UNIT 6: EVOLUTION OF STARS

BINARY STAR MASSES
THANK YOU MRS. RAMSEYER!!! =)

Here are two Nice Reference Websites:

- The Masses of Stars (copyrighted)
- Eclipsing Binary Simulator **REALLY AWESOME!!**

1. If two stars orbit each other with a period of 10 years and a separation of 5 AU, what is their total mass?

   r = 5 AU **P = 10 Years** $M = (m_A + m_B)$ **= Total Mass = ?**

   $$M = (m_A + m_B) = \frac{r^3}{P^2}$$

   $$M_T = m_a + m_b = \frac{5^3}{10^2} = 1.25\ Solar\ Masses = 1.25\ M_\odot$$

   $M_\odot$ **is the symbol for the mass of the Sun, 1.989 x 10^{30} kg**

2. What is the orbital period of a bit of matter in an accretion disk 2 x 10^5 km (convert to AU) from a 10 solar mass black hole?

   r **= 2 x 10^5 km** P **= ?** $M = (m_A + m_B)$ **= Total Mass = 10** $M_\odot$

   $$r = \frac{2\ x\ 10^5\ km}{1} x \frac{1\ AU}{1.5\ x\ 10^8\ km} = 0.0013\ AU$$

   $$M = (m_A + m_B) = \frac{r^3}{P^2}$$

   $$P^2 = \frac{r^3}{M}$$

   $$P = \sqrt{\frac{r^3}{M}} = \sqrt{\frac{(0.0013)^3}{10}} = 1.5\ x\ 10^{-5}\ years$$

   $$\frac{1.5\ x\ 10^{-5}\ years}{1}\ x\ \frac{365\ days}{1\ year}\ x\ \frac{24\ hr}{1\ day}\ x\ \frac{60\ min}{1\ hr} = 8\ minutes$$

3. If SS 433 consists of a 20 solar mass star and a neutron star (3 solar masses) orbiting each other every 13.1 days (convert to years), then what is the average distance between them?

   r = ? **P = 13.1 days** $M = (m_A + m_B) = 20\ M_\odot + 3\ M_\odot = 23\ M_\odot$

   $$r = \frac{13.1\ days}{1} x \frac{1\ year}{365\ days} = 0.0359\ years$$

   $$r^3 = P^2 M \qquad r = \sqrt[3]{MP^2} = \sqrt[3]{(0.036)^2(23)} = 0.31\ AU$$

4. If Star A, a 1 solar mass star, is 2 AU from the center of mass of a binary system and Star B is 42 AU distant, what is the mass of Star B?

$\mathbf{m_A = 1}\ M_{\odot}$ $\mathbf{r_A = 2\ AU}$ $\mathbf{m_B = ?}$ $\mathbf{r_B = 42\ AU}$

$$\frac{m_A}{m_B} = \frac{r_B}{r_A} \qquad \frac{1\ M_{\odot}}{m_B} = \frac{42\ AU}{2\ AU} \qquad m_B = 0.048\ M_{\odot}$$

5. Star A has a mass of 10 solar masses and wobbles about 2 AU from an apparent center of mass. An apparent X-Ray source exists 4 AU from this center of mass. How massive is this dark companion?

$\mathbf{m_A = 10}\ M_{\odot}$ $\mathbf{r_A = 2\ AU}$ $\mathbf{m_B = ?}$ $\mathbf{r_B = 4\ AU}$

$$\frac{m_A}{m_B} = \frac{r_B}{r_A} \qquad \frac{10\ M_{\odot}}{m_B} = \frac{4\ AU}{2\ AU} \qquad m_B = 5\ M_{\odot}$$