ASTR 2030 Problem Set #3 (due March 2nd in class)

(1) Give one reason why radio pulsars are known not to be spinning white dwarfs. (2 points)

(2) White dwarf supernovae are observed in all types of galaxies, whereas the core collapse supernovae that result in the formation of neutron stars are typically seen in galaxies that contain many recently formed stars. Explain why this is so (Chapter 2 of the textbook may be useful here). (3 points)

(3) The formula for the Schwarzschild radius of a black hole (the radius of the event horizon, if the hole is non-spinning) is:

\[ R_s = \frac{2GM}{c^2} \]

where \( G = 6.67 \times 10^{-11} \text{m}^3/\text{kg s}^2 \). The Earth has a mass of \( 6 \times 10^{24} \text{kg} \). Suppose that small black holes with a mass equal to that of the Earth existed. What would their Schwarzschild radius be? (2 points)
(4) You are the scientific consultant for the next James Bond movie, in which the villain develops a device able to (slightly) squeeze the Sun. The villain plans to hold the Earth to ransom, saying that the stronger gravity at the surface of the squeezed Sun will cause the Sun to collapse. Is the villain’s threat credible? Explain why or why not. (4 points)

(5) The force of gravity (in a Newtonian approximation) on a mass \( m \), at the surface of a body of mass \( M \) and radius \( R \), is given by,

\[
F = \frac{GMm}{R^2}
\]

A neutron star has a mass that is 500,000 times greater than that of the Earth, and a radius that is 600 times smaller. By what factor would the force of gravity increase if you were standing on the surface of a neutron star as compared to on the surface of the Earth? (4 points)