EART290Q 2020

PROBLEM SET #1 – due Friday 31st Jan

1. I want you to write a simple 1D, spherical thermal conduction code including exponentially-decaying heat production and make two plots. The first is temperature vs radial position inside an asteroid, at different times: 0.5, 1, 1.5, 2.5, 5 and 10 Myr. The second is to plot the central temperature as a function of time. This second plot should be compared with the analytical solution from Carslaw & Jaeger, Section 9.8:

$$T(t) = \frac{\kappa H_0}{k\lambda} e^{-\lambda t} \left[\frac{a(\frac{\lambda}{\kappa})^{1/2}}{\sin[a(\frac{\lambda}{\kappa})^{1/2}]} - 1 \right] + \frac{2a^2 H_0}{\pi^2 k} \sum_{n=1}^{\infty} \frac{(-1)^n}{(n^2 - \frac{\lambda a^2}{\pi^2 \kappa})} e^{-\frac{\kappa n^2 \pi^2}{a^2} t}$$

The relevant parameters are: a=30 km, κ=10^{-6} m^2s^{-1}, C_p=10^3 J kg^{-1} K^{-1}. The heat production rate is $H_0e^{-\lambda t}$ where H_0=6.28x10^{-8} Wkg^{-1} and λ=3.14x10^{-14} s^{-1}. Density is 3000 kgm^{-3} and you can take the initial/surface temperature to be 200 K.