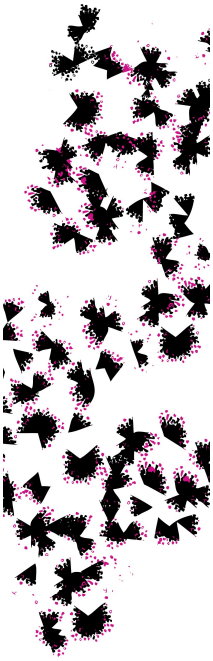

Contact approach trajectory analysis for aerial manipulation and interaction

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BSc Report

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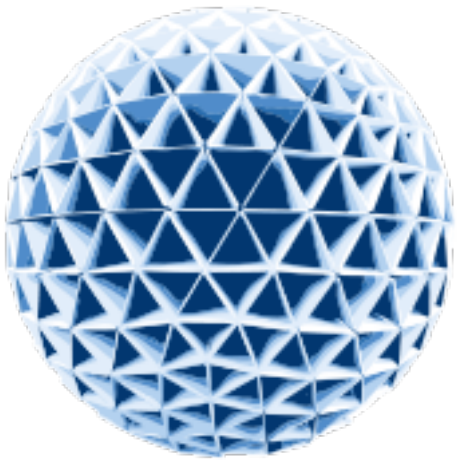
A bachelor project



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Contents

1 Introduction

1.1 Context

Unmanned Aerial Vehicles (UAVs), are playing an increasing role in society. The mobility and reach of UAVs make them very applicable for tasks such as inspection, mapping and search-and-rescue operations [1]. Lately, there has been an increasing interest in aerial physical interaction. There are various financially crucial but remote or dangerous tasks that require physical interaction, such as infrastructure inspection or cleaning and maintenance at high altitudes. The current state of the arts does not yet allow for the safe execution of these tasks. To reduce cost and human safety risks, this challenge has to be overcome. Over the past years, there have been a variety of large-scale research groups that have been or are currently working on the development of the needed capabilities, such as [2][3] and [4].
previous work shows the capabilities of UAVs in remote mapping and inspection [5][6][7]. Nowadays, UAVs have been proven to show potential, in transportation and assembly tasks, both as individual and collaborative units [8][9][10]. Research into aerial manipulation has produced UAVs capable of applying sustained forces [1], collecting samples [11], grasping[12] and manipulation [13][14][15]. This and other research [16][17][18], has contributed to the development of light and versatile manipulators. Additionally, perching has been looked into as a way of saving energy while the UAV is on standby. This is done through a combination of landing or grasping mechanism and different control methods [19][20][21][22][23]. Next to that, the control laws regarding physical interaction have been modeled, simulated, and analyzed [24][25][26][27][28].
The presented research, however, overlooks how the selected approach trajectory influences the stability of the drone when engaging aerial contact. Generation of paths and trajectories has already been done [29] and improved [30]. However, not in relation to contact stability. [31] shows a trajectory generation and contact control method interaction, but focuses on object avoidance and contact position tracking. Understanding what approach angle, velocity or acceleration contributes to the instability at the moment of contact, could help with formulating pathfinders and trajectory generators. As a result, the chance of crashes or damage to the drone and the danger this present to its environment, especially to animals or people can be reduced.

1.2 Goal

This project focuses on researching how different flight approaches, for UAVs that establish contact with the environment, influence the stability at contact. The approach paths, will differ in impact angle, impact velocity and acceleration. Stability is measured by the deviation of the UAV's state, from the desired state. To accurately control for the test variables a sufficiently accurate trajectory generation program and execution is needed. Considering that manual testing reduces repeatably and guarantee of accuracy. Therefore this paper also presents a trajectory generation program based on the work of [32], [33] and [34].
Approaching perpendicular to the surface and being at rest just before contact, are the most stable guaranteed approaches. We expected that more is diverged from the perpendicular path and the higher the velocity and acceleration of the UAV, before contact, the less stable the result. Specifically the effect of impact angle, impact velocity and impact acceleration, on the deviation from the desired end state will be looked at.
Such effects can be taken into account by path planning and trajectory generation algorithms, to create more stable flight paths for physical interaction approach. Increased stability when making contact, reduces the risk of inflicting damage to the UAV or surroundings and increasing the safety of aerial interaction.
Due to limited test-environment, resources and the possible damage to the drone in case of

crashing, this research is limited to simulation. Additionally, this provides a controlled environment, and so reduces the changes of unaccounted disturbances. Instead, disturbances have been added artificially so that their effects, on the UAV and the stability while establishing contact can be observed and analyzed.
The UAV used is a HEXACOPTER model of the real-life HEXACOPTER developed by the Aeroworks project [2].

1.3 Report Outline

This Report is structured in the following manner. In Section 2 the theory behind trajectory generation, aerial contact and flight are explained. Next, Section 3 discusses the designed and used trajectory generator and UAV control programs. Section 4 discusses the test set-up and how the results will be measured. Section 5 presents and discusses the results. Finally, Section 6 presents the conclusions and gives recommendations for future research.

2 Background

2.1 Trajectory generation

This chapter explains the basic concepts of trajectory generation and optimisation. Over the years many papers have described trajectory generation or optimisation and have contributed to their development and application, and it has been a topic of interest for decades [29].
Trajectory generation is a method to find a trajectory from the current state to a desired final state that potentially passes through certain key-points. Many methods exist for generating these trajectory, of which a commonly used one is the usage of polynomial fitting. This method is briefly explained here. A polynomial is an equation of the following form:

$$x(t) = a_0 t^0 + a_1 t^1 + ...a_n t^n + a_{n-1} t^{n-1}$$

The order of the polynomial is determined by the value of n. The order of the equation, determines how many constraints can be placed on the equation. If the amount of constraints is less than $n+1$ then there are infinitely many solutions, if there are more there will be no solutions. If the amount of constraints is exactly $n+1$ there will be one unique real solution.
Therefore, if we want to constrain both the begin and end position, we need a 2^{nd} order polynomial to describe the trajectory. To constrain the begin and end, position, velocity and acceleration, we need a polynomial of the 6^{th} order. If there are a lot of way-points, we would need a very high order polynomial to describe the full trajectory. However, we can also describe only the time-frame between each way-point, a key-frame, and make the end and beginning constraints of two key-frames the same. This way the whole trajectory, is described by a number of polynomials.
For example:

$$x(t) = a_2 t^2 + a_1 t^1 + a_0 t^0$$

Start at the origin with zero velocity and for $t = 10,\ x_{(10)} = 5$ Therefore:

$$x(0) = a_0 = 0, \quad \dot{x}(0) = a_1 = 0,, \quad x(10) = a_2 10^2 + a_1 10 + a_0 = 5, \quad a_2 = 0.05$$
$$x(t) = 0.05 t^2$$

The resulting equation starts at the origin with zero velocity and will be at $x = 10$ after 10 seconds. It meets the constraints for the given time key-frame ($t_0 = 0, \quad t_f = 10$).
We applied exactly the amount of constraints that result in one unique solution. If there was one more constraint, and if the now found function did not already meet it, there would be no solution that meets all the constraints.
Instead of using equality constraints, inequality constraints can also be used. Instead, of that a point has to be reached, the polynomial or its derivative should not go above, below or cross a certain point. In the case of under constraining this can be used to reduce the number of solutions. Additionally, for over constraining, increase the amount by loosening some constraints.
However, it might be that from the available solutions, we want the polynomial with the lowest or highest value for a certain variable. This is where trajectory optimization comes in. It can be explained as adding extra constraints. The maximum or minimum of an equation is simply found by equalling the derivative to zero. Naturally this does not account,for global and local optima or there not being an optima at all.
Additionally, the physical requirements introduce limitations. The mobility and degrees of freedom of the UAV, or any vehicle can be limiting. For example, a standard quadrocopter can move in 3d linear space and rotate on the 3 axes, giving it 6 degrees of freedom. However, it cannot accelerate in each direction. The quadrocopter has to tilt to direct the thrust of its rotors

in the direction it wants to go. For cars this is more evident, they can move in 2d space but they only have two degrees of freedom, they cannot move sideways directly. These limitations have to and can be taken into account when formulating the optimization or generation problem [35][36][37].

2.2 Aerial contact

Contact is interesting for either perching or manipulation, which both require different types of manipulators and control. Examples of manipulators are using bird claw-like grasping extensions [38], spines that engage asperities on the surface [39][19] and vacuum pads for on smooth surfaces [40][21]. Each of these examples requires different conditions to be met, for example, the vacuum pads use the flight impact to get suction.
Additionally, a lot of work has been done on control at the moment of contact, perching, or manipulation. Here the choice has to made which variables to control for. is it more desirable that the drone keeps a certain angle or a certain position, for applying a force, a certain angle is required [1]. In the case of contact tracking, position control is desired [31].

2.3 Control model

The most common control system is a PID controller which stands for Proportional, Integral and Differential. The "P" just multiplies the error with a certain value, generally to create a counter effect. The "I" does the same for the integral to remove consistent errors. The "D" does the same for the integral to reduce the speed at which the error changes, so it does not overshoot.
There can be various interrelated variables in a system one might want to control for. To reduce the error of position a certain velocity is needed, which is generally the result of an applied force. Therefore, it is useful to also control for velocity, since it is also subject to error. Hence, making the correction effort less accurate, and so leaving a position error. the force is not controlled for since its directly related to the control output.
The rotors of a drone exert torques and forces, a wrench, on the drone. However, a standard drone can generally only exert a force upwards. Therefore, to generate a motion sideways the drone has to tilt first. Consequently, a drone controller, for proper position control, controls for position, velocity, orientation and angular velocity. not acceleration, since it is a direct result of the force.

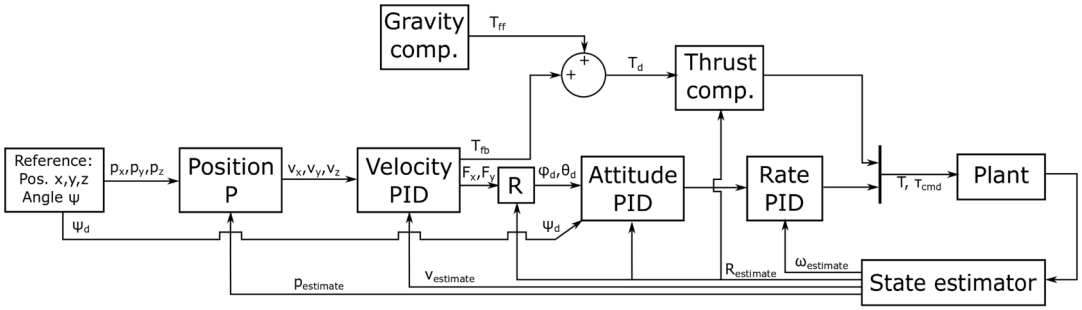

Figure 2.1: Possible drone control system

The system above needs set-points for x, y, z and one of the angles. One angle is needed because we can express a certain orientation in practically infinitely many angle combination. However, each is unique, meaning that if one angle has to be a certain value, the other two can only be one value for a certain orientation. Therefore, we have to set one angle, for the

system to be solvable. Often this is the yaw, since its value does not directly influence the force, but it does directly influence where any contraption part of the UAV, such as a manipulator, is directed at.

2.4 Communication

The trajectory generation produces a polynomial that matches the applied constraints. From the polynomial and UAVs characteristics, we can calculate the UAVs state over time, and what wrench the rotors we want to apply over time. The controller receives the wrench as feed-forward and, in a perfect world, should execute the trajectory as a result. Additionally, the trajectory sends the variables the controller controls for over time, which with feedback can be used to ensure proper trajectory execution. We can derive from this, that is very important that the controller and trajectory programs communicate over the correct time-frame and interval and are using similar units. The values in the control system do not always represent physical units, and messages with data are generally not sent continuously but with time-intervals.

3 Trajectory creation

3.1 Model

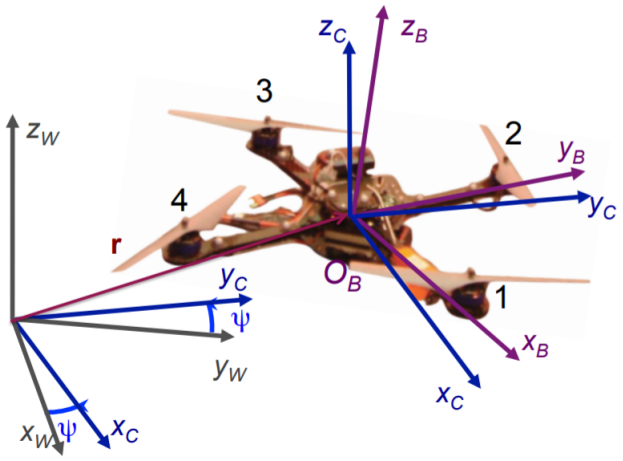

Figure 3.1: The flat outputs and the reference frames [33]

The image shows the used coordinate frames and their relation. W is the world fixed frame, assumed to be inertial. B is the body-fixed frame, generally and here attached to the centre of mass of the drone. The Euler angles are used to define the roll, pitch and yaw (ϕ, θ, ψ). The x-axes of the body-fixed frame extend from the front of the drone. The following model and explanation are based on past research [33][32].
Used variables:

- $m \in \mathbb{R}$, The total mass
- $J \in R^{3\times3}$, The inertia matrix with respect to the body-fixed frame
- $R_{x(\phi)} \in R^{3\times3}$, The orthogonal rotation matrix with a determinant of 1, for the rotation transformation around the x-axes. known as a "special orthogonal (SO) matrix"
- $R_W^B \in SO(3)$, The rotation matrix from the world frame to the body-fixed frame
- $\Omega \in R^3$, The angular velocity in the body-fixed frame
- $\Theta \in R^3$, The angles in the body-fixed frame
- $r \in R^3$, The position vector of the centre of mass in the world frame
- $v \in R^3$, The velocity vector of the centre of mass in the world frame
- $F \in R^3$, The total force vector in the body-fixed frame
- $M \in R^3$, The total moment vector in the body-fixed frame
- $u \in R^4$, The thrust and torques that the rotors collectively exert on the drone.
- $G \in R^{3\times3}$, The external force of gravity, expressed in world-frame.

The thrust and torques that act on the copter are related to the speed of the rotors, ω as each rotor produces a force and moment. The control program already knows this relation and only needs the requested force and torque as input, so only u has to be determined.
The position vector is the derivative of the velocity vector. Newtons equations describe the linear position in time as a result of the acting forces.

$$\dot{r} = v, \qquad m\dot{v} = mG + (R_W^B)^{-1}F = mG + R_B^W F$$

The Euler equations for rigid body dynamics describe the angular acceleration as a result of the moments.

$$M = I\dot{\Omega} + \Omega \times I\Omega, \qquad \Omega = \dot{\Theta}$$

$$R = R_z(\psi) \cdot R_y(\theta) \cdot R_x(\phi), \qquad R^T\dot{R} = \hat{\Omega},$$

Where the hat operator $\hat{()}$, represent the cross product operation: $x \times y = \hat{x}y$. Since the cross product is a linear transformation, it can be represented as a matrix.

3.2 Trajectory variables

To determine the thrust and torques, we only need four variables [33]. x, y, z, ψ and their derivatives. From x, y and z over time, we can determine what forces needs to be exerted on the drone, and so the required thrust, to follow those coordinates in time. However, the provided thrust is directed by the orientation. As explained earlier, an orientation can be expressed in infinite many combinations of angles, but since each one is unique we just have to define one to get the other two. The manipulator operates with an adjustable angle to the z-axes, therefore controlling for ψ gives more intuitive control.
Therefore by expressing $\sigma = [x, y, z, \psi]^T$ over time, we can use the above model to determine the translational and rotational coordinates of the trajectory and the required thrust and torques to follow that trajectory over time.

