Homework 9.

19·37 From the information given in the problem, we can assume that the star need to stay on main sequence for atleast a billion years.
From table 19-1 we can say the maximum threshold mass for 1 billion years of Main sequence is 3 M⊙.

19·38 Each square meter of earth radiates 2000 times more radiation.

$$\therefore \frac{F_2}{F_1} = \frac{\sigma T_2^4}{\sigma T_1^4}$$

$$2000 = \frac{T_2^4}{(14+273)^4}$$

$$\boxed{T_2 = 1919\,k}$$

20·39. The ring nebula's angular dia = 1·4 arc min X 1 arcmin
velocity, Nebula's distance from earth = 2700 ly
Using small angle formula.

$$D = \frac{1 \cdot 4 \times 60 \times 2700 \times 9 \cdot 46 \times 10^{15}}{206265} = 1 \cdot 04 \times 10^{16}\,m$$

∴ Radius of Nebula = $5 \cdot 2 \times 10^{15}$ m. At the speed of 20 km/sec it started expanding around 8245·9 years ago

$10 = \frac{8}{\sqrt{1-v^2/c^2}}$ $1-v^2/c^2 = 0.64$

20.46 The masses of 2 stars in binary system are $18 M_\odot$ & $34 M_\odot$
Period = 19.56 days.

$$\therefore (19.56 \times 24 \times 3600^2) = \frac{4\pi^2}{G(18+34) M_\odot} a^3$$

$a = 0.53$ AU.

20.33 Here The proper time is the time measured in the ship hence $T_0 = 8$ years. When the ship comes back it measures time on earth to be 10 years. Hence using the equation for time dialation:-

$$10 = \frac{8}{\sqrt{1-v^2/c^2}} \quad \therefore 1 - \frac{v^2}{c^2} = 0.64.$$

$$\frac{v^2}{c^2} = 0.36 \quad \therefore \frac{v}{c} = 0.6.$$

$\therefore$ the ship was travelling 60% speed of light.

20.46 Schwarschild radius is given by :- $\frac{2GM}{c^2}$

a) For earth it is $\frac{2G \times 5.974 \times 10^{24}}{9 \times 10^{16}}$

$R = 8.796 \times 10^{-3}$ meters

Radius = 8.79 millimeters.

$\text{Density} = \frac{\text{Mass}}{\text{Volume}} = \frac{5.974 \times 10^{24}}{4/3 \times \pi \times (8.79 \times 10^{-3})^3}$

Density $= 2 \times 10^{30}$ kg/m^3

b) For Sun :- $R_{sch} = \frac{2 \times G \times M_\odot}{c^2} = 2928$ m.

Density $= 1.89 \times 10^{19}$ kg/m^3

c) The mass of black hole $= 1.2 \times 10^9 M_\odot$.

$R_{sch} = \frac{2 \times G \times M}{c^2} = 3.5 \times 10^{12}$ m