SOLUTION SET 5
Physics 2022

1. **The two curves cross at about 20,000 K, which is about at the B3-B4 spectral type.**

2. $L_{rigel} = 1.6\ T_{sun}$ $\quad\quad L_{rigel} = 64{,}000\ L_{sun}$

$L_{rigel} / L_{sun} = (R_{rigel} / R_{sun})^2\ (T_{rigel} / T_{sun})^4$

$(64{,}000) = (R_{rigel} / R_{sun})^2\ (1.6)^4$

$R_{rigel} = 98.8\ R_{sun}$

3. $R_P = 2R_Q$ $\quad\quad T_P = 4000\ K$ $\quad\quad T_Q = 8000\ K$

$L_P / L_Q = (R_P^2 / R_Q^2)\ (T_P^4 / T_Q^4) = (2)^2\ (4000/8000)^4 = 4\ (1/2)^4 = 1/4$

$L_Q = 4\ L_P$

4. $L_X = 12\ L_Y$ $\quad\quad T_X = 3500\ K$ $\quad\quad T_Y = 7800\ K$

$L_X / L_Y = (R_X^2 / R_Y^2)\ (T_X^4 / T_Y^4)$

$(R_X^2 / R_Y^2) = (7800/3500)^4\ (12) = (2.2)^4\ (12) = 296$

$R_X = 17\ R_Y$

5. $L_{star} = 130\ L_{sun}$ $\quad\quad$ B8 therefore $T_{star} \approx 15{,}000\ K$

$L_{star} / L_{sun} = (R_{star} / R_{sun})^2\ (T_{star} / T_{sun})^4$

$(130) = (R_{star} / R_{sun})^2\ (15000 / 5800)^4$

$R_{star} = 1.7\ R_{sun}$

6a. $d = 1/p = 1/0.2 = 5$ pc

6b. $D = d \tan\theta = (5 \text{ pc}) \tan[(4.5 \text{ arcsec})/(3600 \text{ arcsec/deg}]$

$= (5 \text{ pc})(206{,}265 \text{ AU/pc})(2.18 \times 10^{-5}) = 22.5 \text{ AU}$

6c. $(\mathcal{M}_1 + \mathcal{M}_2)\, P^2 = a^3$

$(\mathcal{M}_1 + \mathcal{M}_2) = (22.5)^3 / (87.7)^2 = 1.5$ solar masses

7a. $(\mathcal{M}_1 + \mathcal{M}_2)\, P^2 = a^3$

$(\mathcal{M}_1 + \mathcal{M}_2) = (10)^3 / (5)^2 = 40$ solar masses

7b. $\mathcal{M}_1 / \mathcal{M}_2 = 4.0$ solar masses $\qquad \mathcal{M}_1 = 4.0\, \mathcal{M}_2$

$4.0\, \mathcal{M}_2 + \mathcal{M}_2 = 5.0\, \mathcal{M}_2 = 40$ solar masses

$\mathcal{M}_2 = 8$ solar masses

$\mathcal{M}_1 = 32$ solar masses

8. $(\mathcal{M}_1 + \mathcal{M}_2)\, P^2 = a^3$

$(2 + 2)\; P^2 = (5)^3$

$P^2 = 125 / 4 = 31.25$

$P = 5.59$ yr

9. $(\mathcal{M}_1 + \mathcal{M}_2)\, P^2 = a^3$

$(1.96 + 0.3)\; P^2 = (12{,}000)^3$

$P^2 = (1.728 \times 10^{12}) / 2.26 = 7.646 \times 10^{11}$

$P = 875{,}000$ yr

10. $(\mathcal{M}_1 + \mathcal{M}_2)\, P^2 = a^3$

a) **8 months / 12 months/yr = 0.67 yr**

$(2.0 + 3.5)\,(0.67\ \text{yr})^2 = a^3$

a = CUBE-ROOT{ (5.5)(0.449)} = CUBE-ROOT{ 1.108 } = 1.03 AU

b) 1.25×10^8 **km /** 1.5×10^8 **km/AU = 0.83 AU**

$(0.7 + 0.1)\, P^2 = (0.83\ \text{AU})^3$

P = SQRT[$(0.83\ \text{AU})^3 / 0.8$ **] = SQRT[0.715] = 0.85 yr**

c) **(110 solar radii) (0.004652 AU/solar radii) = 0.51 AU**

$(1.0 + 1.0)\, P^2 = (\ 0.51\ \text{AU}\ )^3$

P = SQRT[$(\ 0.51\ \text{AU})^3 / 2.0$ **] = SQRT[0.066] = 0.26 yr**

d) **48 hr / (24 hr/day x 365.25 day/yr) = 0.005476 yr**

(10 solar radii) (0.004652 AU/solar radii) =0.04652 AU

$(\mathcal{M}_1 + \mathcal{M}_2) = (0.04652\ \text{AU})^3 / (0.005476\ \text{yr})^2 = (1.0067 \times 10^{-4}) / (2.998 \times 10^{-5})$

$(\mathcal{M}_1 + \mathcal{M}_2) =$ **3.36 solar masses**

e) $(1.0 + \mathcal{M}_2)\,(2.5\ \text{yr})^2 = (2.3\ \text{AU})^3$

$(1.0 + \mathcal{M}_2) = (12.167) / (6.25) =$ **1.95 solar masses**

$\mathcal{M}_2 =$ **0.95 solar masses**