3.3 Generation

A trajectory with a low overall jerk, improves stability [35] [41]. Jerk being the derivative of the acceleration. Therefore we want to minimize the integral of the snap. Snap being the derivative of the jerk.
This means we look at the 4^{th} derivative constants for the translational coordinates. However, as can be derived from the above equations, it is the 2^{nd} derivative constant of the rotational coordinates that directly correlate with the jerk. Therefore, minimizing for total jerk is synonymous to minimizing the torque and moment.
Additionally, since we want to minimize the total jerk regardless of its direction, we take the square of the equations. Resulting in the following quadratic equation:

$$\int_{t_0}^{t_f} \mu_r ||\frac{d^4 r}{dt^4}||^2 + \mu_\psi (\frac{d^2\psi}{d^2 t})^2 dt = \int_{t_0}^{t_f} \mu_r ((\frac{d^4 x}{dt^4})^2 + (\frac{d^4 y}{dt^4})^2 + (\frac{d^4 z}{dt^4})^2) + \mu_\psi (\frac{d^2\psi}{d^2 t})^2 dt$$

With μ_r and μ_ψ are constants that make the integral non dimensional, which here are equal to 1.

3.3.1 quadratic program

The above equation can be solved by formulating it as a quadratic program:

$$min \quad g(c) = c^\top Hc + f^\top c$$

$$s.t \quad Ac = b$$

Where, c is a vector containing the variables we want to optimize. H and f are the cost function of the formula, A and b constitute the constraints. f does not apply in our case, since our equation has no non quadratic components.
We wish to constrain the begin and end position, velocity and acceleration of the drone. So x, y and z each have 6 constrains. However, the 3^{rd} derivative constant is neither defined by constraints nor part of the optimization equation. Therefore, we also constrain the jerk position at the beginning to zero, since practically speaking this would already be the case if the drone starts from rest or hovering. Now there are seven constraints and, thus, we need a 6^{th} order polynomial to have at least one solution.
In regards to the rotational coordinates over time we want to constrain the yaw orientation and velocity at the beginning and end. For four constraints we need a 3^{rd} order polynomial to have at least one solution.

To solve the quadratic program, we use the matlab quadprog function. Which uses a "interior-point-convex" algorithm [42]. Which also provides info on if the global or local optima is found. For the generated trajectories the global optima was found every-time.

3.3.2 Cost function

For this model the H matrix variables will solely constitute of the derivation and integration constants of the polynomial. Since we are only interested in optimizing the the 4^{th} and 2^{nd} derivative of the linear and angular position respectively a big part of the H matrix will constitute of zeroes. Additionally, to properly solve the function, the H matrix should be symmetric.
H matrix:
For x:

$$x(t) = x_6 t^6 + x_5 t^5 + x_4 t^4 + x_3 t^3 + x_2 t^2 + x_1 t^1 + x_0 t^0 +$$

$$\int_{t_0}^{t_f} \mu_r (\frac{d^4 x}{dt^4})^2 dt, \qquad \mu_r = 1$$

$$\frac{d^4 x}{dt^4} = 360 x_6 t^2 + 120 x_5 t + 24 x_4$$

$$(\frac{d^4 x}{dt^4})^2 = 360^2 x_6^2 t^4 + 120^2 x_5^2 t^2 + 24^2 x_4^2 + (360 \cdot 120) x_6 x_5 t^3 + (360 \cdot 24) x_6 x_4 t^2 + (120 \cdot 24) x_5 x_4 t$$

$$\int_{t_0}^{t_f} \frac{d^4 x}{dt^4}^2 dt = 360^2 x_6^2 \frac{t_f^5 - t_0^5}{5} + 120^2 x_5^2 \frac{t_f^3 - t_0^3}{3} + 24^2 x_4^2 (t_f - t_0) + ...$$

$$...(360 \cdot 120) x_6 x_5 \frac{t_f^4 - t_0^4}{4} + (360 \cdot 24) x_6 x_4 \frac{t_f^3 - t_0^3}{3} + (120 \cdot 24) x_5 x_4 \frac{t_f^2 - t_0^2}{2}$$

$$X = [x_6, x_5, x_4, x_3, x_2, x_1, x_0]^T$$

$$H = \begin{bmatrix} 360^2 \frac{t_f^5 - t_0^5}{5} & \frac{360 \cdot 120}{2} \frac{t_f^4 - t_0^4}{4} & \frac{360 \cdot 24}{2} \frac{t_f^3 - t_0^3}{3} & [0]^{1\times 3} \\ \frac{360 \cdot 120}{2} \frac{t_f^4 - t_0^4}{4} & 120^2 \frac{t_f^3 - t_0^3}{3} & \frac{120 \cdot 24}{2} \frac{t_f^2 - t_0^2}{2} & [0]^{1\times 3} \\ \frac{360 \cdot 24}{2} \frac{t_f^3 - t_0^3}{3} & \frac{120 \cdot 24}{2} \frac{t_f^2 - t_0^2}{2} & 24^2 (t_f - t_0) & [0]^{1\times 3} \\ [0]^{3\times 1} & [0]^{3\times 1} & [0]^{3\times 1} & [0]^{3\times 3} \end{bmatrix}$$

$$X^T H X = \int_{t_0}^{t_f} \frac{d^4 x}{dt^4}^2 dt$$

The steps and result are exactly the same for y and z. The H matrix are combined like a block diagram.

$$H = \begin{bmatrix} H_x & [0]^{7\times 7} & [0]^{7\times 7} \\ [0]^{7\times 7} & H_y & [0]^{7\times 7} \\ [0]^{7\times 7} & [0]^{7\times 7} & H_z \end{bmatrix}$$

Yaw part:
Same steps as above but with less derivation:

$$\psi(t) = \psi_6 t^6 + \psi_5 t^5 + \psi_4 t^4 + \psi_3 t^3 + \psi_2 t^2 + \psi_1 t + \psi_0$$

$$\frac{d^2 \psi}{dt^2} = 30 \psi_6 t^4 + 20 \psi_5 t^3 + 12 \psi_4 t^2 + 6 \psi_3 t + 2 \psi_2$$

$$H_\psi = \begin{bmatrix} 30^2\frac{t_f^9-t_0^9}{9} & \frac{30\cdot20}{2}\frac{t_f^8-t_0^8}{8} & \frac{30\cdot12}{2}\frac{t_f^7-t_0^7}{7} & \frac{30\cdot6}{2}\frac{t_f^6-t_0^6}{6} & \frac{30\cdot2}{2}\frac{t_f^5-t_0^5}{5} & [0]^{1\times2} \\ \frac{30\cdot20}{2}\frac{t_f^8-t_0^8}{8} & 20^2\frac{t_f^7-t_0^7}{7} & \frac{20\cdot12}{2}\frac{t_f^6-t_0^6}{6} & \frac{20\cdot6}{2}\frac{t_f^5-t_0^5}{5} & \frac{20\cdot2}{2}\frac{t_f^4-t_0^4}{4} & [0]^{1\times2} \\ \frac{30\cdot12}{2}\frac{t_f^7-t_0^7}{7} & \frac{20\cdot12}{2}\frac{t_f^6-t_0^6}{6} & 12^2\frac{t_f^5-t_0^5}{5} & \frac{12\cdot6}{2}\frac{t_f^4-t_0^4}{4} & \frac{12\cdot2}{2}\frac{t_f^3-t_0^3}{3} & [0]^{1\times2} \\ \frac{30\cdot6}{2}\frac{t_f^6-t_0^6}{6} & \frac{20\cdot6}{2}\frac{t_f^5-t_0^5}{5} & \frac{12\cdot6}{2}\frac{t_f^4-t_0^4}{4} & 6^2\frac{t_f^3-t_0^3}{3} & \frac{6\cdot2}{2}\frac{t_f^2-t_0^2}{2} & [0]^{1\times2} \\ \frac{30\cdot2}{2}\frac{t_f^5-t_0^5}{5} & \frac{20\cdot2}{2}\frac{t_f^4-t_0^4}{4} & \frac{12\cdot2}{2}\frac{t_f^3-t_0^3}{3} & \frac{6\cdot2}{2}\frac{t_f^2-t_0^2}{2} & 2^2(t_f-t_0) & [0]^{2\times1} \\ [0]^{2\times1} & [0]^{2\times1} & [0]^{2\times1} & [0]^{2\times1} & [0]^{2\times1} & [0]^{2\times2} \end{bmatrix}$$

3.3.3 constraints

Ac represent the polynomial equation and its possible derivatives. Since the polynomial constants are in c, A just constants powers of t and derivation constants. By matching the constrain values of b with the correct rows of A, the polynomial constraints can be expressed. A is a $n\times28$ matrix and b a $n\times1$ matrix, n being here the number of constraints. For the generation $n=25$, we constrain the begin and end, position, velocity, and acceleration, and begin jerk, of x, y and z, and the begin and end angle and angular velocity of the yaw. With this we have defined all the polynomial constants in QP formulation. Below the A and B for just the constraints on x.

$$Ac = \begin{bmatrix} t_0^6 & t_0^5 & t_0^4 & t_0^3 & t_0^2 & t_0^1 & t_0^0 & 0^{1\times21} \\ 6t_0^5 & 5t_0^4 & 4t_0^3 & 3t_0^2 & 2t_0^1 & t_0^0 & 0 & 0^{1\times21} \\ 30t_0^4 & 20t_0^3 & 12t_0^2 & 6t_0^1 & t_0^0 & 0 & 0 & 0^{1\times21} \\ 120t_0^3 & 60t_0^2 & 24t_0^1 & 6t_0^0 & 0 & 0 & 0 & O^{1\times21} \\ t_f^6 & t_f^5 & t_f^4 & t_f^3 & t_f^2 & t_f^1 & t_f^0 & 0^{1\times21} \\ 6t_f^5 & 5t_f^4 & 4t_f^3 & 3t_f^2 & 2t_f^1 & t_f^0 & 0 & {}_{1\times21} \\ 30t_f^4 & 20t_f^3 & 12t_f^2 & 6t_f^1 & t_f^0 & 0 & 0 & 0^{1\times21} \end{bmatrix} c = \begin{bmatrix} r_{x-\text{start}} \\ v_{x-\text{start}} \\ \dot{v}_{x-\text{start}} \\ \ddot{v}_{x-\text{start}} \\ r_{x-\text{end}} \\ v_{x-\text{end}} \\ \dot{v}_{x-\text{end}} \end{bmatrix} = b$$

3.3.4 Trajectory

From the resulting polynomial constants, the x, y, z and ψ and their derivatives can be expressed over time. Using the equations noted at the beginning, the desired thrust and torque for executing the minimum snap are found. However, these could be of a bigger magnitude than what the UAV can deliver. By taking this into account when formulating the constraints this can be avoided. Mainly in regards to the distance required to travel and the set time-frame. Still it is recommended to check the values, in for example graphs, to detect any problems, with the trajectory or possible mathematical mistakes or errors.

4 Experimental design

4.1 Test plan

In the introduction we stated that we are going to look at how different impact angles, impact velocity and impact acceleration, influence the deviation of the pitch and position during contact. Their are two impact angles, the angle with the horizontal axes, parallel to the surface and the angle with the vertical axes parallel to the surface. We expect that coming from the left or right, or from below or above, has no significant difference. If true, only one side has to be tested, right or left, below or above, halving the necessary testing. Therefore, this will be tested first.
Then the various values of acceleration and velocity will be tested. The value of the acceleration is limited by the velocity. If the acceleration value is low enough compared to the velocity, the drone first move backwards, to get enough velocity without a high acceleration at the end. If the acceleration value goes a certain amount above the velocity, then it can happen that the at the end, move back a bit and then accelerates. In the case of a big difference, it can happen that the drone even goes past the desired position and then moves back, in the case of there being a surface this results in crashing. As a result the number of practical velocity acceleration combinations is limited.
Additionally, due to time constraints, the path that arrives perpendicular to the surface will be more extensively tested. Thus, the effect of the impact angle in relation to the acceleration and velocity will be less mapped.
The start and end points of each trajectory will have a Euclidean distance of 5 meters and will take 15 seconds. After those 15 seconds the drone goes into approach mode for 0.5 seconds and then stays into contact mode for 10 seconds. During the contact mode the drone aims for a pitch of 20 degrees, needed to deliver a substantial force to the surface[1]. Data from the first 5 seconds contact mode will be used to analyze the state of the drone. 5 seconds was chosen since afterwards the drone should have stabilized. The end coordinates are:

$$x = 5, \quad y = 0, \quad z = 6$$

The starting point differs based on the angle of impact desired.

4.2 Set-up

The tests are carried out by using the necessary simulation, modelling, disturbance generation and control programs of the AEROWORKS project [2] which were already developed these as a result of other research and design projects. Therefore only a communication node had to be built with the controller. All communication goes through ROS messages (Robotic Operating System)[43].

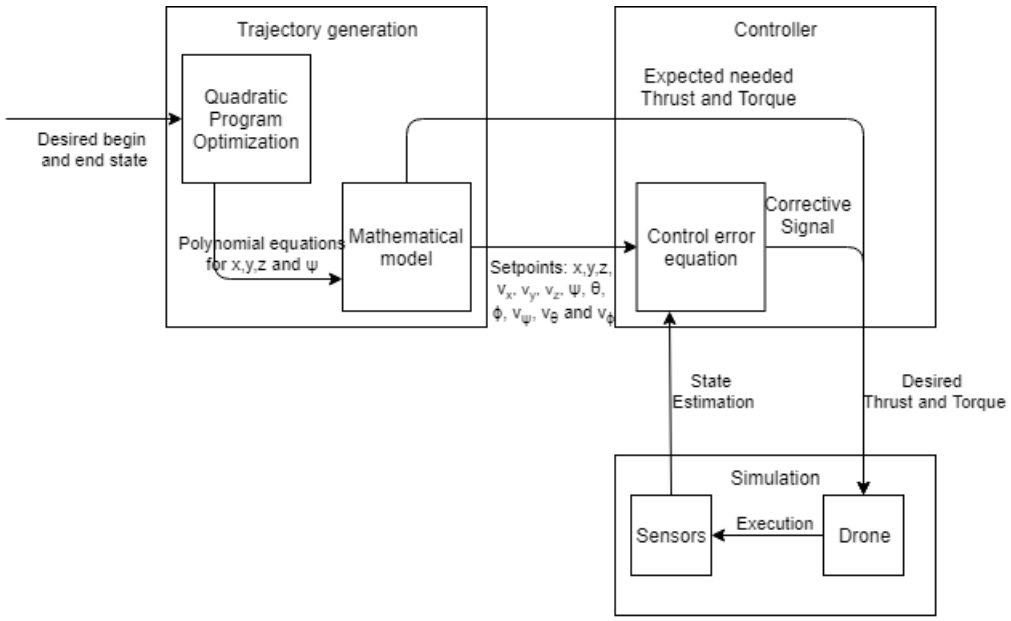

Figure 4.1: Communication model

Initial testing showed that with this set-up the trajectory was followed with very little error, even with disturbances.

