)**
   If the gravitational and pressure forces are seriously out of balance, the star contracts or expands significantly in a time t_d. If the pressure gradient of solar material were not present, the radius of the Sun would change significantly in less than an hour. We will derive an expression for the dynamical timescale of a star later.

2. **thermal (or Kelvin-Helmholtz) timescale (t_{th})**
   The ratio of the total thermal energy of a star to the rate of energy loss from its surface is called the thermal timescale, t_{th}.

   The thermal timescale is the time for which the Sun can supply its radiation by cooling down, i.e. it measures the rate at which the heat content of the star is being used up. As we shall see later, this timescale is equal (to within a factor of 2, which is insignificant in this discussion) to the time for which the Sun can maintain its present rate of radiation through the release of gravitational potential energy, i.e. by contracting.

   The thermal timescale for the Sun is about 30 million years.

3. **nuclear timescale (t_n)**
   The total nuclear energy resources of a star divided by the rate of energy loss is called the nuclear timescale, t_n. The nuclear timescale for the Sun is around 10^{10} years.

Hence, for most stars at most stages in their evolution, the following inequalities are true:

$$t_d << t_{th} << t_n.$$

These inequalities enable some important approximations to be made when working with the equations of stellar structure.