Problem 1.

Solution.
Mean motion $n = \sqrt{\frac{mu}{a^3}} = 2.699\,75 \times 10^{-4}\,\mathrm{rad/s}$.
Mean anomaly $M = n(t-\tau) = 2.699\,75 \times 10^{-4}\,\mathrm{rad/s} \times 2.5\,\mathrm{hrs} = 2.429\,77\,\mathrm{rad}$.
Eccentric anomaly E: use Newton's iteration to find E. If starting from $E_0 = M$, the first few iterations are

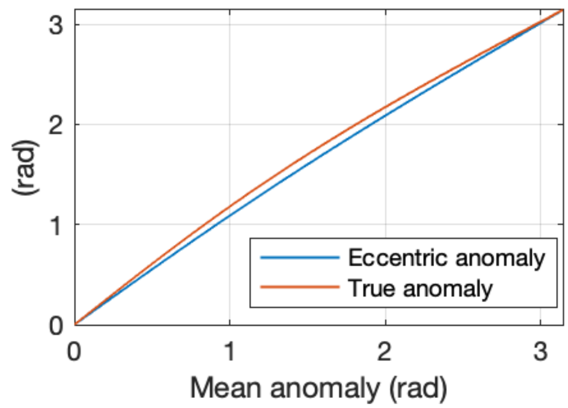
k	E_k
0	2.429771612202175
1	2.666685855513955
2	2.660949960140585
3	2.660947344723798
4	2.660947344723250

We have $E \approx 2.660\,95\,\mathrm{rad}$.
Then $\nu = 2\arctan\left(\sqrt{\frac{1+e}{1-e}}\tan\frac{E}{2}\right) \approx 2.860\,49\,\mathrm{rad}$.
Distance from the planet to spacecraft $R = \frac{a(1-e^2)}{1+e\cos\nu} = 20\,206.9\,\mathrm{km}$.
Position $\vec{R} = R\begin{pmatrix}\cos\nu\\ \sin\nu\\ 0\end{pmatrix} = \begin{pmatrix}-19\,413.8\\ 5605.71\\ 0\end{pmatrix}$ km.
Velocity $\vec{v} = \sqrt{\frac{\mu}{a(1-e^2)}}\begin{pmatrix}-\sin\nu\\ e+\cos\nu\\ 0\end{pmatrix} = \begin{pmatrix}-1.210\,74\\ -2.010\,88\\ 0\end{pmatrix}$ km/s.

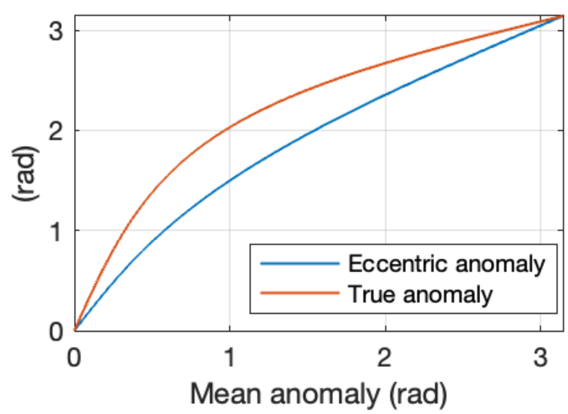
Problem 2.

Solution.

Eccentric and True Anomaly vs. Mean anomaly ($e = 0.1$)



Eccentric and True Anomaly vs. Mean anomaly ($e = 0.1$)



Problem 3.

Solution. By vis-viva equation, specific energy $\mathcal{E} = -\frac{\mu}{2a} = -3.569\,\mathrm{MJ/kg}$.
Given $r = 5000\,\mathrm{km}$, solving for v, we have

$$v = \sqrt{2\left(\mathcal{E} + \frac{\mu}{r}\right)} \approx 3.161\,20\,\mathrm{km/s}.$$

Given $v = 3.2\,\mathrm{km/s}$, solving for r, we have

$$r = -\frac{\mu}{\mathcal{E} - \frac{v^2}{2}} \approx 4928.99\,\mathrm{km}.$$

Problem 4.

Solution.
The distance from planet center to the vehicle is $r = 2106\,\mathrm{km} + 50\,\mathrm{km} = 2156\,\mathrm{km}$. By vis-viva equation, the minimum speed v to escape from this point satisfies

or by the escape speed formula directly

$$\mathcal{E} = 0 = \frac{v^2}{2} - \frac{\mu}{r} \quad \rightsquigarrow \quad v = \sqrt{\frac{2\mu}{r}} \approx 6.303\,10\,\mathrm{km/s}.$$

Problem 5.

Solution. Using vis-viva equation, we find

$$\mathcal{E} = -\frac{\mu^2(1-e^2)}{2h^2} \approx 2.599\,54\,\mathrm{MJ/kg}.$$

Given $r = 4000$, solving for v yields

$$v = \sqrt{2\left(\mathcal{E} + \frac{\mu}{r}\right)} \approx 5.158\,79\,\mathrm{km/s}.$$

Similarly, for $r = 1 \times 10^4\,\mathrm{km}$,

$$v = \sqrt{2\left(\mathcal{E} + \frac{\mu}{r}\right)} \approx 3.710\,08\,\mathrm{km/s}.$$

For $r = 1 \times 10^6\,\mathrm{km}$,

$$v = \sqrt{2\left(\mathcal{E} + \frac{\mu}{r}\right)} \approx 2.298\,86\,\mathrm{km/s}.$$