4.3 Processing results

We look at three categories of error, the average absolute error during flight, the average end position absolute error, and the deviation during contact. Since the end-position is averaged we take the crashes out as not to contaminated the data. Instead the crashes are represented in the deviation representation. The errors regarding flight and end-position, are for taken for flights without any disturbance since we wish to look at the relation between the generation and execution for these errors.
For each flight, the x, y and z, error vectors, for position, velocity and acceleration are combined using Pythagoras, to determine the Euclidean distance between the desired path and executed path, in a moment of time. Then the average error over the whole flight path is taken and used to find the average error over all flight paths. We similarly find the average yaw error (in radians), but then for just the yaw and none of its derivations or the other angles, instead the absolute taken instead of using Pythagoras.

$$\text{average absolute flight error} = \frac{\text{SUM}(\text{SUM}(\sqrt{x^2_{\text{error vector}} + y^2_{\text{error vector}} + z^2_{\text{error vector}}})}{N_{\text{timesteps}} \cdot N_{\text{trajectories}}}$$

We find the average absolute end position error, by taking the absolute position error, of x, y, z, ψ and the pitch(θ)(angles in radians) at the end of the 5 second contact period, and averaging that over all the flight paths.
We find the deviation by taking the square of the error of the x, y, z and ψ during the contact period, for each moment in time, and then averaging that over the whole period.

$$\text{deviation} = \frac{\text{SUM}(\text{error}^2)}{N_{\text{timesteps}}}$$

5 Results

5.1 Unexpected bug

Originally the results were surprising, according to the recording in some cases the drone appeared to execute the commands before the drone received them. Trough some experimenting no clear cause could be confidently determined. The current theory is that the real-time factor of the simulation somehow messed with the time-stamps. Though since the system does not record the real-time factor, we base this on casual observation and so no clear correlation can be found nor confirmed. As a result, however, the execution trajectory and send trajectory are out of sync. Consequently, it becomes tough to find the data that we want, since the time cannot be trusted and any applied disturbance, immediately compromises the position.
To solve this, we took for the middle half of the trajectories the average time error and used that to sync the two trajectories. As a result, reducing the time error from up to multiple seconds to 0.1 and less than 0.006, one time-step, seconds. The higher the impact velocity and acceleration, the bigger the time error left after syncing. This comes due to paths with higher impact velocity and acceleration, generally having more complex path profiles, as in they contain more minimums, maximums, and curves.
However, trough this time translation, it could also be directly observed that the executed trajectory is the practically the same as the generated trajectory.

5.2 Data-analyses

We found that there was no significant difference between approaching from the left or right and above or below. Therefore, only we only tested for coming from above and the right.

5.2.1 During flight

Average absolute error, without any disturbance:

$$r = 0.0810, \quad v = 0.0384, \quad a = 0.1830, \quad \psi = 0.0055$$

Average absolute error, without any disturbance, and zero impact velocity or accelerations:

$$r = 0.0298, \quad v = 0.0133, \quad a = 0.0776, \quad \psi = 0.0027$$

average absolute error, without any disturbance, and zero impact accelerations:

$$r = 0.0770, \quad v = 0.0325, \quad a = 0.1538, \quad \psi = 0.0041$$

As mentioned at the beginning of this chapter, syncing the trajectories with higher impact velocity and acceleration, are harder to sync, resulting in them having a bigger error. Even so, the errors are quite low, for position never going over the 10 centimeters and without impact velocity or acceleration, even half that. As also mentioned above, it was observed that the drone, follows the desired trajectories quite precisely. Therefore, these numbers, rather, illustrate the error of the time shift left after the syncing, than the capability of the drone to follow the desired trajectory.

5.2.2 End contact

Average absolute end position error, without any disturbance, and straight impact angle:

$$x = 0.0682, \quad y = 0.0330, \quad z = 0.0823, \quad \theta = 0.0541, \quad \psi = 0.0167$$

Average absolute end position error, without any disturbance, straight impact angle, and zero impact velocity or accelerations:

$$x = 0.0321, \quad y = 0.0070, \quad z = 0.0284, \quad \theta = 0.0203, \quad \psi = 0.0067$$

Average absolute end position error, without any disturbance, straight impact angle, and zero impact accelerations:

$$x = 0.0646, \quad y = 0.0461, \quad z = 0.0662, \quad \theta = 0.0763, \quad \psi = 0.0325$$

Increasing the impact velocity or acceleration, increases the average error. This can be explained by the increasing tendency of the drone to bounce, with increasing impact velocity or acceleration.

5.2.3 During contact

The full data can be found in the Appendix. Graphs below indicate the deviation during contact with no disturbance. From the data it was observed that there was a slight correlation, between the impact velocity and acceleration, and the deviation. However, the deviation is extremely small, partly due to squaring the error. Additionally, there are also a number of tests not conforming to this correlation, instead the data appears sporadic.
Coming in with an angle and velocity, as expected increases the error in the direction of the velocity. In some cases the error could become too big and overshoot. It also happened a couple of times, with trajectories almost parallel to the surface, that the arm collided with the surface, resulting in the drone turning and no facing the direction it came from. After which it went into approach mode and flew of in the opposite direction.

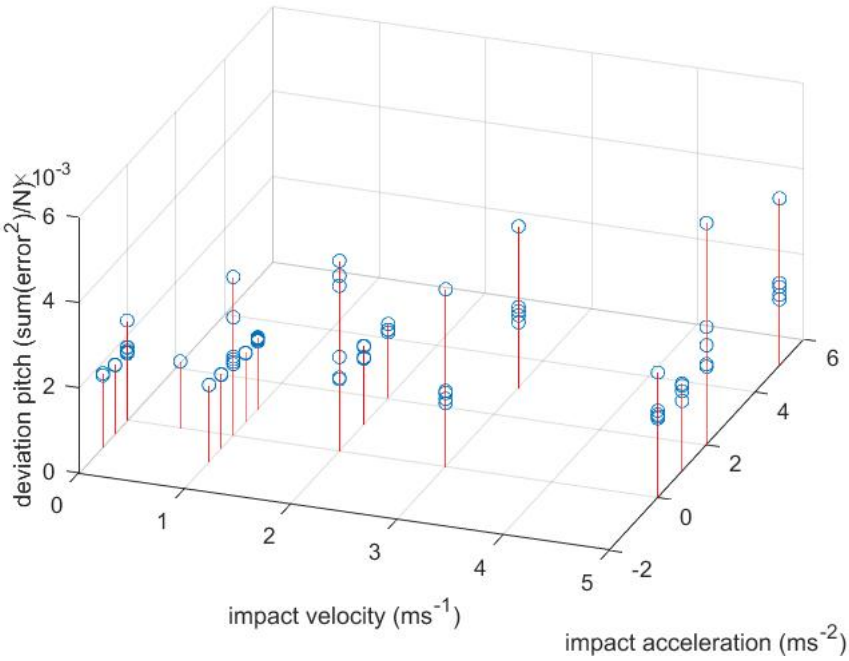

Figure 5.1: Pitch deviation during contact, with no applied disturbance

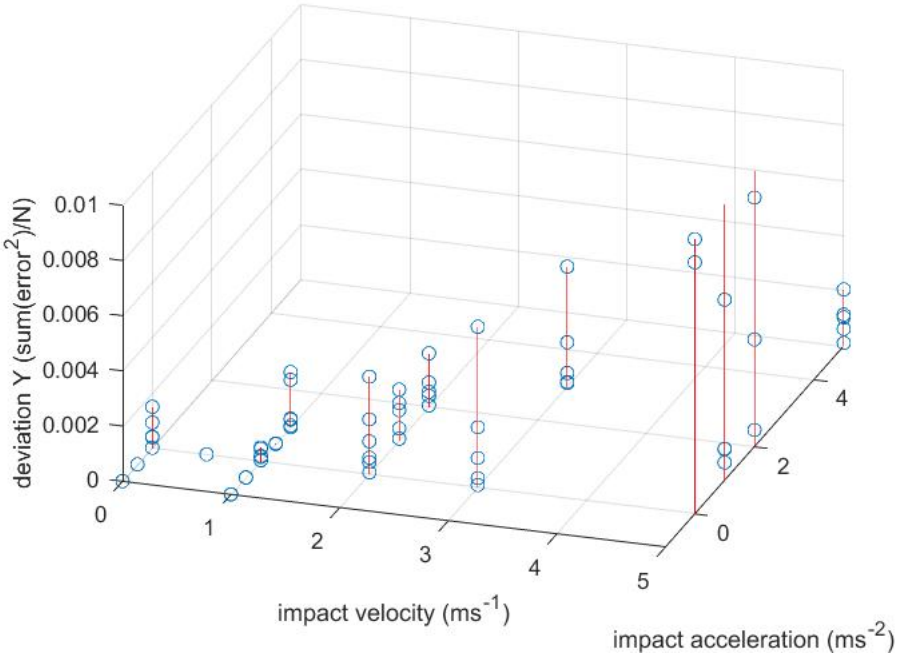

Figure 5.2: Y deviation during contact, with no applied disturbance

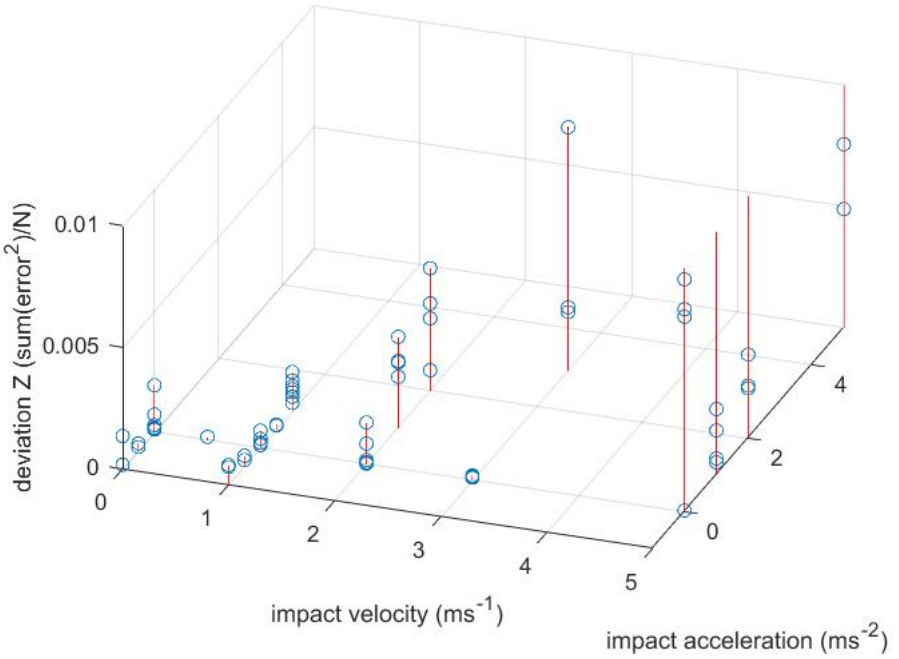

Figure 5.3: Z deviation during contact, with no applied disturbance levels

6 Conclusions and Recommendations

We presented a way to generate optimal snap trajectories for approach testing. The main challenge of building the system was the interaction with the simulation and control systems. In particular using the same time-frame, time step, signal and units is important.
Testing was done, on the effects of the approach angles on the contact position under various velocities, and the effects of impact velocity and acceleration of the drone on contact instability. There was a small correlation found between the velocity and acceleration, and the instability. However, the resulting deviation and correlation, are quite insignificant, practically looking. Additionally, we found that increasing velocity and acceleration results in an increase of the error and contact. However, any error found was still relatively small. The approach angle also had no direct effect on the instability and error. The exception being that velocities parallel to the surface, resulting in overshoot for the drone.
However, the drone executed the generated trajectories with little error. Therefore, showing that the set-up trajectory generation and controller system, worked with little issue.
It is recommended to take paths with lower impact velocity and acceleration. However, to also improve the controller in regards to coming into contact, to reduce the resulting contact error. For the velocities and accelerations tested the resulting deviation is too small to pose a serious problem generally.
Lastly, the limited duration of the project prevented the gathering of data to preferable amounts. Therefore, more data and testing of a wider range of variables could lead to different conclusions.

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Appendix

Disturbance levels:
0 means no applied disturbance
1 means low disturbance levels
3 means medium disturbance levels
5 means high disturbance levels

