8)

$$\dot\phi = 0$$

$$\frac{1}{2} m\dot r^2 + \cancel{\frac{1}{2} m(r\dot\phi)^2}\left(1-\frac{2GM}{c^2 r}\right) - \frac{GMm}{r} = \frac{1}{2} mc^2(k^2-1)$$

and $\dot r(\infty) = 0 \quad \Rightarrow \quad k = \pm 1$

$$\Rightarrow \quad \frac{1}{2}\cancel{m}\dot r^2 = \frac{GM\cancel{m}}{r}$$

$$\dot r = -\left(\frac{2GM}{r}\right)^{1/2}$$ (must be zero at ∞, negative).

$$\frac{1}{(2GM)^{1/2}}\int_{r_s}^{0} dr\, r^{1/2} = -\int_0^{\tau} d\tau'$$

$$\frac{1}{(2GM)^{1/2}}\,\frac{2}{3}\left[r^{3/2}\right]_{r_s}^{0} = -\tau$$

$$\frac{1}{(c^2 r_s)^{1/2}}\cdot -\frac{2}{3} r_s^{3/2} = -\tau$$

$$c\tau = \frac{2}{3} r_s$$

For solar mass, $\tau \sim 7\times 10^{-6}$ s.