Applied Physics – Problem set #3

1. What orbit does a satellite have to follow, so that it continuously stays above the same point on the surface of the Earth? Calculate its altitude, speed, and radial acceleration! The mass and radius of Earth: ($M = 5.972 \cdot 10^{24}$ kg, $R = 6371$ km)

2. What is the speed of an object that can orbit the Earth near its surface if we can ignore the atmosphere and the mountains?

3. Along the equator two motor engines travel on the railway tracks. They are both 25 tons, and one travels to the East, the other to the West at the same 72 km/h speed. Due to the rotation of the Earth, they won't exert the same normal force on the tracks. Which one exerts more force and by how much?

4. An interstellar comet is approaching a stationary star with mass $6 \cdot 10^{29}$ kg. When it is still very far from the star, its speed is 5000m/s, and the line of the velocity vector passes $6.67 \cdot 10^{11}$ m from the center of the star. What will be the closest distance between the comet and the center of the star? The gravitational constant is $G = 6.67 \cdot 10^{-11}\ \frac{Nm^2}{kg^2}$.

5. The mass of Mercury is $3.3 \cdot 10^{23}$ kg, its orbital period is about 88 days around the Sun that has mass $1.99 \cdot 10^{30}$ kg. Along the elliptical orbit, its closest distance is 46,001,200 km, and its speed at the perihelion is 58.98 km/s. What is the momentum, angular momentum and mechanical energy of Mercury at that point? What is its speed at the aphelion, if that is 69,816,900 km from the Sun? The gravitational constant is $G = 6.67 \cdot 10^{-11}\ \frac{\mathrm{Nm^2}}{\mathrm{kg^2}}$

<u>Homework #3</u>

1. Low Earth orbits for satellites span between 160 km and 2000 km altitudes. Calculate how the orbital periods, orbital speeds, and radial accelerations compare for the 160 km and 2000 km altitudes!

2. According to the plans, the basic idea of a space elevator is a counterweight orbiting beyond the geosynchronous distance connected to a point on the equator. If the counterweight is at an orbit with 100,000 km radius, what should its mass be, so that 5 tons can be pulled up on the connecting wire, if we can ignore the mass and stretching of the wire? The mass of the Earth and the gravitational constant: $M = 5.972 \cdot 10^{24}$ kg, $G = 6.67 \cdot 10^{-11}\ \frac{\mathrm{Nm^2}}{\mathrm{kg^2}}$!

3. Not long ago, astronomers discovered a new dwarf planet in our solar system. Along its elliptical orbit, the dwarf planet takes 700 days to orbit the Sun. At its aphelion it is 120 times further from the Sun than the Earth on average.
(a) What is the minimum distance of the dwarf planet from the Sun?
(b) How many times is the dwarf planet faster at its perihelion than at its aphelion?