Straight approach, with varying velocities and accelerations

Horizontal angle (rad)	Vertical angle (rad)	Impact velocity (ms^(-1))	Impact acceleration (ms^(-2))	Disturbance level	Average position error	Average velocity error	Average acceleration error	Average yaw error	Roll contact deviation	Pitch contact deviation	Yaw contact deviation	X contact deviation	Y contact deviation	Z contact deviation	X end position	Y end position	Z end position	Pitch end orientation	Yaw end orientation
1.57E+00	1.57E+00	0.00E+00	-1.00E+00	0.00E+00	9.64E-02	4.33E-02	7.93E-02	3.15E-05	4.30E-08	1.67E-03	2.32E-07	2.62E-03	5.28E-07	1.69E-04	5.05E+00	-6.35E-04	6.01E+00	3.07E-01	8.85E-05
1.57E+00	1.57E+00	0.00E+00	-1.00E+00	0.00E+00	1.22E-01	5.35E-02	8.93E-02	2.98E-05	1.32E-08	1.72E-03	7.27E-08	2.61E-03	2.89E-07	1.36E-03	5.05E+00	4.98E-04	6.04E+00	3.07E-01	-6.33E-05
1.57E+00	1.57E+00	0.00E+00	-5.00E-01	0.00E+00	1.19E-02	3.45E-03	5.74E-03	1.51E-05	2.19E-08	1.61E-03	1.08E-07	2.66E-03	1.01E-06	2.89E-04	5.05E+00	1.04E-03	6.01E+00	3.07E-01	5.05E-05
1.57E+00	1.57E+00	0.00E+00	-5.00E-01	0.00E+00	8.47E-03	3.02E-03	5.39E-03	1.39E-05	9.71E-09	1.59E-03	4.44E-08	2.65E-03	5.25E-08	1.48E-04	5.05E+00	-2.50E-04	6.00E+00	3.07E-01	2.17E-05
1.57E+00	1.57E+00	0.00E+00	0.00E+00	0.00E+00	8.78E-03	2.60E-03	3.97E-03	1.60E-05	1.68E-08	1.56E-03	6.91E-08	2.64E-03	1.94E-08	1.03E-04	5.05E+00	-9.33E-05	6.00E+00	3.07E-01	1.40E-05
1.57E+00	1.57E+00	0.00E+00	0.00E+00	0.00E+00	8.70E-03	2.65E-03	4.55E-03	1.34E-05	3.59E-08	1.58E-03	1.92E-07	2.65E-03	1.03E-07	1.26E-04	5.05E+00	1.93E-04	6.00E+00	2.20E-01	-9.86E-05
1.57E+00	1.57E+00	0.00E+00	0.00E+00	0.00E+00	1.73E-02	3.62E-02	4.67E-01	1.55E-02	1.54E-04	1.70E-03	7.81E-04	2.65E-03	4.02E-04	1.40E-04	5.05E+00	3.05E-03	6.01E+00	2.22E-01	3.59E-02
1.57E+00	1.57E+00	0.00E+00	0.00E+00	0.00E+00	1.43E-02	3.11E-02	5.03E-01	2.01E-02	2.65E-04	1.62E-03	1.47E-03	2.69E-03	3.79E-04	2.85E-04	5.05E+00	-4.72E-03	5.98E+00	2.01E-01	1.10E-02
1.57E+00	1.57E+00	0.00E+00	0.00E+00	0.00E+00	1.63E-02	2.74E-02	4.85E-01	2.01E-02	9.26E-05	2.34E-03	4.10E-04	2.75E-03	3.81E-04	1.92E-03	5.05E+00	-1.76E-02	5.95E+00	3.06E-01	1.43E-02
1.57E+00	1.57E+00	0.00E+00	0.00E+00	0.00E+00	1.87E-02	3.28E-02	4.95E-01	1.96E-02	3.86E-04	1.72E-03	2.12E-03	2.71E-03	1.48E-03	1.81E-04	5.05E+00	8.32E-03	5.99E+00	2.47E-01	-6.76E-02
1.57E+00	1.57E+00	0.00E+00	0.00E+00	0.00E+00	1.43E-02	2.85E-02	4.86E-01	1.28E-02	3.93E-04	1.62E-03	2.17E-03	2.71E-03	9.15E-04	7.25E-04	5.05E+00	1.28E-02	6.02E+00	1.69E-01	1.46E-02
1.57E+00	1.57E+00	0.00E+00	0.00E+00	1.00E+00	4.62E-02	9.16E-02	1.44E+00	5.31E-02	1.89E-03	1.64E-03	9.75E-03	2.91E-03	4.16E-03	1.56E-04	5.05E+00	3.55E-02	5.99E+00	2.34E-01	-1.33E-02
1.57E+00	1.57E+00	0.00E+00	0.00E+00	1.00E+00	4.99E-02	1.20E-01	1.46E+00	5.47E-02	3.14E-03	2.51E-03	1.61E-02	3.15E-03	4.91E-03	5.46E-04	5.06E+00	6.23E-02	6.00E+00	2.10E-01	-1.58E-01
1.57E+00	1.57E+00	0.00E+00	0.00E+00	1.00E+00	4.43E-02	8.76E-02	1.47E+00	4.34E-02	1.44E-03	1.66E-03	7.11E-03	2.79E-03	2.40E-03	7.12E-04	5.05E+00	-4.82E-02	6.02E+00	3.04E-01	1.30E-02
1.57E+00	1.57E+00	0.00E+00	0.00E+00	1.00E+00	3.16E-02	8.77E-02	1.47E+00	5.16E-02	3.83E-03	2.04E-03	1.95E-02	3.17E-03	6.57E-02	9.73E-04	5.05E+00	2.63E-01	6.03E+00	2.55E-01	-1.09E-01
1.57E+00	1.57E+00	0.00E+00	0.00E+00	1.00E+00	4.97E-02	1.01E-01	1.46E+00	6.54E-02	9.72E-04	1.68E-03	5.05E-03	2.77E-03	5.63E-03	1.59E-04	5.05E+00	-8.44E-02	6.00E+00	1.54E-01	-2.15E-02
1.57E+00	1.57E+00	0.00E+00	0.00E+00	3.00E+00	7.20E-02	1.77E-01	2.49E+00	1.15E-01	6.04E-03	1.66E-03	2.94E-02	3.43E-03	5.29E-02	8.06E-04	5.08E+00	3.57E-01	6.03E+00	2.81E-01	-3.30E-01
1.57E+00	1.57E+00	0.00E+00	0.00E+00	3.00E+00	7.77E-02	1.84E-01	2.45E+00	6.26E-02	1.96E-02	3.45E-03	1.04E-01	5.95E-03	1.03E-01	4.17E-03	5.07E+00	-3.63E-01	6.07E+00	1.55E-01	2.53E-01
1.57E+00	1.57E+00	0.00E+00	0.00E+00	3.00E+00	6.65E-02	1.72E-01	2.52E+00	1.06E-01	3.56E-03	3.00E-03	1.62E-02	3.26E-03	6.46E-03	1.20E-03	5.08E+00	2.01E-01	5.97E+00	2.20E-01	-3.22E-01
1.57E+00	1.57E+00	0.00E+00	0.00E+00	3.00E+00	7.69E-02	1.85E-01	2.45E+00	9.89E-02	6.20E-03	2.26E-03	3.35E-02	3.53E-03	2.52E-02	5.98E-04	5.06E+00	3.48E-02	6.01E+00	2.81E-01	-2.23E-01
1.57E+00	1.57E+00	0.00E+00	0.00E+00	3.00E+00	6.08E-02	1.72E-01	2.50E+00	9.53E-02	6.65E-03	2.89E-03	3.60E-02	3.74E-03	5.17E-02	8.98E-04	5.06E+00	-1.37E-01	6.04E+00	1.16E-01	-4.18E-02
1.57E+00	1.57E+00	0.00E+00	0.00E+00	5.00E+00	6.23E-02	2.10E-02	9.96E-02	2.30E-05	9.22E-08	3.64E-03	6.23E-07	2.64E-03	8.06E-06	1.48E-04	5.06E+00	3.11E-03	6.01E+00	5.95E-02	3.21E-03
1.57E+00	1.57E+00	0.00E+00	0.00E+00	5.00E+00	1.52E-02	2.70E-03	5.31E-03	1.41E-05	5.42E-08	1.76E-03	2.97E-07	2.62E-03	5.91E-06	4.74E-04	5.05E+00	2.41E-03	6.02E+00	1.34E-01	3.97E-05
1.57E+00	1.57E+00	0.00E+00	0.00E+00	5.00E+00	9.56E-03	1.77E-03	3.88E-03	5.84E-05	9.94E-09	1.75E-03	5.05E-08	2.62E-03	1.00E-08	9.41E-04	5.05E+00	6.26E-05	6.03E+00	1.52E-01	6.98E-04
1.57E+00	1.57E+00	0.00E+00	0.00E+00	5.00E+00	5.02E-02	1.61E-02	9.39E-02	1.91E-05	8.31E-08	3.25E-03	6.38E-07	2.63E-03	2.49E-06	1.51E-04	5.06E+00	1.91E-03	6.01E+00	8.48E-02	3.82E-03
1.57E+00	1.57E+00	0.00E+00	0.00E+00	5.00E+00	1.80E-02	3.35E-03	6.73E-03	1.80E-05	5.61E-08	2.02E-03	3.09E-07	2.62E-03	7.91E-06	7.82E-04	5.06E+00	2.86E-03	6.03E+00	1.02E-01	7.67E-04
1.57E+00	1.57E+00	5.00E-01	0.00E+00	0.00E+00	7.57E-03	1.39E-03	4.25E-03	1.17E-05	3.37E-09	1.56E-03	1.73E-08	2.64E-03	3.85E-07	1.38E-04	5.05E+00	6.25E-04	6.01E+00	3.07E-01	-1.48E-05
1.57E+00	1.57E+00	1.00E+00	-1.00E+00	0.00E+00	1.26E-01	5.91E-02	1.35E-01	6.06E-05	3.32E-08	1.80E-03	1.74E-07	2.61E-03	4.64E-07	8.08E-04	5.05E+00	6.74E-04	6.03E+00	3.07E-01	1.01E-04
1.57E+00	1.57E+00	1.00E+00	-1.00E+00	0.00E+00	1.03E-01	4.64E-02	1.22E-01	5.96E-05	1.09E-07	1.81E-03	6.52E-07	2.61E-03	1.45E-05	7.36E-04	5.05E+00	3.77E-03	6.03E+00	3.07E-01	-2.21E-05
1.57E+00	1.57E+00	1.00E+00	-5.00E-01	0.00E+00	6.28E-02	2.53E-02	9.75E-02	3.21E-05	1.61E-07	1.75E-03	9.01E-07	2.61E-03	1.78E-05	2.61E-04	5.05E+00	4.16E-03	6.02E+00	3.07E-01	-1.18E-04
1.57E+00	1.57E+00	1.00E+00	-5.00E-01	0.00E+00	8.53E-02	3.68E-02	1.15E-01	3.31E-05	7.28E-08	1.73E-03	3.86E-07	2.61E-03	6.20E-07	4.40E-04	5.05E+00	-6.98E-04	6.02E+00	3.07E-01	1.35E-04
1.57E+00	1.57E+00	1.00E+00	0.00E+00	0.00E+00	3.64E-02	1.02E-02	9.38E-02	1.90E-05	2.26E-07	1.79E-03	1.24E-06	2.61E-03	1.90E-05	2.05E-04	5.05E+00	4.29E-03	6.01E+00	3.07E-01	-2.17E-04
1.57E+00	1.57E+00	1.00E+00	0.00E+00	0.00E+00	2.23E-02	3.78E-02	4.88E-01	1.90E-02	1.08E-04	1.73E-03	4.96E-04	2.62E-03	1.46E-04	7.17E-04	5.05E+00	1.35E-02	6.02E+00	3.02E-01	-1.73E-02
1.57E+00	1.57E+00	1.00E+00	0.00E+00	0.00E+00	1.95E-02	3.03E-02	4.95E-01	1.43E-02	1.53E-04	1.85E-03	7.34E-04	2.63E-03	1.77E-04	1.20E-04	5.05E+00	-8.20E-03	6.02E+00	1.18E-01	1.63E-02
1.57E+00	1.57E+00	1.00E+00	0.00E+00	0.00E+00	1.60E-02	2.93E-02	4.87E-01	2.19E-02	1.87E-04	1.68E-03	1.04E-03	2.64E-03	4.43E-04	3.85E-04	5.05E+00	-5.05E-02	6.02E+00	2.22E-01	7.94E-02
1.57E+00	1.57E+00	1.00E+00	0.00E+00	0.00E+00	6.13E-02	4.83E-02	5.97E-01	2.13E-02	4.27E-05	3.72E-03	2.37E-04	2.65E-03	2.80E-05	2.18E-04	5.06E+00	8.37E-03	6.01E+00	5.24E-02	8.99E-03
1.57E+00	1.57E+00	1.00E+00	0.00E+00	0.00E+00	4.27E-02	3.32E-02	5.72E-01	2.12E-02	1.27E-04	2.78E-03	6.50E-04	2.63E-03	4.96E-04	1.30E-04	5.06E+00	2.56E-02	6.01E+00	1.40E-01	-1.60E-02
1.57E+00	1.57E+00	1.00E+00	0.00E+00	1.00E+00	4.87E-02	9.34E-02	1.48E+00	8.12E-02	1.52E-03	1.70E-03	7.36E-03	2.81E-03	2.24E-03	5.47E-04	5.06E+00	-9.74E-02	6.03E+00	3.05E-01	1.33E-01
1.57E+00	1.57E+00	1.00E+00	0.00E+00	1.00E+00	5.94E-02	1.06E-01	1.50E+00	7.03E-02	4.73E-03	3.46E-03	2.56E-02	3.32E-03	7.28E-03	3.76E-04	5.06E+00	-7.24E-02	6.02E+00	1.15E-01	9.08E-02
1.57E+00	1.57E+00	1.00E+00	0.00E+00	1.00E+00	7.10E-02	1.02E-01	1.58E+00	5.69E-02	5.32E-04	2.51E-03	2.93E-03	2.74E-03	2.92E-04	3.62E-04	5.06E+00	-8.46E-03	6.02E+00	1.15E-01	3.54E-02
1.57E+00	1.57E+00	1.00E+00	0.00E+00	1.00E+00	1.03E-01	1.15E-01	1.58E+00	4.15E-02	2.04E-03	5.19E-03	1.13E-02	2.94E-03	9.56E-04	1.04E-04	5.05E+00	-2.29E-02	6.01E+00	2.10E-02	1.35E-01
1.57E+00	1.57E+00	1.00E+00	0.00E+00	1.00E+00	9.64E-02	9.82E-02	1.47E+00	5.29E-02	2.18E-03	1.70E-03	1.11E-02	2.91E-03	1.37E-03	1.26E-03	5.06E+00	-4.70E-02	6.03E+00	2.87E-01	2.09E-01
1.57E+00	1.57E+00	1.00E+00	0.00E+00	3.00E+00	1.20E-01	1.73E-01	2.56E+00	1.09E-01	3.98E-03	5.31E-03	1.60E-02	3.08E-03	1.99E-02	3.77E-04	5.05E+00	7.60E-02	6.02E+00	6.78E-03	-1.33E-02
1.57E+00	1.57E+00	1.00E+00	0.00E+00	3.00E+00	9.44E-02	1.68E-01	2.50E+00	1.02E-01	2.73E-03	1.40E-03	1.26E-02	2.95E-03	3.28E-02	2.66E-03	5.06E+00	-8.34E-02	6.05E+00	3.03E-01	-1.56E-01

