Mekaniikan jatko-osa (FYSP102), Kevät 2013

Exam 1.

Do 4 tasks out of 5. 4 best will be counted.

1. (2 p per item)
   a) Explain what is (simple) harmonic oscillator.
   b) Explain what is torque.
   c) Explain Archimedes' principle.

2. (3 p per item)
   a) Calculate the position of the center of the mass, $\vec{r}_{CM} = \frac{1}{M}\int_{mass-distribution} \vec{r} dm$, of a homogenic uniform rod of length L and mass M (detailed figure and coordinates 1 p, calculation 2 p).
   b) Calculate the moment of inertia, $I = \int_{mass-distribution} r^2 dm$, of a homogenic uniform rod of length L and mass M that rotates about a pivot point at the center of the rod and the rotational axis is perpendicular to the rod (detailed figure and coordinates 1 p, calculation 2 p).

3. It is aproximately a year 1680 and your name is Isaac Newton. You know your laws: Newton I (If there is no net force on an object, then its velocity is constant. The object is either at rest (if its velocity is equal to zero), or it moves with constant speed in a single direction), Newton II ($F = ma$) and Newton III:n (law of force and opposite force) and that in a circular motion the centripetal force is $F = mv^2/r$. Moreover, you know Kepler's III law which states that the square of a planet's orbital period is proportional to the cube of the semimajor-axis length $T^2 \propto r^3$ (assume circular orbits). By using given information derive Newton's law for gravity.

4. Make detailed analysis of a mathematical pendelum. (figure 1/2 p, coordinate axis 1/2 p, freebody diagram and forces 1/2 p, equations on motion 1 p, differential equation 1 p, extra assumption 1/2 p, solution 1 p, ω=? 1/2 p, T=? 1/2 p)

5. Assume that at the time t=0 a function $y = f(x) = Ae^{-Bx^2}$ describes a wave pulse, where $A = 1.0\ m$ and $B = 1.0\ m^{-2}$ (x measured in meters).
   a) If the given wave pulse maintains its shape and travels along positive direction of the x-axis at speed of v=2.0 m/s, what kind of wave function describes it at the moment $t > 0$? Do not only give the answer but explain it too. (3 p)
   b) Draw a detailed picture the wave function at times t=0 and t=1. (3 p)