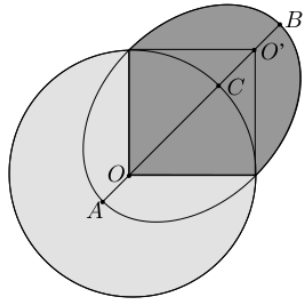
3. Ballistic rocket

1) The net energy depends only on the longer semi-axes. Hence, the longer semi-axes is the same as in the case of near-Earth orbit: $a = R$.



2) The ellipse has a property that the sum of lengths from each point on the orbit to the both foci of the orbit is constant (equals to $2a$). Hence, the other focus (i.e. which is not the centre of Earth) is at the distance R from both the launching point and landing point, see Fig. So, the height

$$h = |CB| = |OB| - R;$$

since $|OB| = R + \frac{1}{2}|OO'| = R\left(1 + \frac{\sqrt{2}}{2}\right)$, we finally obtain

$$h = \frac{R}{\sqrt{2}}.$$

3) The ratio of the flight time to the period along the elliptic orbit equals to the ratio of two surface areas: the one painted dark grey in Fig, and the overall area of the ellipse. The rotation period is the same as in the case of near-Earth orbit (due to Kepler's third law),

$$T = \frac{2\pi R}{v} = 2\pi\sqrt{\frac{R}{g}}.$$

The dark gray surface area is calculated as the sum of half of the ellipse area, and a triangle area. So,

$$\tau = T \cdot \frac{\frac{\pi}{2}R \cdot \frac{R}{\sqrt{2}} + \frac{R^2}{2}}{\pi R \cdot \frac{R}{\sqrt{2}}} = (\pi + \sqrt{2})\sqrt{\frac{R}{g}}.$$