An extra solar planet is found orbiting a star in the Orion nebula. Determine the mass of the star if the planet has an orbital period of 420.0 Earth Days and has an orbital radius of 1.29x10^11m?

Solution

According to Kepler's Third Law, the orbital period $T = 420.0 \text{ days} = 420.0 \cdot 86400 \text{ s} = 36288000 \text{ s}$ of the planet orbiting a star is:

$$T = 2\pi \sqrt{\frac{r^3}{GM}},$$

where $r = 1.29 \cdot 10^{11} m$ is an orbital radius, $G = 6.6 \cdot 10^{-11} \, m^3 \, kg^{-1} \, s^{-2}$ is the gravitational constant, M is the mass of the star.

Therefore, the mass of the star is

$$M = \frac{(2\pi)^2 r^3}{GT^2} = \frac{(2\pi)^2 (1.29 \cdot 10^{11})^3}{6.6 \cdot 10^{-11} \cdot (36288000)^2} = 0.975 \cdot 10^{30} kg.$$

Answer: $0.975 \cdot 10^{30} kg$.