Allowed material: writing implements and a scientific calculator. You are not allowed to use any other material. There are some formulas and constants tabulated in last page of the exam. Justify the formulas you use in your answers, the intermediate steps in you take, and the assumptions you make. Introduce the meaning of the symbols within these formulas. In every problem both the presentation and the contents are evaluated when grading the exam. Solve each problem on separate page.

It is important that you at least try each problem. Good luck!

1. (a) Define the following terms/concepts using at most about 30 words / term. Using only formulas is not a sufficient answer. Considerably too long an answer will decrease the points awarded. A. Central force B. Conservative force C. Physical pendulum

   Answer the following question using at most about 200 words. Significantly overlong or poorly structured answer will not be awarded full points. You may use drawing to support your answer, but answering using only figures will not yield points.

   (b) The gravitational pull and motion of a large celestial body can be used to accelerate a space craft by flying past the celestial body at a close distance. This maneuver is known as the gravitational slingshot. In the vicinity of the body, the orbit of the space craft can be approximated with an ellipse. Based on Kepler's second law, explain the basis of this increase in velocity.

2. An object lies on a horizontal platform, which oscillates in a simple harmonic motion. The amplitude of the motion is $0.52\,\mathrm{m}$ and its period is $2.0\,\mathrm{s}$. Determine the magnitude of the static coefficient of friction between the object and the platform for the object not to move with respect to the platform.

3. A satellite (mass m) orbits the Earth on a circular orbit such that its radius is η times the radius of the Earth, R. The effect of the atmosphere and cosmic dust also orbiting the Earts is to exert a resisting force on the satellite's motion. This frictional force is given by the expression $F = \alpha v^2$, where v is the orbital velocity of the satellite. Determine how long it takes for the satellite to crash into the surface of the Earth. You may assume the α to be small enough such that the satellite's orbit remains circular at all times.