3. MISSION TO MARS (7 points)

A crew of astronauts is going to be sent to explore the polar region of Mars and search for buried water ice. Their spaceship will travel from Earth to Mars along an elliptic transfer orbit tangential to the orbits of both planets. Despite its shortcomings, this orbit is commonly used in space travel due to its relatively good fuel economy. Future manned missions to Mars are very likely based on this kind of transfer. In this problem you will examine some aspects of this orbit.

The mean orbital radius of Mars is $R_a = 1.52\,\mathrm{AU}$. The mean orbital radius of Earth is $R_g = 1\,\mathrm{AU} = 149\,600\,000\,\mathrm{km}$. Mars has a mean radius of $r_a = 3397\,\mathrm{km}$ and surface gravity $g_a = 3.71\,\mathrm{m/s^2}$. Earth has a mean radius of $r_g = 6371\,\mathrm{km}$.

i) *(1 point)* Find the orbital period T_a of Mars, i.e. find the length of Martian "year" in Earth years.

ii) *(1.5 points)* How long (t_t) does a one-way trip to Mars take?

iii) *(1.5 points)* The spaceship is put into this orbit by using a powerful rocket. It is more efficient to burn fuel as a short burst when the spaceship is still near Earth. How much additional speed (Δv_1) does the booster have to be able to give to the spaceship to enter the transfer orbit, starting from the north pole? Neglect the air resistance.

iv) *(1.5 points)* Estimate the Δv_2 needed to enter a circular orbit close to Mars.

v) *(1.5 points)* What is the minimal duration of the trip to Mars and back?