

Astro 2

Quiz 3 Math Extra Problems

$$v_{esc} = \sqrt{\frac{2GM}{R}}$$

1. What happens to the escape velocity from the surface of a planet if you:
 - a. Increase the mass of the planet by a factor of 9 but keep the radius constant?
 - b. Decrease the mass of the planet to 1/16 of the original mass but keep the radius the same?
 - c. Increase the radius by a factor of 25 but keep the mass of the planet the same?
 - d. Keep the mass of the planet the same but shrink the radius to 1/81 of its original size?
 - e. Increase the mass of the planet by a factor of 2 and increase the radius by a factor of 8?
 - f. Increase the mass of the object that is trying to escape by a factor of 6, but keep everything else the same?

2. The escape velocity from the surface of Jupiter is 60,000 m/s. If the mass of Jupiter was quadrupled and its radius shrinks to 1/16 of its original size, what would the new escape velocity be?

3. If you start from the orbit of the Earth, you have to go 42,000 m/s to escape the sun's gravity. How fast do you have to go to escape the sun's gravity if you start at the orbit of Saturn, which is 9 times farther away from the sun than Earth is?

4. Derive the formula for the Schwarzschild Radius, starting from the formula for escape velocity.

5. How does the Schwarzschild Radius change if you:
 - a. Increase the mass of your black hole by a factor of 3?

 - b. Decrease the mass of the black hole to $\frac{1}{3}$ of the original mass?

6. The Schwarzschild Radius of a $5M_{\odot}$ black hole is 15,000 m. As the black hole sucks in mass, the Schwarzschild Radius increases. By the time the Schwarzschild radius is 45,000 m, how much mass has the black hole eaten? Give your answer in units of M_{\odot} .