

UNIVERSITY OF KANSAS
Department of Physics and Astronomy
Astrophysics I (ASTR 691) — Prof. Crossfield — Fall 2026

In-Class Problems 11 [23 pts]

You may use your OoMA Sheet, your handwritten notes, and a scientific or graphing calculator – and you may work in a group. As always, be sure to: show your work, circle or highlight your final answer, list units, use the appropriate number of significant figures, and write your name.

1. **Stellar Interiors: I** You measure the size and mass of a star in an eclipsing binary system to be R_* and M_* , respectively. What are conditions like in its interior?

- (a) Assume (naively) that the star has a constant density ρ_0 . In this case, what is ρ_0 , and what is the density at the star's core, in terms of R_* and M_* ? [3 pts]
- (b) Assume a (slightly) more realistic density profile for $r \leq R_*$,

$$\rho_1(r) = \rho_c \left(1 - \frac{r}{R_*} \right) \quad (1)$$

where density is highest at the core ($\rho_1(r = 0) = \rho_c$), and lowest at the surface. Calculate the enclosed mass profile $M_{\text{enc}}(r)$ in terms of ρ_c and R_* . [4 pts]

- (c) Sketch a graph of $M_{\text{enc}}(r)$, over the range $0 \leq r \leq 2R_*$. [3 pts]
- (d) Based on the simple $\rho_1(r)$ density-profile model, calculate the density at the star's core in terms of R_* and M_* . [2 pts]
- (e) Calculate the star's internal gravity profile, $g(r)$ in terms of ρ_c and R_* . [2 pts]
- (f) Sketch a graph of $g(r)$, over the range $0 \leq r \leq 2R_*$. [3 pts]
- (g) At what value of r is the star's gravity field strongest? How does the gravity g at that radius compare to the star's surface gravity? [3 pts]
- (h) For the linear model $\rho_1(r)$, calculate the central density ρ_c and the surface gravity g (all in SI units) for:
 - (i) the Sun; (ii) Jupiter; (iii) the Earth. [3 pts]