1.57E+00	1.57E+00	1.00E+00	0.00E+00	3.00E+00	9.19E-02	1.54E-01	2.49E+00	1.15E-01	1.31E-03	1.29E-03	5.86E-03	2.80E-03	5.39E-03	8.25E-04	5.06E+00	1.17E-01	6.02E+00	2.91E-01	-1.36E-01
1.57E+00	1.57E+00	1.00E+00	0.00E+00	3.00E+00	7.66E-02	1.39E-01	2.43E+00	9.57E-02	5.34E-03	1.75E-03	2.68E-02	3.42E-03	3.64E-02	3.60E-04	5.05E+00	-1.81E-01	6.00E+00	3.00E-01	8.81E-02
1.57E+00	1.57E+00	1.00E+00	0.00E+00	3.00E+00	1.59E-01	2.15E-01	2.57E+00	8.40E-02	1.22E-02	9.56E-03	6.82E-02	4.76E-03	2.92E-02	2.95E-03	5.04E+00	9.69E-02	6.03E+00	-1.58E-01	2.54E-01
1.57E+00	1.57E+00	1.00E+00	0.00E+00	5.00E+00	9.23E-03	4.65E-03	7.04E-03	5.66E-05	4.15E-07	1.63E-03	2.20E-06	2.65E-03	1.62E-05	5.11E-04	5.05E+00	3.89E-03	6.02E+00	1.96E-01	-1.76E-04
1.57E+00	1.57E+00	1.00E+00	0.00E+00	5.00E+00	8.90E-03	4.85E-03	7.22E-03	1.90E-05	1.17E-07	1.81E-03	7.01E-07	2.62E-03	4.52E-06	9.87E-04	5.05E+00	-2.05E-03	6.03E+00	1.29E-01	2.97E-04
1.57E+00	1.57E+00	1.00E+00	0.00E+00	5.00E+00	9.14E-03	4.60E-03	7.05E-03	2.03E-05	3.83E-08	1.56E-03	2.13E-07	2.63E-03	6.93E-07	8.46E-04	5.05E+00	-8.06E-04	6.03E+00	3.04E-01	-2.86E-05
1.57E+00	1.57E+00	1.00E+00	0.00E+00	5.00E+00	1.22E-02	6.73E-03	3.16E-02	4.31E-05	2.82E-07	1.63E-03	1.50E-06	2.65E-03	1.10E-05	5.02E-04	5.05E+00	3.21E-03	6.02E+00	2.14E-01	-3.31E-04
1.57E+00	1.57E+00	1.00E+00	0.00E+00	5.00E+00	9.22E-03	5.16E-03	7.45E-03	2.75E-05	4.69E-08	1.65E-03	2.64E-07	2.63E-03	8.30E-07	9.36E-04	5.05E+00	-8.42E-04	6.03E+00	1.74E-01	4.48E-04
1.57E+00	1.57E+00	1.00E+00	5.00E-01	0.00E+00	7.18E-03	2.31E-03	4.21E-03	9.31E-06	9.11E-07	1.64E-03	4.73E-06	2.66E-03	3.28E-05	2.08E-04	5.05E+00	5.52E-03	6.00E+00	3.07E-01	-2.92E-04
1.57E+00	1.57E+00	1.00E+00	5.00E-01	0.00E+00	7.15E-03	2.10E-03	3.84E-03	9.36E-06	1.41E-07	1.62E-03	7.81E-07	2.62E-03	3.05E-06	1.71E-04	5.05E+00	-1.68E-03	6.01E+00	3.07E-01	3.53E-05
1.57E+00	1.57E+00	1.00E+00	1.00E+00	0.00E+00	9.21E-03	4.65E-03	9.73E-03	3.36E-05	7.50E-08	1.65E-03	3.93E-07	2.62E-03	2.48E-06	1.61E-03	5.05E+00	1.51E-03	6.04E+00	3.07E-01	-1.47E-04
1.57E+00	1.57E+00	1.00E+00	1.00E+00	0.00E+00	9.15E-03	4.74E-03	8.71E-03	1.78E-05	1.58E-07	1.59E-03	8.87E-07	2.63E-03	5.51E-06	1.03E-03	5.05E+00	-2.27E-03	6.03E+00	3.07E-01	4.02E-05
1.57E+00	1.57E+00	1.00E+00	1.00E+00	0.00E+00	1.66E-02	3.42E-02	4.70E-01	1.77E-02	1.31E-04	1.62E-03	5.69E-04	2.65E-03	6.50E-05	7.85E-04	5.05E+00	-1.38E-03	6.02E+00	2.61E-01	-1.16E-02
1.57E+00	1.57E+00	1.00E+00	1.00E+00	0.00E+00	1.72E-02	3.24E-02	4.98E-01	1.58E-02	1.26E-04	1.69E-03	7.45E-04	2.64E-03	2.85E-04	5.98E-04	5.05E+00	2.40E-02	6.02E+00	2.17E-01	-1.75E-03
1.57E+00	1.57E+00	1.00E+00	1.00E+00	0.00E+00	1.59E-02	2.76E-02	4.86E-01	1.37E-02	5.27E-04	1.66E-03	2.85E-03	2.71E-03	2.00E-03	9.09E-04	5.05E+00	-2.25E-02	6.02E+00	2.73E-01	4.08E-04
1.57E+00	1.57E+00	1.00E+00	1.00E+00	0.00E+00	1.53E-02	3.18E-02	4.96E-01	1.76E-02	5.17E-04	1.67E-03	2.85E-03	2.69E-03	1.72E-03	1.28E-03	5.05E+00	4.01E-02	6.03E+00	2.88E-01	-3.93E-02
1.57E+00	1.57E+00	1.00E+00	1.00E+00	0.00E+00	1.89E-02	3.85E-02	5.04E-01	2.32E-02	1.14E-04	1.61E-03	4.78E-04	2.64E-03	3.18E-04	3.41E-04	5.05E+00	1.11E-02	6.02E+00	1.81E-01	4.80E-03
1.57E+00	1.57E+00	1.00E+00	1.00E+00	1.00E+00	4.18E-02	1.06E-01	1.49E+00	4.21E-02	1.35E-03	1.92E-03	7.01E-03	2.80E-03	2.29E-03	7.14E-04	5.05E+00	1.26E-02	6.02E+00	2.45E-01	-8.05E-02
1.57E+00	1.57E+00	1.00E+00	1.00E+00	1.00E+00	4.07E-02	9.64E-02	1.40E+00	5.65E-02	1.35E-03	1.48E-03	6.46E-03	2.82E-03	7.10E-03	7.41E-04	5.05E+00	9.54E-02	6.02E+00	3.21E-01	-9.33E-02
1.57E+00	1.57E+00	1.00E+00	1.00E+00	1.00E+00	3.96E-02	8.87E-02	1.45E+00	5.66E-02	2.08E-03	1.79E-03	1.03E-02	2.90E-03	7.54E-03	2.20E-03	5.05E+00	7.62E-02	6.05E+00	2.40E-01	-1.02E-02
1.57E+00	1.57E+00	1.00E+00	1.00E+00	1.00E+00	5.29E-02	1.08E-01	1.51E+00	5.51E-02	4.34E-03	2.20E-03	2.42E-02	3.26E-03	6.77E-03	1.75E-04	5.06E+00	5.12E-02	5.99E+00	2.65E-01	-1.48E-01
1.57E+00	1.57E+00	1.00E+00	1.00E+00	1.00E+00	3.55E-02	1.03E-01	1.51E+00	6.54E-02	2.55E-03	1.84E-03	1.19E-02	2.94E-03	1.89E-03	5.17E-04	5.06E+00	8.03E-02	6.02E+00	2.53E-01	-2.12E-01
1.57E+00	1.57E+00	1.00E+00	1.00E+00	3.00E+00	6.49E-02	1.63E-01	2.41E+00	8.91E-02	1.76E-02	3.71E-03	9.90E-02	5.78E-03	1.36E-01	8.91E-04	5.10E+00	1.80E-01	6.03E+00	2.81E-01	4.58E-01
1.57E+00	1.57E+00	1.00E+00	1.00E+00	3.00E+00	6.66E-02	1.51E-01	2.45E+00	1.10E-01	5.70E-03	1.39E-03	3.53E-02	3.65E-03	4.12E-02	3.07E-03	5.08E+00	3.90E-02	6.04E+00	2.65E-01	-3.42E-01
1.57E+00	1.57E+00	1.00E+00	1.00E+00	3.00E+00	7.57E-02	1.68E-01	2.59E+00	1.07E-01	1.11E-02	2.87E-03	6.47E-02	4.77E-03	5.12E-02	7.19E-04	5.05E+00	8.34E-02	5.97E+00	2.79E-01	1.15E-01
1.57E+00	1.57E+00	1.00E+00	1.00E+00	3.00E+00	7.51E-02	1.64E-01	2.50E+00	7.17E-02	7.25E-03	1.91E-03	4.02E-02	3.83E-03	1.82E-02	1.98E-03	5.06E+00	1.55E-01	6.03E+00	3.08E-01	-2.29E-01
1.57E+00	1.57E+00	1.00E+00	1.00E+00	3.00E+00	6.94E-02	1.76E-01	2.53E+00	1.07E-01	1.25E-03	1.20E-03	5.70E-03	2.84E-03	4.07E-03	1.13E-03	5.06E+00	9.25E-02	6.02E+00	6.82E-02	-1.09E-01
1.57E+00	1.57E+00	1.00E+00	1.00E+00	5.00E+00	1.52E-01	8.97E-02	2.35E-01	1.36E-04	1.46E-04	5.02E-03	7.89E-04	2.68E-03	8.09E-04	7.99E-05	5.05E+00	2.61E-02	6.00E+00	1.53E-02	-2.01E-02
1.57E+00	1.57E+00	1.00E+00	1.00E+00	5.00E+00	3.90E-02	1.15E-02	1.23E-02	1.76E-04	1.19E-04	1.49E-03	6.60E-04	2.63E-03	4.60E-04	8.14E-04	5.05E+00	2.06E-02	5.97E+00	3.10E-01	-2.38E-02
1.57E+00	1.57E+00	1.00E+00	1.00E+00	5.00E+00	1.48E-01	8.53E-02	2.37E-01	1.62E-04	1.26E-04	5.39E-03	7.11E-04	2.67E-03	5.36E-04	3.47E-04	5.05E+00	2.04E-02	6.00E+00	-2.04E-03	-3.13E-02
1.57E+00	1.57E+00	1.00E+00	1.00E+00	5.00E+00	1.33E-01	7.68E-02	2.21E-01	1.85E-04	1.57E-04	4.14E-03	8.62E-04	2.68E-03	1.31E-03	3.46E-05	5.05E+00	3.30E-02	6.00E+00	5.67E-02	-2.64E-02
1.57E+00	1.57E+00	1.00E+00	1.00E+00	5.00E+00	5.00E-02	1.40E-02	1.91E-01	1.57E-04	1.40E-04	1.84E-03	7.76E-04	2.65E-03	8.14E-04	1.42E-04	5.06E+00	2.73E-02	6.01E+00	8.25E-02	-2.45E-02
1.57E+00	1.57E+00	2.00E+00	0.00E+00	0.00E+00	1.00E-01	5.73E-02	2.06E-01	6.64E-05	6.49E-07	1.69E-03	3.50E-06	2.60E-03	6.60E-05	1.71E-05	5.05E+00	7.97E-03	6.00E+00	3.07E-01	-3.32E-04
1.57E+00	1.57E+00	2.00E+00	0.00E+00	0.00E+00	6.03E-02	4.21E-02	6.24E-01	1.82E-02	6.82E-04	2.21E-03	3.67E-03	2.71E-03	1.19E-03	8.14E-05	5.06E+00	-2.44E-02	6.01E+00	1.29E-01	-3.57E-02
1.57E+00	1.57E+00	2.00E+00	0.00E+00	0.00E+00	1.00E-01	6.70E-02	6.82E-01	1.71E-02	3.79E-04	3.88E-03	1.98E-03	2.77E-03	4.35E-04	8.42E-04	5.06E+00	9.79E-03	5.98E+00	7.93E-02	-4.06E-02
1.57E+00	1.57E+00	2.00E+00	0.00E+00	0.00E+00	1.39E-01	9.74E-02	6.80E-01	1.79E-02	5.75E-04	4.47E-03	3.07E-03	2.74E-03	5.96E-04	1.61E-04	5.05E+00	-2.48E-02	6.00E+00	3.76E-02	3.22E-02
1.57E+00	1.57E+00	2.00E+00	0.00E+00	0.00E+00	1.16E-01	7.99E-02	6.85E-01	2.14E-02	4.87E-04	4.12E-03	2.68E-03	2.72E-03	3.53E-03	4.60E-05	5.05E+00	5.76E-02	6.00E+00	5.91E-02	-3.55E-02
1.57E+00	1.57E+00	2.00E+00	0.00E+00	0.00E+00	5.46E-02	4.38E-02	6.55E-01	1.92E-02	1.30E-04	1.72E-03	5.97E-04	2.65E-03	1.99E-03	1.70E-03	5.06E+00	4.57E-02	6.04E+00	1.12E-01	-1.38E-02
1.57E+00	1.57E+00	2.00E+00	0.00E+00	1.00E+00	1.17E-01	1.42E-01	1.68E+00	6.75E-02	6.67E-03	4.21E-03	3.82E-02	3.79E-03	3.20E-02	2.17E-03	5.06E+00	-1.25E-01	6.04E+00	5.23E-02	-1.41E-01
1.57E+00	1.57E+00	2.00E+00	0.00E+00	1.00E+00	1.23E-01	1.17E-01	1.64E+00	4.88E-02	2.00E-03	3.27E-03	1.05E-02	2.92E-03	2.65E-03	2.34E-03	5.07E+00	1.03E-01	6.05E+00	9.03E-02	-1.82E-01
1.57E+00	1.57E+00	2.00E+00	0.00E+00	1.00E+00	1.51E-01	1.39E-01	1.65E+00	5.79E-02	1.46E-03	4.54E-03	8.06E-03	2.87E-03	8.87E-04	6.16E-04	5.05E+00	-3.26E-02	6.01E+00	5.02E-02	1.22E-02
1.57E+00	1.57E+00	2.00E+00	0.00E+00	1.00E+00	1.00E-01	1.19E-01	1.67E+00	6.41E-02	8.94E-04	2.62E-03	4.03E-03	2.75E-03	3.81E-03	1.84E-04	5.06E+00	1.37E-01	6.01E+00	8.39E-02	-1.30E-01
1.57E+00	1.57E+00	2.00E+00	0.00E+00	1.00E+00	9.80E-02	1.25E-01	1.64E+00	4.25E-02	5.04E-03	3.43E-03	2.32E-02	3.42E-03	5.81E-03	8.95E-04	5.06E+00	-1.12E-01	6.00E+00	1.44E-01	2.81E-02
1.57E+00	1.57E+00	2.00E+00	0.00E+00	3.00E+00	7.64E-02	1.63E-01	2.40E+00	7.96E-02	3.72E-02	5.35E-03	2.07E-01	1.82E+00	5.68E-01	2.28E+00	9.42E+00	-2.13E+00	1.51E+00	1.32E-01	-6.98E-01
1.57E+00	1.57E+00	2.00E+00	0.00E+00	3.00E+00	8.19E-02	1.50E-01	2.64E+00	7.59E-02	3.12E-03	2.04E-03	1.87E-02	3.15E-03	1.87E-02	9.97E-04	5.08E+00	2.21E-01	6.04E+00	1.41E-01	-3.07E-01
1.57E+00	1.57E+00	2.00E+00	0.00E+00	3.00E+00	1.98E-01	2.48E-01	2.59E+00	1.44E-01	6.90E-03	5.50E-03	3.36E-02	3.56E-03	1.92E-02	1.21E-04	5.05E+00	9.03E-02	5.99E+00	2.16E-02	5.61E-03
1.57E+00	1.57E+00	2.00E+00	0.00E+00	3.00E+00	6.62E-02	1.58E-01	2.34E+00	8.24E-02	7.36E-03	2.09E-03	4.02E-02	3.80E-03	1.26E-01	1.14E-02	5.05E+00	3.81E-01	6.11E+00	3.11E-01	1.38E-04
1.57E+00	1.57E+00	2.00E+00	0.00E+00	3.00E+00	1.53E-01	1.77E-01	2.59E+00	7.85E-02	1.77E-02	6.29E-03	9.96E-02	5.95E-03	6.56E-02	1.13E-03	5.09E+00	1.23E-02	6.04E+00	8.21E-02	3.30E-01

