# 3. Experiments

In the following chapter we are going to discuss our conducted experiments. We start with a comparison of our novel approach of the position-state transformed PINN with a well-known Vanilla PINN, in two dimension and on a plane in three dimensions *(Note that the 2d-Vanilla PINN problem setup is adapted from Seo*). We already described that our new method imposes exact boundary conditions i.e. it eliminates the boundary loss term of a Vanilla-PINN. Therefore, to achieve meaningful, comparable results, we need to pre-tune the boundary loss term weight w\_BC of our Vanilla-PINN. We determined w\_BC using a brute force grid search of the total loss landscape, for different cases. Namely, in two and three dimensions, with a fixed time of flight (TOF) of t\_TOF = 1, and for a trainable t\_TOF in two dimensions. The latter, a trainable t\_TOF is mostly desired in trajectory optimization problems as one can’t predominantly know an optimal trajectory’s TOF. However, the effects of keeping t\_TOF untrainable but varying it are highly interesting. Another experiment therefore is the sweep of untrainable t\_TOFs. Furthermore, as an extension of our model on a plane on three dimensions, we look at slight spatial deviations from a plane. These includes rotating the plane the planets lay in, shifting z-coordinates of the initial and final conditions or of the planets.

Understanding spatial boundary conditions lets us extend our approach to restrictions in phase space. With exact initial and final positions and velocities we call our method kinematic state transformed PINN. TBA

Hohnmann-Transfer TBA

## 3.1 Position State transformed

As a reminder, the loss function of a Vanilla PINN, which aims to optimize a trajectory for given boundary conditions, consists of two terms. One to minimize the needed thrust L\_Physics \eqref{eq:T}, and another to enforce the boundary conditions L\_BC \eqref{eq:BC]. Position-state transformed, is what we call it to impose exact spatial boundary conditions on a PINN by eliminating L\_BC. To achieve this, we proceed by transforming the PINNs output according to equation (5) with the functions…

3.1.1 Vanilla vs position state-transformed PINNs

- add 2d grid search of dynamic TOF  
- rewrite

TODO:

* ~~Cleanup and push weight search code~~
* ~~Add overleaf: Convergence criterion~~
* ~~Sanity check of position vs vanilla results~~
* ~~Redo static time grid search after kinematic bug fix~~
* Add E\_kin, to result class
* ~~Mail Anerkennung Physics: AQM und Statistical Physics~~
* Describe shifted BC Experiment in Overleaf
* Add Experiment to show that kinematic transformation works ???