AP/Honors HW: Gravity and Circular Motion

Full Name, Period, AP/Honors: **due: 12/16**

Instructions: A calculator might actually help for a few of these. All students should attempt all problems, but only AP students will have AP problems graded on correctness. For short answer questions, work must be shown to receive credit.

1 Failing to understand the gravity of our situation,

1. Jupiter and Earth both orbit the sun in approximately circular orbits. Jupiter is about 300 Earth masses, and orbits at a distance of about 5 AU (the Earth orbits at 1 AU by definition). What is the ratio of the force of gravity the Sun exerts on Earth to the force that the Sun exerts on Jupiter.
   A. $\frac{F_e}{F_j} = \frac{1}{12}$
   B. $\frac{F_e}{F_j} = 12$
   C. $\frac{F_e}{F_j} = \frac{1}{1800}$
   D. $\frac{F_e}{F_j} = 1800$

2. The masses of Earth and Jupiter are suddenly doubled, and the distance between them is also doubled. By what factor does the gravitational force between the Earth and Jupiter change?
   A. $F_{new} = \frac{1}{4}F_{old}$
   B. $F_{new} = \frac{1}{2}F_{old}$
   C. $F_{new} = F_{old}$
   D. $F_{new} = 2F_{old}$
   E. $F_{new} = 4F_{old}$

3. Two metal spheres with masses M_1 and M_2 and radii R are placed in physical contact with each other. The radius of one object is tripled, while the other is unchanged, and the density of both objects are doubled. What happens to the gravitational force between them?
   A. 27 times as large
   B. 9 times as large
   C. $\frac{54}{9}$ times as large
   D. $\frac{36}{21}$ times as large

4. (AP Only) You are on board a spacecraft that is orbiting the Earth at a radius of R from the Earth's center. The thrusters on the spacecraft are being used so that the orbital speed does not match the natural orbital speed at the spacecraft's radius. How fast must the spacecraft orbit so that the astronauts experience an apparent gravity of g away from the Earth's center? R_e is the radius of Earth.
   A. $\sqrt{\frac{2GMR}{R_e^2}}$
   B. $\sqrt{gR + \frac{GM}{R}}$
   C. $\sqrt{\frac{R}{R_e}(g + \frac{GM}{R_e})}$
   D. $\sqrt{2g\frac{R_e}{R}}$
   E. $\sqrt{g(R - R_e)}$

2 we will continue going in circles

1. A pendulum with a mass of M_1 is suspended from the ceiling by a string of length l. It has traveled from its maximum height of h_{max} to it's minimum height of h_{min}.

   (a) Find the speed of the pendulum.

   (b) Find the tension in the string that holds the pendulum up.

   (c) Find the acceleration of the pendulum.

2. An object with mass M is on the surface of a planet with radius R and isn't moving relative to the planet's surface. It is on the planet's equator and has a speed of v as a result of the planets spin.

   (a) Find the length of a day on the planet.

   (b) (AP only) There is another object that is half way between the equator and the poles. What is its speed as a result of the planet's motion?

3. (AP Only) You want to put a satellite in solarstationary orbit (ie stays above the same point on the surface of the Sun) over a point on the Sun's equator. The sun takes 27 days to complete one rotation. Given that the mass of the Sun is 2×10^{30} kg and the radius of the sun is 7×10^5 m, does this orbit around the Sun exist?

3 until we escape.

1. Find the escape speed of Earth. Relevant values: $G = 6.67 \times 10^{-11}\ \frac{\text{N}\cdot\text{m}^2}{\text{kg}^2}$, $R_e = 6400$ km, $M_e = 6 \times 10^{24}$ kg.

2. A white dwarf is a star with the a mass about the same as the sun ($M_{sun} = 3.3 \times 10^5 M_e$) and the radius of Earth. What is the escape velocity of a white dwarf? Do not recalculate the value from scratch!

3. How far do we need to be from the SURFACE of a planet with radius R_p for the escape velocity to be reduced by half?

   A. R_p

   B. $2R_p$

   C. $3R_p$

   D. $4R_p$