1.57E+00	1.57E+00	2.00E+00	0.00E+00	5.00E+00	6.37E-03	2.21E-03	8.68E-03	3.69E-05	5.13E-06	1.64E-03	2.67E-05	2.65E-03	1.13E-04	2.10E-03	5.05E+00	-1.02E-02	6.04E+00	2.42E-01	4.12E-05
1.57E+00	1.57E+00	2.00E+00	0.00E+00	5.00E+00	6.96E-03	2.63E-03	1.06E-02	3.61E-05	2.03E-07	1.69E-03	1.26E-06	2.66E-03	4.14E-07	2.82E-03	5.05E+00	-4.06E-04	6.05E+00	2.05E-01	-4.33E-04
1.57E+00	1.57E+00	2.00E+00	0.00E+00	5.00E+00	7.44E-03	2.59E-03	1.07E-02	4.23E-05	4.37E-07	1.71E-03	2.23E-06	2.64E-03	1.80E-06	2.54E-03	5.05E+00	-1.08E-03	6.05E+00	1.55E-01	4.05E-04
1.57E+00	1.57E+00	2.00E+00	0.00E+00	5.00E+00	7.29E-03	2.45E-03	1.16E-02	4.48E-05	2.65E-07	1.64E-03	1.32E-06	2.64E-03	7.34E-07	2.40E-03	5.05E+00	-6.36E-04	6.05E+00	2.05E-01	-5.52E-05
1.57E+00	1.57E+00	2.00E+00	0.00E+00	5.00E+00	6.35E-03	2.11E-03	9.92E-03	3.53E-05	1.45E-07	1.68E-03	7.68E-07	2.62E-03	4.91E-06	3.22E-03	5.05E+00	2.15E-03	6.06E+00	2.05E-01	4.77E-05
1.57E+00	1.57E+00	2.00E+00	1.00E+00	0.00E+00	1.66E-02	3.34E-02	5.04E-01	1.96E-02	4.93E-04	1.83E-03	2.62E-03	2.73E-03	1.85E-03	3.72E-03	5.05E+00	-3.15E-02	6.05E+00	2.55E-01	8.80E-03
1.57E+00	1.57E+00	2.00E+00	1.00E+00	0.00E+00	1.66E-02	3.65E-02	5.14E-01	2.35E-02	6.68E-05	1.59E-03	2.85E-04	2.64E-03	7.23E-05	2.07E-03	5.05E+00	-1.70E-02	6.04E+00	1.78E-01	2.02E-02
1.57E+00	1.57E+00	2.00E+00	1.00E+00	0.00E+00	1.90E-02	3.84E-02	5.27E-01	2.13E-02	5.30E-04	1.85E-03	2.71E-03	2.70E-03	1.36E-03	2.73E-03	5.05E+00	-5.49E-02	6.05E+00	1.95E-01	1.52E-02
1.57E+00	1.57E+00	2.00E+00	1.00E+00	0.00E+00	1.66E-02	3.12E-02	5.08E-01	1.90E-02	7.15E-05	1.55E-03	3.40E-04	2.65E-03	1.11E-03	2.73E-03	5.05E+00	4.41E-02	6.05E+00	2.64E-01	-3.45E-02
1.57E+00	1.57E+00	2.00E+00	1.00E+00	0.00E+00	1.61E-02	3.80E-02	5.16E-01	2.41E-02	2.33E-04	1.57E-03	1.20E-03	2.68E-03	4.43E-04	2.66E-03	5.05E+00	-1.08E-03	6.04E+00	2.34E-01	1.13E-02
1.57E+00	1.57E+00	2.00E+00	1.00E+00	1.00E+00	4.51E-02	8.86E-02	1.30E+00	5.07E-02	3.98E-03	2.28E-03	2.10E-02	3.15E-03	4.53E-03	1.33E-03	5.06E+00	-3.13E-02	6.03E+00	2.91E-01	1.39E-01
1.57E+00	1.57E+00	2.00E+00	1.00E+00	1.00E+00	4.92E-02	1.13E-01	1.50E+00	4.98E-02	4.22E-04	1.73E-03	1.91E-03	2.68E-03	9.29E-04	1.21E-03	5.05E+00	-9.50E-03	6.03E+00	1.15E-01	-5.43E-02
1.57E+00	1.57E+00	2.00E+00	1.00E+00	1.00E+00	8.24E-02	1.25E-01	1.65E+00	6.53E-02	2.36E-03	3.63E-03	1.11E-02	2.92E-03	6.08E-03	1.91E-03	5.06E+00	-2.41E-02	6.03E+00	4.26E-02	-7.15E-02
1.57E+00	1.57E+00	2.00E+00	1.00E+00	1.00E+00	4.71E-02	1.02E-01	1.43E+00	4.29E-02	4.66E-03	2.03E-03	2.46E-02	3.31E-03	6.50E-03	2.97E-03	5.06E+00	7.15E-02	6.05E+00	3.24E-01	-1.38E-01
1.57E+00	1.57E+00	2.00E+00	1.00E+00	1.00E+00	4.41E-02	8.01E-02	1.43E+00	4.78E-02	2.72E-03	1.92E-03	1.56E-02	3.03E-03	2.52E-02	9.09E-04	5.05E+00	1.52E-01	6.03E+00	3.15E-01	-1.12E-01
1.57E+00	1.57E+00	2.00E+00	1.00E+00	3.00E+00	8.13E-02	1.96E-01	2.68E+00	1.03E-01	4.38E-03	3.36E-03	2.19E-02	3.20E-03	2.41E-02	3.70E-04	5.06E+00	-4.09E-02	6.03E+00	1.02E-01	-1.27E-01
1.57E+00	1.57E+00	2.00E+00	1.00E+00	3.00E+00	8.29E-02	1.65E-01	2.48E+00	1.45E-01	4.73E-02	9.65E-03	2.41E-01	2.11E+00	1.08E+00	3.30E+00	9.56E+00	3.33E+00	5.29E-01	2.27E-01	5.70E-01
1.57E+00	1.57E+00	2.00E+00	1.00E+00	3.00E+00	7.74E-02	1.47E-01	2.42E+00	8.81E-02	2.36E-01	5.69E-02	1.20E+00	4.23E+01	4.97E+00	1.13E+01	1.72E+01	-1.58E+00	4.98E-01	1.30E-01	1.07E+00
1.57E+00	1.57E+00	2.00E+00	1.00E+00	3.00E+00	1.02E-01	1.88E-01	2.47E+00	9.50E-02	8.42E-03	2.45E-03	4.91E-02	4.29E-03	1.09E-02	1.98E-03	5.06E+00	4.89E-02	6.03E+00	3.09E-01	-1.44E-01
1.57E+00	1.57E+00	2.00E+00	1.00E+00	3.00E+00	7.82E-02	1.56E-01	2.44E+00	1.08E-01	3.69E-03	1.49E-03	1.38E-02	3.01E-03	4.83E-03	1.68E-03	5.06E+00	-1.51E-01	6.02E+00	2.86E-01	2.09E-01
1.57E+00	1.57E+00	2.00E+00	1.00E+00	5.00E+00	6.78E-02	4.40E-02	3.55E-02	2.42E-05	4.59E-06	1.52E-03	2.18E-05	2.61E-03	4.76E-05	1.48E-03	5.05E+00	-6.39E-03	6.03E+00	3.07E-01	-5.01E-04
1.57E+00	1.57E+00	2.00E+00	1.00E+00	5.00E+00	7.66E-02	4.93E-02	3.96E-02	4.68E-05	2.24E-06	1.66E-03	1.16E-05	2.55E-03	2.85E-05	2.80E-03	5.05E+00	-5.04E-03	6.05E+00	3.07E-01	-4.61E-04
1.57E+00	1.57E+00	2.00E+00	1.00E+00	5.00E+00	7.03E-02	4.53E-02	3.71E-02	3.04E-05	3.36E-06	1.54E-03	1.53E-05	2.61E-03	4.14E-05	6.82E-04	5.05E+00	-6.17E-03	6.02E+00	3.07E-01	-4.61E-04
1.57E+00	1.57E+00	2.00E+00	1.00E+00	5.00E+00	8.67E-02	5.57E-02	4.44E-02	2.37E-05	1.82E-06	1.51E-03	8.85E-06	2.55E-03	7.42E-05	3.62E-03	5.05E+00	8.39E-03	6.06E+00	3.07E-01	-3.93E-05
1.57E+00	1.57E+00	2.00E+00	1.00E+00	5.00E+00	6.39E-02	4.11E-02	3.31E-02	2.47E-05	1.38E-06	1.87E-03	5.74E-06	2.67E-03	7.82E-06	1.02E-03	5.05E+00	-2.62E-03	6.02E+00	3.07E-01	-4.25E-04
1.57E+00	1.57E+00	2.00E+00	2.00E+00	0.00E+00	8.11E-02	6.36E-02	5.10E-01	2.01E-02	3.06E-04	1.61E-03	1.65E-03	2.58E-03	4.13E-04	5.03E-03	5.05E+00	1.91E-02	6.07E+00	3.05E-01	-3.02E-02
1.57E+00	1.57E+00	2.00E+00	2.00E+00	0.00E+00	7.62E-02	6.09E-02	5.11E-01	1.84E-02	1.21E-04	1.60E-03	5.52E-04	2.60E-03	5.75E-05	8.32E-04	5.05E+00	-1.29E-02	6.02E+00	3.09E-01	9.26E-03
1.57E+00	1.57E+00	2.00E+00	2.00E+00	0.00E+00	8.51E-02	6.79E-02	5.10E-01	2.93E-02	4.33E-04	1.61E-03	2.14E-03	2.61E-03	8.95E-04	3.58E-03	5.05E+00	1.25E-02	6.06E+00	3.10E-01	-5.93E-02
1.57E+00	1.57E+00	2.00E+00	2.00E+00	0.00E+00	7.86E-02	6.32E-02	5.15E-01	2.19E-02	6.69E-04	1.74E-03	3.33E-03	2.62E-03	1.95E-03	5.02E-03	5.05E+00	-2.21E-03	6.07E+00	3.08E-01	-8.27E-02
1.57E+00	1.57E+00	2.00E+00	2.00E+00	0.00E+00	8.15E-02	6.80E-02	5.16E-01	1.69E-02	2.72E-04	1.54E-03	1.38E-03	2.59E-03	5.62E-04	2.96E-03	5.05E+00	4.30E-02	6.05E+00	3.04E-01	-4.89E-02
1.57E+00	1.57E+00	2.00E+00	2.00E+00	1.00E+00	8.06E-02	1.07E-01	1.49E+00	6.74E-02	3.95E-03	1.86E-03	1.97E-02	3.10E-03	6.54E-03	1.30E-03	5.05E+00	7.24E-02	6.03E+00	3.02E-01	-6.11E-02
1.57E+00	1.57E+00	2.00E+00	2.00E+00	1.00E+00	1.04E-01	1.26E-01	1.46E+00	6.40E-02	3.66E-03	2.19E-03	2.02E-02	3.07E-03	6.52E-03	4.65E-03	5.05E+00	5.10E-02	6.06E+00	3.05E-01	3.78E-02
1.57E+00	1.57E+00	2.00E+00	2.00E+00	1.00E+00	8.15E-02	1.09E-01	1.48E+00	6.89E-02	1.30E-02	2.58E-03	6.50E-02	4.91E-03	1.52E-02	8.86E-03	5.05E+00	-5.15E-02	6.09E+00	3.16E-01	-2.55E-02
1.57E+00	1.57E+00	2.00E+00	2.00E+00	1.00E+00	8.33E-02	1.08E-01	1.48E+00	5.71E-02	3.03E-03	2.70E-03	1.57E-02	3.07E-03	1.08E-02	3.39E-03	5.05E+00	-9.31E-02	6.04E+00	3.07E-01	3.02E-02
1.57E+00	1.57E+00	2.00E+00	2.00E+00	1.00E+00	8.03E-02	1.25E-01	1.48E+00	5.41E-02	5.33E-03	2.05E-03	2.65E-02	3.26E-03	5.39E-03	4.78E-03	5.05E+00	-5.12E-03	6.06E+00	3.04E-01	-9.08E-02
1.57E+00	1.57E+00	2.00E+00	2.00E+00	3.00E+00	9.62E-02	1.65E-01	2.45E+00	8.55E-02	5.96E-03	1.82E-03	2.86E-02	3.36E-03	9.62E-03	6.23E-04	5.06E+00	1.14E-01	6.03E+00	3.12E-01	-1.35E-01
1.57E+00	1.57E+00	2.00E+00	2.00E+00	3.00E+00	1.15E-01	1.78E-01	2.48E+00	8.42E-02	1.41E-02	2.85E-03	6.05E-02	4.84E-03	2.79E-02	1.37E-02	5.05E+00	-2.12E-01	6.11E+00	3.15E-01	9.24E-02
1.57E+00	1.57E+00	2.00E+00	2.00E+00	3.00E+00	9.49E-02	1.69E-01	2.41E+00	9.71E-02	1.82E-02	3.97E-03	1.01E-01	5.81E-03	9.73E-02	2.27E-02	5.05E+00	2.82E-01	6.16E+00	3.26E-01	-5.66E-02
1.57E+00	1.57E+00	2.00E+00	2.00E+00	3.00E+00	1.04E-01	1.84E-01	2.48E+00	9.33E-02	1.88E-03	1.74E-03	6.91E-03	2.75E-03	5.79E-03	3.39E-04	5.05E+00	6.80E-02	5.99E+00	3.11E-01	3.92E-03
1.57E+00	1.57E+00	2.00E+00	2.00E+00	3.00E+00	1.12E-01	1.87E-01	2.45E+00	9.98E-02	6.63E-03	1.63E-03	2.65E-02	3.37E-03	1.29E-02	5.10E-03	5.05E+00	-1.24E-01	6.06E+00	2.94E-01	1.20E-01
1.57E+00	1.57E+00	2.00E+00	2.00E+00	5.00E+00	8.96E-02	3.70E-02	1.53E-02	1.29E-04	3.99E-07	1.54E-03	2.00E-06	2.65E-03	5.61E-05	1.05E-04	5.05E+00	7.40E-03	6.00E+00	3.07E-01	-1.99E-04
1.57E+00	1.57E+00	2.00E+00	2.00E+00	5.00E+00	1.92E-02	9.48E-03	1.01E-02	1.39E-04	9.60E-08	1.54E-03	4.92E-07	2.66E-03	2.57E-05	8.65E-05	5.05E+00	5.02E-03	5.99E+00	2.57E-01	-2.18E-04
1.57E+00	1.57E+00	2.00E+00	2.00E+00	5.00E+00	1.53E-01	6.12E-02	2.48E-02	1.27E-04	2.06E-07	1.57E-03	1.06E-06	2.72E-03	4.35E-05	1.34E-04	5.05E+00	6.55E-03	6.00E+00	3.07E-01	-6.92E-05
1.57E+00	1.57E+00	2.00E+00	2.00E+00	5.00E+00	3.43E-01	1.36E-01	5.30E-02	1.30E-04	2.33E-06	2.61E-03	1.12E-05	2.98E-03	1.38E-04	3.39E-03	5.05E+00	1.16E-02	6.06E+00	3.07E-01	3.82E-04
1.57E+00	1.57E+00	2.00E+00	2.00E+00	5.00E+00	2.07E-01	8.23E-02	3.38E-02	1.27E-04	9.57E-07	2.13E-03	5.07E-06	3.31E-03	4.05E-06	3.94E-05	5.05E+00	-1.26E-03	6.00E+00	3.07E-01	-4.59E-04
1.57E+00	1.57E+00	3.00E+00	0.00E+00	0.00E+00	6.02E-02	4.26E-02	4.97E-01	1.44E-02	1.62E-04	1.59E-03	6.63E-04	2.67E-03	9.03E-05	1.10E-04	5.05E+00	-2.04E-03	5.99E+00	3.06E-01	2.07E-02
1.57E+00	1.57E+00	3.00E+00	0.00E+00	0.00E+00	1.76E-01	7.85E-02	4.83E-01	2.14E-02	1.75E-04	1.78E-03	1.03E-03	3.00E-03	3.39E-04	1.23E-04	5.05E+00	1.80E-02	6.01E+00	3.06E-01	-2.56E-02
1.57E+00	1.57E+00	3.00E+00	0.00E+00	0.00E+00	2.82E-02	3.99E-02	5.03E-01	1.90E-02	5.57E-05	1.49E-03	2.43E-04	2.57E-03	1.07E-03	8.86E-05	5.05E+00	2.90E-02	6.00E+00	2.46E-01	-7.62E-04

