

First exercise sheet on Relativity and Cosmology I

Winter term 2020/21

Release: Mon, Nov. 9th

Submit: Mon, Nov. 16th on ILIAS

Discuss: Thu, Nov. 19th

Exercise 1 (10 points): *Newtonian Gravity I: Radial motion of a mass point*

Consider a mass m in the gravitational field of a mass $M \gg m$, such that M sits at the origin. At some initial time $t = 0$, m is located at a distance $r(0) = R$ and has an initial velocity $\dot{r}(0) = v_0 > 0$, so that it undergoes one-dimensional motion.

1.1 When is the solution $r(t)$ unbounded?

1.2 Give an explicit solution for $r(t)$ for the lowest initial velocity that allows for an unbounded solution.

Exercise 2 (10 points): *Newtonian Gravity II: Potential of a homogeneous spherical shell*

Consider a spherical shell of a mass M with constant density ρ . Denote the inner radius with R_1 and the outer radius with R_2 .

Calculate the Newtonian potential at a distance r from the origin. Distinguish between the cases $r < R_1$, $R_1 < r < R_2$, and $r > R_2$. Take care of continuity (why?) and boundary conditions at $r \rightarrow 0^+$ and $r \rightarrow +\infty$.