**7. Satellite Calculations**

Name and date submitted (3 pts):

Create space below and complete the problems. YOU MUST SHOW ALL YOUR WORK including formulas used.

(4 questions; 100 points)

Equations: W = F x d Work = force in the direction of the displacement x displacement

KE = ½ mv2 (K = ½ mv2) Kinetic energy formula

PE = mgh (Ugrav = mgh) Potential energy formula for gravity

P = ∆W/∆t Power = work ÷ time

Units: Work and energy both use Joules (N · m). Power uses Watts (J/sec).

Other info: Radius of earth = 6.4 x 106 m

1. A 1.20 x 104 kg space probe, after being launched from a space shuttle that is 1.50 x 107 m from the earth’s center, travels to its orbit, an additional 2.25 x 107 m farther away from the earth.
2. What is the probe’s potential energy with respect to the earth’s surface at the time it is launched?
3. What is the probe’s potential energy with respect to the earth’s surface when it reaches its orbit?
4. How much work was done against gravity to move the probe to its orbit after its launch from the shuttle?
5. If the probe falls back to the earth’s surface after attaining its orbit, how much potential energy will it lose?
6. How much work will the earth have done on the probe in such a fall?
7. By how much would the probe’s kinetic energy change during such a fall? (ignore air resistance in the atmosphere)
8. If the probe has zero radial velocity before it starts its plunge, what is its speed as it reaches the earth’s surface? (ignore air resistance)
9. Now let’s say the probe crashes into the California desert.
10. How many joules of energy are released when the probe crashes into the earth?
11. Gasoline releases 130,000 J/gallon of energy when burned. The energy released by the probe crash is equivalent to how many gallons of gasoline exploding?
12. Soil-and-rock mixture weighs approximately 20,000 N/m3. How large a crater in cubic meters would be formed if the soil-rock had to be lifted an average of 10 meters to form the crater? Assume all the crash-energy goes into crater-formation. As an approximation, assume the crater is an upside down cone and the volume of a cone is 1/3πr3.
13. Orbital velocity: Instead of crashing, let’s say the probe is launched from the space shuttle and stays in perfect orbit 3.75 x 107 m from the earth’s center.

Question: How fast must it travel radially in m/s (what must its orbital velocity be) to stay in orbit at exactly that height without falling or moving farther out?

1. Geosynchronous satellite: Let’s say you want to permanently ‘park’ the probe above a certain location in geosynchronous orbit. To make the calculations easier, assume the location is directly above the earth’s equator, where the earth’s rotational speed is 460 m/s (1,000 mph) and its radius is 6400 km.

Question: How high in km above the earth, and at what orbital speed in m/s, must you place the probe in order to keep it in orbit above that one location?