1.57E+00	1.57E+00	3.00E+00	0.00E+00	0.00E+00	3.55E-01	1.49E-01	4.93E-01	2.49E-02	3.13E-04	4.16E-03	1.74E-03	2.83E-03	5.83E-03	1.79E-04	5.05E+00	7.82E-02	6.01E+00	3.13E-01	-7.99E-03
1.57E+00	1.57E+00	3.00E+00	0.00E+00	0.00E+00	1.86E-01	8.40E-02	4.82E-01	2.13E-02	2.86E-04	1.73E-03	1.45E-03	2.65E-03	2.18E-03	1.37E-04	5.05E+00	6.18E-02	6.00E+00	3.02E-01	-5.27E-02
1.57E+00	1.57E+00	3.00E+00	0.00E+00	1.00E+00	4.70E-02	9.08E-02	1.33E+00	5.70E-02	1.24E-03	1.56E-03	5.91E-03	2.79E-03	1.23E-03	1.11E-04	5.05E+00	-4.72E-02	6.00E+00	1.94E-01	1.31E-02
1.57E+00	1.57E+00	3.00E+00	0.00E+00	1.00E+00	3.80E-01	1.92E-01	1.50E+00	4.90E-02	3.27E-03	4.07E-03	1.61E-02	3.58E-03	3.84E-03	1.66E-04	5.09E+00	1.85E-01	6.00E+00	2.77E-01	-4.00E-01
1.57E+00	1.57E+00	3.00E+00	0.00E+00	1.00E+00	3.60E-01	1.89E-01	1.40E+00	5.00E-02	4.87E-03	4.14E-03	2.82E-02	4.04E-03	2.55E-02	1.22E-03	5.05E+00	1.20E-01	6.03E+00	2.96E-01	-4.27E-02
1.57E+00	1.57E+00	3.00E+00	0.00E+00	1.00E+00	9.91E-02	1.02E-01	1.48E+00	7.44E-02	1.18E-03	2.41E-03	5.05E-03	2.85E-03	1.28E-02	5.34E-04	5.05E+00	-1.39E-01	6.00E+00	3.13E-01	7.96E-02
1.57E+00	1.57E+00	3.00E+00	0.00E+00	1.00E+00	7.75E-02	1.21E-01	1.52E+00	6.98E-02	4.80E-03	2.83E-03	2.74E-02	3.24E-03	3.22E-02	7.80E-04	5.05E+00	-1.44E-01	6.04E+00	1.05E-01	-4.49E-02
1.57E+00	1.57E+00	3.00E+00	0.00E+00	3.00E+00	1.43E-01	1.80E-01	2.45E+00	1.40E-01	3.63E-01	6.69E-02	1.48E+00	4.00E+01	1.09E+00	1.16E+01	1.68E+01	2.32E-01	8.33E-01	-6.15E-02	1.46E+00
1.57E+00	1.57E+00	3.00E+00	0.00E+00	3.00E+00	1.87E-01	1.84E-01	2.46E+00	8.62E-02	1.97E-02	3.71E-03	1.04E-01	5.22E-03	2.04E-01	1.06E-02	5.06E+00	-4.57E-01	6.10E+00	3.16E-01	1.36E-01
1.57E+00	1.57E+00	3.00E+00	0.00E+00	3.00E+00	1.35E-01	1.82E-01	2.49E+00	1.12E-01	7.07E-03	2.14E-03	3.58E-02	3.53E-03	3.50E-02	4.62E-03	5.06E+00	-2.16E-01	6.08E+00	3.31E-01	1.31E-01
1.57E+00	1.57E+00	3.00E+00	0.00E+00	3.00E+00	8.48E-02	1.84E-01	2.45E+00	1.29E-01	2.70E+00	2.80E-01	2.71E+00	1.09E-01	9.12E+01	1.53E+01	4.50E+00	-1.41E+01	4.91E-02	-2.51E-04	-2.57E+00
1.57E+00	1.57E+00	3.00E+00	0.00E+00	3.00E+00	7.43E-02	1.49E-01	2.27E+00	9.27E-02	6.03E-03	2.00E-03	2.79E-02	3.20E-03	8.52E-02	4.48E-04	5.06E+00	2.19E-01	6.02E+00	2.97E-01	1.96E-01
1.57E+00	1.57E+00	3.00E+00	0.00E+00	5.00E+00	7.76E-02	5.92E-02	4.68E-02	4.54E-05	9.58E-06	1.65E-03	4.82E-05	2.57E-03	1.07E-04	1.92E-02	5.05E+00	-9.80E-03	6.14E+00	3.07E-01	-1.10E-03
1.57E+00	1.57E+00	3.00E+00	0.00E+00	5.00E+00	2.57E-02	1.75E-02	1.51E-02	5.54E-05	1.50E-06	1.56E-03	7.85E-06	2.58E-03	7.35E-05	1.36E-02	5.05E+00	8.32E-03	6.11E+00	3.07E-01	-5.82E-04
1.57E+00	1.57E+00	3.00E+00	0.00E+00	5.00E+00	3.04E-02	2.16E-02	1.84E-02	5.67E-05	1.97E-06	1.53E-03	1.04E-05	2.57E-03	4.55E-05	5.69E-03	5.05E+00	6.35E-03	6.07E+00	3.07E-01	-7.97E-04
1.57E+00	1.57E+00	3.00E+00	0.00E+00	5.00E+00	5.28E-02	3.92E-02	3.17E-02	4.83E-05	2.49E-06	1.64E-03	1.31E-05	2.58E-03	4.58E-06	1.85E-02	5.05E+00	-1.30E-03	6.13E+00	3.07E-01	-8.05E-04
1.57E+00	1.57E+00	3.00E+00	0.00E+00	5.00E+00	3.53E-02	2.55E-02	2.16E-02	5.28E-05	2.03E-06	1.63E-03	1.09E-05	2.64E-03	1.25E-04	2.07E-02	5.05E+00	1.09E-02	6.14E+00	3.07E-01	-4.21E-04
1.57E+00	1.57E+00	3.00E+00	3.00E+00	0.00E+00	9.46E-02	8.14E-02	4.99E-01	1.96E-02	1.25E-04	1.53E-03	6.63E-04	2.64E-03	4.99E-04	2.56E-03	5.05E+00	3.25E-02	6.05E+00	3.11E-01	-4.05E-02
1.57E+00	1.57E+00	3.00E+00	3.00E+00	0.00E+00	2.89E-02	3.73E-02	4.93E-01	1.83E-02	4.56E-04	3.78E-03	1.59E-03	2.89E-03	1.77E-04	9.96E-03	5.05E+00	-4.34E-03	6.08E+00	3.04E-01	-1.89E-02
1.57E+00	1.57E+00	3.00E+00	3.00E+00	0.00E+00	1.20E-01	1.02E-01	5.03E-01	2.30E-02	1.15E-04	1.88E-03	5.28E-04	2.69E-03	1.39E-04	2.36E-03	5.05E+00	-2.27E-02	6.05E+00	3.06E-01	4.08E-02
1.57E+00	1.57E+00	3.00E+00	3.00E+00	0.00E+00	2.25E-02	3.90E-02	7.21E-01	1.98E-02	3.06E-04	1.69E-03	1.48E-03	2.66E-03	1.61E-03	3.01E-02	5.05E+00	-5.58E-02	6.17E+00	2.96E-01	2.61E-02
1.57E+00	1.57E+00	3.00E+00	3.00E+00	0.00E+00	7.34E-02	7.03E-02	4.94E-01	1.24E-02	8.31E-04	1.79E-03	4.41E-03	2.67E-03	4.36E-03	1.93E-02	5.05E+00	-6.42E-02	6.14E+00	3.05E-01	2.62E-02
1.57E+00	1.57E+00	3.00E+00	3.00E+00	1.00E+00	1.21E-01	1.49E-01	1.51E+00	4.36E-02	7.36E-03	2.00E-03	3.40E-02	3.48E-03	8.64E-03	3.07E-02	5.05E+00	3.10E-02	6.16E+00	3.04E-01	-6.80E-02
1.57E+00	1.57E+00	3.00E+00	3.00E+00	1.00E+00	1.87E-01	1.84E-01	1.49E+00	4.35E-02	2.64E-03	1.97E-03	1.32E-02	2.83E-03	5.06E-03	4.44E-03	5.05E+00	2.32E-03	6.07E+00	3.19E-01	9.36E-02
1.57E+00	1.57E+00	3.00E+00	3.00E+00	1.00E+00	5.42E-02	1.01E-01	1.47E+00	4.90E-02	2.03E-03	1.58E-03	9.01E-03	2.82E-03	1.45E-02	1.74E-03	5.06E+00	-1.78E-01	6.03E+00	2.97E-01	1.70E-01
1.57E+00	1.57E+00	3.00E+00	3.00E+00	1.00E+00	4.80E-02	9.05E-02	1.46E+00	8.09E-02	1.18E-02	2.72E-03	5.98E-02	4.65E-03	3.47E-02	2.40E-02	5.05E+00	-1.63E-01	6.15E+00	3.03E-01	-7.83E-02
1.57E+00	1.57E+00	3.00E+00	3.00E+00	1.00E+00	1.35E-01	1.48E-01	1.47E+00	5.94E-02	9.76E-03	2.68E-03	5.05E-02	3.79E-03	4.32E-02	6.07E-03	5.05E+00	-1.92E-01	6.08E+00	3.17E-01	6.75E-02
1.57E+00	1.57E+00	3.00E+00	3.00E+00	3.00E+00	8.89E-02	1.72E-01	2.33E+00	9.70E-02	6.49E-03	1.96E-03	3.24E-02	3.44E-03	8.61E-03	1.62E-02	5.07E+00	5.81E-02	6.12E+00	2.85E-01	-2.86E-01
1.57E+00	1.57E+00	3.00E+00	3.00E+00	3.00E+00	1.07E-01	1.88E-01	2.47E+00	9.30E-02	6.88E-03	2.03E-03	3.34E-02	3.22E-03	2.89E-02	8.70E-03	5.06E+00	2.05E-01	6.09E+00	2.94E-01	-1.50E-01
1.57E+00	1.57E+00	3.00E+00	3.00E+00	3.00E+00	1.44E-01	1.96E-01	2.51E+00	1.51E-01	1.29E-02	4.57E-03	7.48E-02	4.66E-03	1.93E-02	8.53E-03	5.06E+00	5.56E-02	6.09E+00	2.80E-01	2.24E-01
1.57E+00	1.57E+00	3.00E+00	3.00E+00	3.00E+00	1.18E-01	1.92E-01	2.46E+00	1.04E-01	3.92E-01	8.29E-02	1.29E+00	2.28E+01	3.45E+01	1.48E+01	1.29E+01	-1.07E+01	3.45E-01	3.18E-01	4.38E-02
1.57E+00	1.57E+00	3.00E+00	3.00E+00	3.00E+00	1.08E-01	2.17E-01	2.54E+00	1.04E-01	5.00E-03	1.62E-03	1.90E-02	3.07E-03	3.60E-03	1.17E-02	5.05E+00	-7.49E-02	6.10E+00	3.03E-01	8.60E-02
1.57E+00	1.57E+00	3.00E+00	3.00E+00	5.00E+00	1.28E-01	5.70E-02	2.34E-02	3.69E-04	3.19E-07	2.12E-03	1.88E-06	1.03E-02	1.41E-04	1.34E-02	5.05E+00	1.18E-02	5.88E+00	3.07E-01	-2.18E-04
1.57E+00	1.57E+00	3.00E+00	3.00E+00	5.00E+00	1.66E-01	7.40E-02	2.68E-02	3.65E-04	9.31E-06	1.69E-03	4.80E-05	5.74E-03	1.21E-04	2.02E-03	5.05E+00	-1.03E-02	5.95E+00	3.07E-01	-1.05E-03
1.57E+00	1.57E+00	3.00E+00	3.00E+00	5.00E+00	1.03E-01	4.82E-02	2.44E-02	3.74E-04	1.47E-06	2.02E-03	8.19E-06	8.34E-03	1.40E-05	4.10E-02	5.05E+00	2.85E-03	5.79E+00	3.07E-01	-6.11E-04
1.57E+00	1.57E+00	3.00E+00	3.00E+00	5.00E+00	1.35E-01	6.15E-02	2.56E-02	3.74E-04	7.27E-06	1.68E-03	3.69E-05	7.20E-03	7.89E-05	5.06E-03	5.05E+00	-8.17E-03	5.93E+00	3.07E-01	-8.99E-04
1.57E+00	1.57E+00	3.00E+00	3.00E+00	5.00E+00	2.50E-01	1.05E-01	4.11E-02	3.67E-04	3.49E-06	1.77E-03	1.79E-05	9.51E-03	1.38E-05	7.91E-03	5.05E+00	-2.19E-03	5.91E+00	3.07E-01	-8.54E-04
1.57E+00	1.57E+00	5.00E+00	0.00E+00	0.00E+00	2.83E-01	1.26E-01	4.47E-01	1.62E-02	5.71E-04	1.90E-03	2.82E-03	9.19E-03	9.12E-03	1.88E-02	5.05E+00	1.07E-01	5.85E+00	3.08E-01	-1.29E-03
1.57E+00	1.57E+00	5.00E+00	0.00E+00	0.00E+00	3.78E-01	1.66E-01	4.77E-01	1.75E-02	4.61E-04	2.04E-03	2.17E-03	9.62E-03	9.96E-03	9.55E-03	5.05E+00	1.34E-01	5.89E+00	3.02E-01	-7.86E-02
1.57E+00	1.57E+00	5.00E+00	0.00E+00	0.00E+00	3.92E-01	1.67E-01	4.75E-01	1.73E-02	2.37E-03	2.93E-03	1.31E-02	9.97E-03	4.50E-02	8.32E-03	5.05E+00	2.31E-01	5.90E+00	2.99E-01	3.90E-03
1.57E+00	1.57E+00	5.00E+00	0.00E+00	0.00E+00	3.36E-01	1.47E-01	4.99E-01	2.09E-02	3.67E-03	1.86E-03	1.82E-02	8.49E-03	2.78E-02	4.75E-05	5.05E+00	1.47E-01	6.00E+00	3.05E-01	4.28E-02
1.57E+00	1.57E+00	5.00E+00	0.00E+00	0.00E+00	2.23E-01	1.01E-01	4.87E-01	1.80E-02	1.69E-03	1.95E-03	8.66E-03	7.84E-03	1.00E-02	8.01E-03	5.05E+00	6.90E-02	5.90E+00	3.04E-01	6.27E-02
1.57E+00	1.57E+00	5.00E+00	0.00E+00	1.00E+00	3.48E-01	1.82E-01	1.49E+00	6.16E-02	3.78E-03	1.73E-03	1.82E-02	5.33E-03	7.49E-03	8.14E-04	5.05E+00	-4.51E-02	5.97E+00	3.07E-01	1.23E-02
1.57E+00	1.57E+00	5.00E+00	0.00E+00	1.00E+00	3.78E-01	1.98E-01	1.50E+00	4.68E-02	6.77E-03	1.94E-03	3.26E-02	7.02E-03	7.11E-02	2.16E-04	5.05E+00	2.85E-01	5.98E+00	2.97E-01	4.59E-02
1.57E+00	1.57E+00	5.00E+00	0.00E+00	1.00E+00	2.82E-01	1.70E-01	1.48E+00	6.22E-02	7.51E-03	2.77E-03	4.29E-02	6.51E-03	5.57E-02	1.15E-04	5.06E+00	-3.14E-01	6.00E+00	2.84E-01	1.74E-01
1.57E+00	1.57E+00	5.00E+00	0.00E+00	1.00E+00	3.31E-01	1.69E-01	1.48E+00	5.17E-02	1.30E-01	2.20E-01	1.72E+00	2.17E+01	3.60E+01	1.47E+01	1.07E+01	-9.30E+00	4.07E-01	2.54E-02	1.25E+00
1.57E+00	1.57E+00	5.00E+00	0.00E+00	1.00E+00	2.50E-01	1.46E-01	1.46E+00	7.05E-02	1.37E+00	1.45E-01	1.03E+00	4.79E+01	1.65E+01	1.24E+01	1.66E+01	-5.17E+00	2.54E-01	-2.38E-01	-1.05E+00
1.57E+00	1.57E+00	5.00E+00	0.00E+00	3.00E+00	2.57E-01	1.95E-01	2.39E+00	1.04E-01	8.64E-03	1.95E-03	4.26E-02	7.05E-03	1.04E-01	3.78E-02	5.05E+00	-3.97E-01	5.80E+00	3.20E-01	5.26E-02

