general relativity - practice problems

1. In the rocket thought experiment, why does Einstein connect gravity with acceleration?

2. A neutron star has mass 2.8 solar masses and radius 12 km. Use 1 solar mass = 2.0 × 10 30 kg. If 30 s pass far from the neutron star, how much time passes on the surface?

3. A clock on Earth's surface runs slightly slow because of Earth's gravity. Use Earth mass 5.97 × 10 24 kg and Earth radius 6.37 × 10 6 m. If 1.00 year passes far from Earth's gravity, how many fewer seconds pass on Earth's surface?

4. Why does gravity bends the path of light if photons have no rest mass?

5. Earth has mass 5.97 × 10 24 kg. If Earth were compressed until it became a black hole, what would its Schwarzschild radius be?

6. A collapsed star has mass 6.0 solar masses. Use 1 solar mass = 2.0 × 10 30 kg. What is its Schwarzschild radius?

7. A 6.0 solar mass collapsed star has physical radius 15 km. From the previous example, its Schwarzschild radius is 17.8 km. Is the surface inside or outside the event horizon?

8. The event horizon is sometimes drawn as a dark surface. Is it a solid surface that an astronaut would hit?

9. Astronomers estimate a black hole event horizon radius of 45 km. Assuming it is non-rotating, what mass does the Schwarzschild radius equation give?

10. A clock hovers 60 km from the center of a non-rotating 10 solar mass black hole. Use 1 solar mass = 2.0 × 10 30 kg. If 2.0 s pass far from the black hole, how much time passes on the hovering clock?

11. Why does general relativity predict gravitational waves?

12. A non-rotating black hole has mass 10 solar masses. How far from its center would a hovering clock need to be for its time to run at half the far-away rate?

13. The Milky Way's central black hole has mass about 4.0 million solar masses. Use 1 solar mass = 2.0×10^{30} kg. What is its Schwarzschild radius in meters and in million kilometers?

14. Why does a full black hole model probably needs both general relativity and quantum mechanics?