

1st exercise sheet on Relativity and Cosmology I

Winter term 2017/18

Deadline for delivery: Thursday, 26th October 2017 at the beginning of the first exercise class.

Exercise 1: *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 $\dot{r}(0) = v_0 > 0$ (one-dimensional motion).

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

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

Exercise 2: *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 $r > R_2$.

Exercise 3: *Inertial frames*

A rocket with a rest length L_0 moves with constant velocity radially away from Earth. From Earth a light pulse is emitted, which is then reflected by mirrors at the front as well as at the rear of the rocket. The first signal is received after the time t_A , the second after the time t_B .

3.1 Calculate the velocity at which the rocket moves in terms of L_0 , t_A and t_B .

3.2 Determine at which distance from Earth the rocket is located when the first signal reaches Earth.