Worksheet – Stellar Masses

1. Stars A and B form a binary pair. They are separated by 8 AU and orbit each other in a time of 12 Earth years. What is their combined mass?

$$M_A + M_B = \frac{a^3}{P^2} = \frac{8^3}{12^2} = 3.56 \text{ solar masses}$$

2. Stars C and D form a binary pair. Star C has a mass of 4 solar mass, and star D has a mass of 6 solar masses. If they orbit each other in a time of 10 Earth years. What is their separation?

$$a^3 = (M_C + M_D) P^2 = (4+6) 10^2 = 1{,}000$$
$$a = \sqrt[3]{1000} = 10 \text{ AU}$$

3. Stars E and F form a binary pair. They are separated by 12 AU, and orbit each other in a time of 15 years. If their masses are equal, what are their individual masses?

$$M_E + M_F = \frac{a^3}{P^2} = \frac{12^3}{15^2} = 7.68 \text{ solar masses}$$
$$2 M_E = 7.68 \text{ solar masses}$$
$$M_E = M_F = \frac{7.68}{2} = 3.84 \text{ solar masses}$$

4. Stars G and H form a binary pair. They are separated by 12 AU, and orbit each other in a time of 15 years. If star G has mass 3 times that of star H, what are their individual masses?

$$M_G + M_H = \frac{a^3}{P^2} = \frac{12^3}{15^2} = 7.68 \text{ solar masses}$$
$$3 M_H + M_H = 4 M_H = 7.68 \text{ solar masses}$$
$$M_H = \frac{7.68}{4} = 1.92 \text{ solar masses}$$
$$M_G = 3 M_H = 3 * 1.92 = 5.76 \text{ solar masses}$$

5. Stars J and K form a binary pair, orbiting each other in a time of 8 years. If the orbit of star J has a radius of 12 AU, and the orbit of star K is 8 AU, what are their individual masses?

$$a = a_J + a_K = 12 + 8 = 20 \text{ AU}$$

$$M_J + M_K = \frac{a^3}{P^2} = \frac{20^3}{8^2} = 125 \text{ solar masses}$$

$$\frac{M_J}{M_K} = \frac{a_K}{a_J} = \frac{8}{12} = \frac{2}{3} \quad \text{and so} \quad M_J = \frac{2}{3} M_K$$

$$\frac{2}{3} M_K + M_K = \frac{5}{3} M_K = 125 \text{ solar masses}$$

$$M_K = \frac{3}{5} * 125 = 75 \text{ solar masses}$$

$$M_J = \frac{2}{3} M_K = \frac{2}{3} * 75 = 25 \text{ solar masses}$$

6. Stars L and M form a binary pair, orbiting each other in a time of 20 years at a separation of 16 AU. If the orbital speed of star L is 9000 km/s, and the orbital speed of star M is 5000 km/s, what are their individual masses?

$$M_L + M_M = \frac{a^3}{P^2} = \frac{16^3}{20^2} = 10.24 \text{ solar masses}$$

$$\frac{M_L}{M_M} = \frac{v_M}{v_L} = \frac{5000}{9000} = \frac{5}{9} \quad \text{and so} \quad M_L = \frac{5}{9} M_M$$

$$\frac{5}{9} M_M + M_M = \frac{14}{9} M_M = 10.24 \text{ solar masses}$$

$$M_M = \frac{9}{14} * 10.24 = 6.58 \text{ solar masses}$$

$$M_L = \frac{5}{9} M_M = \frac{5}{9} * 6.58 = 3.66 \text{ solar masses}$$