Applied Physics – Problem set #4

1. The relaxed length of a spring is 0.5m, and it has a spring constant D=100N/m. We fix one end to the ceiling, to the other end we attach a small object with mass m=0.5kg. Then we pull down on the object until the spring stretches to 0.7m. What will be the initial acceleration of the object, its maximum speed, its amplitude, and how will its displacement change as a function of time?

2. A point-like mass of 50g performs simple harmonic oscillation with a period of 0.16s and with amplitude 3.2cm. What is the power of the harmonic net force acting on the object 0.06s after it went through the equilibrium point moving towards the positive x-axis?

3. A point-like mass of 10kg is moving along the x-axis. Two forces are acting on it: a restoring force toward the origin, which is proportional to the displacement with coefficient 250N/m, and a force proportional to its speed, pointing opposite to the velocity vector with coefficient 60Ns/m. The initial displacement is 8m and the initial velocity is zero. What will be the displacement as a function of time?

4. A point-like mass of 10kg is moving along the x-axis. Three forces are acting on it: a restoring force toward the origin, which is proportional to the displacement with coefficient 250N/m, a force proportional to its speed, pointing opposite to the velocity vector with coefficient 60Ns/m, and a fictitious force in the accelerating reference frame of the shaker that has tunable frequency. What is the critical damping and the damping factor? What will be the natural frequency of the resulting motion (resonance), and what will be the value of the transmissibility function at the natural frequency?

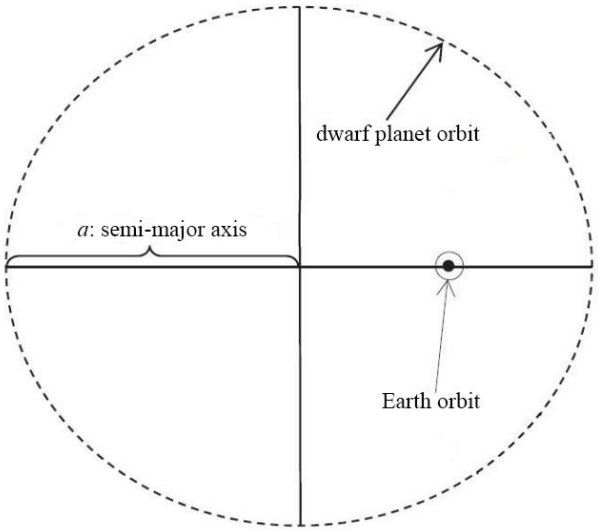
5. Jupiter orbits the Sun at an average speed of about 13km/s. The velocity vector of the 800kg satellite when it is very far from the planet makes a 120º angle with the velocity of the Jupiter, and its speed relative to the Sun is 18km/s. What will be the speed of the satellite after the slingshot maneuver and by what percent did its kinetic energy increase?

Homework #4

1. The relaxed length of a spring is 0.5m, and it has a spring constant D=100N/m. We fix one end to the ceiling, to the other end we attach a small object with mass m=0.5kg. The spring will be slightly stretched by the object at equilibrium, then we push the object upward at 2m/s. What will be the peak acceleration of the object, its maximum speed, its amplitude, and how will its displacement change as a function of time?

2. The 10kg mass point P is performing rectilinear motion due to a restoring force that is proportional to the distance from the C center. When the object is 1m from C, the force is 20N. The medium around the object exerts a braking force proportional to the speed of the small object. After 3 complete cycles the CP distance is only $1/10^{th}$ of the initial value. What is the period? What is the ratio of the damping factor to the critical damping? What would be the resonant frequency of this system, if we added a harmonic driving force and create a forced vibration?

3. Performing the gravity assist maneuver in the opposite direction, we can slow down the spacecraft in order to put it in orbit for example. This is how Jupiter captures all those asteroids getting close to it along their original trajectories. For this all the arrows have to be inverted on the original diagram in the slides, and the spacecraft has to pass in from of the planet, not behind ($v_{0x} > u$). Create the appropriate diagrams and derivation in the Jupiter's frame of reference and in the Sun's frame of reference, and prove that the spacecraft will slow down during such an encounter!


dwarf planet orbit
a: semi-major axis
Earth orbit