1.57E+00	1.57E+00	5.00E+00	0.00E+00	3.00E+00	3.47E-01	2.27E-01	2.50E+00	8.85E-02	6.06E-03	1.94E-03	2.81E-02	1.41E-02	5.78E-02	1.68E-03	5.06E+00	1.49E-01	6.04E+00	2.92E-01	2.33E-01
1.57E+00	1.57E+00	5.00E+00	0.00E+00	3.00E+00	2.44E-01	2.08E-01	2.40E+00	6.09E-02	9.41E-03	2.80E-03	4.71E-02	6.26E-03	2.99E-02	1.47E-04	5.06E+00	-1.66E-01	6.00E+00	2.92E-01	-1.94E-01
1.57E+00	1.57E+00	5.00E+00	0.00E+00	3.00E+00	2.16E-01	1.99E-01	2.47E+00	5.57E-02	1.89E-02	4.11E-03	1.04E-01	5.67E-03	1.04E-01	1.82E-02	5.06E+00	2.03E-01	6.13E+00	3.00E-01	1.31E-01
1.57E+00	1.57E+00	5.00E+00	0.00E+00	3.00E+00	3.66E-01	2.66E-01	2.49E+00	9.00E-02	1.15E+00	7.10E-02	1.45E+00	3.21E+01	1.75E+01	1.03E+01	1.54E+01	6.22E+00	4.85E-02	1.28E-03	2.67E+00
1.57E+00	1.57E+00	5.00E+00	0.00E+00	5.00E+00	3.70E-01	4.33E-01	8.12E-01	6.13E-04	3.99E-06	1.92E-02	2.27E-05	2.54E-03	2.91E-05	5.43E-03	4.97E+00	-4.09E-03	6.01E+00	-2.50E-01	-2.87E-03
1.57E+00	1.57E+00	5.00E+00	0.00E+00	5.00E+00	1.02E-01	1.44E-01	5.66E-01	2.24E-04	9.97E-06	3.01E-03	4.94E-05	2.62E-03	1.61E-05	3.97E-03	5.06E+00	-2.02E-03	6.05E+00	1.01E-01	3.91E-03
1.57E+00	1.57E+00	5.00E+00	0.00E+00	5.00E+00	1.11E-01	9.27E-02	7.01E-02	1.15E-04	2.19E-05	2.69E-03	9.11E-05	3.39E-03	3.01E-05	6.68E-03	5.05E+00	-2.90E-03	6.07E+00	3.07E-01	-2.49E-03
1.57E+00	1.57E+00	5.00E+00	0.00E+00	5.00E+00	1.07E-01	8.89E-02	6.62E-02	1.09E-04	3.48E-05	4.46E-03	1.44E-04	2.70E-03	3.25E-05	2.29E-01	5.05E+00	1.12E-03	6.47E+00	3.07E-01	-3.03E-03
1.57E+00	1.57E+00	5.00E+00	0.00E+00	5.00E+00	2.48E-02	1.98E-02	4.20E-01	1.40E-04	8.22E-06	1.51E-03	4.22E-05	2.77E-03	8.36E-05	1.66E-02	5.05E+00	8.22E-03	6.13E+00	2.53E-01	-1.66E-03
1.57E+00	1.57E+00	5.00E+00	1.00E+00	0.00E+00	2.80E-01	1.38E-01	4.72E-01	1.81E-02	7.94E-04	2.01E-03	4.20E-03	5.90E-03	1.49E-02	1.83E-03	5.05E+00	1.16E-01	5.97E+00	3.10E-01	1.19E-02
1.57E+00	1.57E+00	5.00E+00	1.00E+00	0.00E+00	2.84E-01	1.40E-01	4.91E-01	1.61E-02	5.47E-04	2.01E-03	2.94E-03	5.92E-03	1.14E-03	2.71E-03	5.05E+00	-3.87E-02	5.95E+00	2.98E-01	5.95E-02
1.57E+00	1.57E+00	5.00E+00	1.00E+00	0.00E+00	2.69E-01	1.32E-01	4.89E-01	1.67E-02	4.05E-04	1.88E-03	1.81E-03	4.75E-03	6.55E-03	5.18E-04	5.05E+00	-9.32E-02	6.01E+00	3.08E-01	1.63E-02
1.57E+00	1.57E+00	5.00E+00	1.00E+00	0.00E+00	1.50E-01	8.69E-02	4.80E-01	2.39E-02	1.60E-04	1.65E-03	8.00E-04	7.22E-03	6.51E-04	6.77E-04	5.05E+00	3.35E-02	5.97E+00	3.05E-01	-2.16E-02
1.57E+00	1.57E+00	5.00E+00	1.00E+00	0.00E+00	2.95E-01	1.42E-01	4.89E-01	1.45E-02	4.44E-04	2.05E-03	2.36E-03	9.15E-03	1.15E-03	2.42E-02	5.05E+00	3.94E-02	5.83E+00	3.02E-01	-2.49E-03
1.57E+00	1.57E+00	5.00E+00	1.00E+00	1.00E+00	2.08E-01	1.54E-01	1.45E+00	6.17E-02	1.55E-03	2.20E-03	7.92E-03	5.83E-03	7.98E-03	1.06E-02	5.05E+00	-1.03E-01	5.89E+00	3.06E-01	-3.98E-02
1.57E+00	1.57E+00	5.00E+00	1.00E+00	1.00E+00	1.54E-01	1.70E-01	1.95E+00	4.74E-02	4.60E-03	3.48E-03	2.32E-02	4.17E-03	5.40E-02	1.57E-02	5.07E+00	-2.65E-01	5.90E+00	1.32E-01	6.01E-02
1.57E+00	1.57E+00	5.00E+00	1.00E+00	1.00E+00	2.88E-01	1.59E-01	1.48E+00	8.47E-02	6.60E-03	2.14E-03	3.14E-02	4.90E-03	5.95E-02	1.39E-02	5.05E+00	-2.32E-01	6.13E+00	3.11E-01	3.43E-02
1.57E+00	1.57E+00	5.00E+00	1.00E+00	1.00E+00	2.26E+00	1.24E+00	1.54E+00	4.91E-02	1.23E-03	1.88E-02	5.20E-03	3.19E+01	3.16E-03	9.65E-04	5.06E+00	-2.02E-01	5.98E+00	3.05E-01	1.61E-01
1.57E+00	1.57E+00	5.00E+00	1.00E+00	1.00E+00	2.70E-01	1.66E-01	1.47E+00	6.03E-02	9.44E-04	1.71E-03	4.93E-03	6.68E-03	9.85E-03	1.20E-02	5.05E+00	-1.56E-01	5.89E+00	3.20E-01	6.31E-02
1.57E+00	1.57E+00	5.00E+00	1.00E+00	3.00E+00	2.73E-01	2.38E-01	2.49E+00	1.16E-01	5.99E-03	1.66E-03	2.42E-02	3.23E-03	1.99E-02	4.06E-03	5.05E+00	1.08E-01	6.04E+00	3.01E-01	-3.72E-02
1.57E+00	1.57E+00	5.00E+00	1.00E+00	3.00E+00	1.36E-01	1.91E-01	2.47E+00	1.39E-01	6.52E-03	1.85E-03	3.15E-02	4.12E-03	1.03E-02	6.08E-04	5.05E+00	3.34E-02	6.00E+00	3.33E-01	1.20E-01
1.57E+00	1.57E+00	5.00E+00	1.00E+00	3.00E+00	2.67E-01	2.28E-01	2.49E+00	1.22E-01	7.02E-03	2.16E-03	3.62E-02	1.22E-02	1.25E-01	1.39E-02	5.05E+00	-3.39E-01	5.89E+00	3.33E-01	-2.93E-02
1.57E+00	1.57E+00	5.00E+00	1.00E+00	3.00E+00	2.94E-01	2.19E-01	2.42E+00	1.16E-01	1.72E-01	1.29E-01	1.16E+00	1.54E+01	5.43E+01	1.19E+01	1.19E+01	1.28E+01	4.81E-01	-8.85E-01	2.68E+00
1.57E+00	1.57E+00	5.00E+00	1.00E+00	3.00E+00	3.02E-01	2.13E-01	2.13E+00	1.02E-01	2.87E-03	2.20E-03	1.39E-02	7.04E-03	1.64E-03	1.54E-02	5.06E+00	3.81E-02	5.87E+00	3.09E-01	-1.71E-01
1.57E+00	1.57E+00	5.00E+00	1.00E+00	5.00E+00	1.80E-01	9.96E-02	3.79E-02	1.78E-04	3.89E-06	1.98E-03	2.07E-05	3.26E-03	2.25E-04	6.21E-03	5.05E+00	1.46E-02	6.06E+00	3.07E-01	-8.20E-04
1.57E+00	1.57E+00	5.00E+00	1.00E+00	5.00E+00	7.45E-02	6.75E-02	4.77E-01	2.40E-04	9.10E-06	2.58E-03	4.59E-05	2.67E-03	1.68E-04	1.77E-02	5.06E+00	1.21E-02	6.12E+00	1.11E-01	-2.76E-03
1.57E+00	1.57E+00	5.00E+00	1.00E+00	5.00E+00	1.84E-01	1.02E-01	3.92E-02	1.76E-04	1.36E-05	7.09E-03	5.38E-05	2.85E-03	6.16E-05	5.62E-02	5.05E+00	6.62E-03	6.22E+00	3.07E-01	-1.76E-03
1.57E+00	1.57E+00	5.00E+00	1.00E+00	5.00E+00	1.75E-01	9.74E-02	3.78E-02	2.45E-04	6.77E-06	1.97E-03	3.41E-05	8.36E-03	2.94E-05	1.94E-02	5.05E+00	3.81E-03	5.85E+00	3.07E-01	-1.24E-03
1.57E+00	1.57E+00	5.00E+00	1.00E+00	5.00E+00	1.76E-02	7.84E-03	6.18E-02	2.19E-04	3.72E-06	1.84E-03	2.05E-05	3.40E-03	3.09E-04	1.26E-03	5.05E+00	1.72E-02	5.97E+00	2.60E-01	-1.09E-03
1.57E+00	1.57E+00	5.00E+00	2.00E+00	0.00E+00	1.86E-01	1.13E-01	4.84E-01	2.21E-02	5.02E-03	5.21E-03	1.85E-02	3.24E-03	1.06E-02	9.34E-02	5.05E+00	8.97E-02	6.29E+00	2.99E-01	1.77E-02
1.57E+00	1.57E+00	5.00E+00	2.00E+00	0.00E+00	1.85E-01	1.20E-01	4.82E-01	2.24E-02	6.64E-04	1.84E-03	3.32E-03	5.96E-03	9.04E-03	2.16E-03	5.05E+00	1.23E-01	5.96E+00	3.09E-01	-1.90E-02
1.57E+00	1.57E+00	5.00E+00	2.00E+00	0.00E+00	2.21E-01	1.33E-01	4.83E-01	2.23E-02	2.39E-03	2.77E-03	1.12E-02	3.23E-03	3.90E-03	1.25E-02	5.05E+00	-4.62E-02	6.10E+00	3.08E-01	-1.81E-02
1.57E+00	1.57E+00	5.00E+00	2.00E+00	0.00E+00	1.83E-01	1.12E-01	4.99E-01	2.01E-02	3.48E-05	1.89E-03	1.11E-04	5.45E-03	6.12E-04	3.43E-03	5.05E+00	1.99E-02	5.96E+00	3.13E-01	1.25E-02
1.57E+00	1.57E+00	5.00E+00	2.00E+00	0.00E+00	1.70E-01	1.04E-01	4.87E-01	1.91E-02	2.40E-03	2.34E-03	1.28E-02	3.74E-03	1.66E-02	2.05E-03	5.05E+00	-1.18E-01	6.02E+00	3.06E-01	2.23E-03
1.57E+00	1.57E+00	5.00E+00	2.00E+00	1.00E+00	1.71E-01	1.55E-01	1.50E+00	4.09E-02	2.11E-03	2.04E-03	1.05E-02	2.84E-03	3.07E-03	6.51E-02	5.05E+00	-3.63E-02	6.25E+00	3.13E-01	5.85E-02
1.57E+00	1.57E+00	5.00E+00	2.00E+00	1.00E+00	1.66E-01	1.41E-01	1.49E+00	5.43E-02	2.42E-03	2.21E-03	1.26E-02	4.36E-03	1.27E-02	1.80E-03	5.05E+00	-1.47E-01	6.01E+00	3.07E-01	9.99E-02
1.57E+00	1.57E+00	5.00E+00	2.00E+00	1.00E+00	1.79E-01	1.51E-01	1.49E+00	6.04E-02	2.14E-01	2.35E-01	2.70E+00	8.12E+00	2.36E+01	1.48E+01	7.11E+00	7.51E+00	7.79E-01	-3.29E-01	3.06E+00
1.57E+00	1.57E+00	5.00E+00	2.00E+00	1.00E+00	1.17E-01	1.21E-01	1.47E+00	6.24E-02	2.60E-02	1.18E-02	8.09E-02	6.16E-03	2.33E-02	3.30E-02	5.05E+00	1.44E-01	6.11E+00	2.91E-01	-6.15E-02
1.57E+00	1.57E+00	5.00E+00	2.00E+00	1.00E+00	1.18E-01	1.40E-01	1.49E+00	5.94E-02	2.62E-03	2.24E-03	1.23E-02	5.71E-03	5.75E-02	8.11E-03	5.05E+00	-2.29E-01	5.90E+00	3.11E-01	-4.16E-02
1.57E+00	1.57E+00	5.00E+00	2.00E+00	3.00E+00	2.23E-01	2.38E-01	2.52E+00	7.33E-02	8.62E-03	1.06E-02	3.72E-02	3.76E-03	9.79E-03	4.04E-02	5.06E+00	1.03E-01	6.18E+00	3.30E-01	-1.19E-01
1.57E+00	1.57E+00	5.00E+00	2.00E+00	3.00E+00	1.42E-01	2.02E-01	2.48E+00	6.63E-02	5.85E-03	2.14E-03	3.19E-02	3.31E-03	1.53E-02	5.88E-03	5.08E+00	4.58E-02	6.08E+00	2.93E-01	-3.55E-01
1.57E+00	1.57E+00	5.00E+00	2.00E+00	3.00E+00	1.92E-01	2.08E-01	2.50E+00	1.11E-01	8.94E-02	2.48E-01	1.83E+00	4.06E+01	6.52E+01	9.87E+00	-6.35E+00	1.35E+01	2.06E+00	-2.20E-02	-1.20E+00
1.57E+00	1.57E+00	5.00E+00	2.00E+00	3.00E+00	1.45E-01	1.81E-01	2.49E+00	9.97E-02	7.17E-03	1.96E-03	3.72E-02	5.37E-03	3.14E-02	4.42E-04	5.05E+00	-8.90E-02	5.98E+00	3.08E-01	-1.29E-01
1.57E+00	1.57E+00	5.00E+00	2.00E+00	3.00E+00	1.50E-01	1.64E-01	2.37E+00	1.11E-01	4.28E-03	2.07E-03	2.06E-02	5.39E-03	2.26E-02	3.33E-03	5.06E+00	-1.96E-01	6.03E+00	3.02E-01	1.75E-01
1.57E+00	1.57E+00	5.00E+00	5.00E+00	0.00E+00	6.23E-02	6.15E-02	4.94E-01	2.12E-02	1.15E-04	1.66E-03	5.87E-04	2.83E-03	1.18E-04	4.89E-03	5.05E+00	1.29E-02	6.06E+00	3.07E-01	-1.50E-02
1.57E+00	1.57E+00	5.00E+00	5.00E+00	0.00E+00	7.45E-02	7.25E-02	4.62E-01	2.08E-02	3.36E-04	1.56E-03	1.54E-03	2.79E-03	6.28E-04	1.49E-02	5.05E+00	4.39E-02	6.12E+00	3.09E-01	-6.16E-02
1.57E+00	1.57E+00	5.00E+00	5.00E+00	0.00E+00	3.57E-02	4.66E-02	8.83E-01	1.87E-02	1.47E-03	1.85E-03	7.48E-03	2.76E-03	2.06E-03	7.55E-03	5.05E+00	4.01E-02	6.09E+00	2.08E-01	-1.06E-03
1.57E+00	1.57E+00	5.00E+00	5.00E+00	0.00E+00	4.56E-02	5.04E-02	4.91E-01	1.42E-02	1.18E-03	3.92E-03	5.05E-03	2.98E-03	1.05E-03	3.68E-02	5.05E+00	7.91E-03	6.17E+00	3.07E-01	1.49E-03

1.57E+00	1.57E+00	5.00E+00	5.00E+00	0.00E+00	8.79E-02	8.23E-02	4.89E-01	1.98E-02	4.42E-04	1.94E-03	1.99E-03	2.70E-03	1.15E-03	7.90E-02	5.05E+00	2.91E-02	6.27E+00	3.02E-01	-2.79E-02
1.57E+00	1.57E+00	5.00E+00	5.00E+00	1.00E+00	1.38E-01	1.57E-01	1.46E+00	6.78E-02	4.84E-03	2.21E-03	2.16E-02	3.18E-03	7.05E-03	4.07E-02	5.05E+00	-1.14E-01	6.19E+00	3.00E-01	3.53E-02
1.57E+00	1.57E+00	5.00E+00	5.00E+00	1.00E+00	6.24E-02	1.09E-01	1.46E+00	6.40E-02	8.97E-03	3.03E-03	4.40E-02	3.97E-03	1.09E-02	1.85E-02	5.05E+00	-2.93E-03	6.13E+00	3.18E-01	-5.28E-03
1.57E+00	1.57E+00	5.00E+00	5.00E+00	1.00E+00	6.78E-02	1.06E-01	1.49E+00	6.97E-02	1.61E-02	2.17E-03	7.39E-02	5.19E-03	2.08E-02	1.90E-02	5.05E+00	-1.04E-01	6.12E+00	3.20E-01	-1.84E-02
1.57E+00	1.57E+00	5.00E+00	5.00E+00	1.00E+00	2.40E-01	2.38E-01	1.49E+00	3.54E-02	2.51E-03	3.79E-03	9.81E-03	3.55E-03	1.81E-02	7.79E-03	5.05E+00	1.11E-01	6.07E+00	3.03E-01	7.83E-02
1.57E+00	1.57E+00	5.00E+00	5.00E+00	1.00E+00	1.36E-01	1.64E-01	1.45E+00	7.22E-02	6.67E-03	1.98E-03	3.40E-02	4.88E-03	2.90E-02	2.68E-03	5.05E+00	1.29E-01	6.06E+00	3.28E-01	4.53E-04
1.57E+00	1.57E+00	5.00E+00	5.00E+00	3.00E+00	1.77E-01	2.55E-01	2.47E+00	8.98E-02	5.50E-03	1.79E-03	2.31E-02	3.22E-03	8.49E-03	1.60E-02	5.06E+00	4.41E-02	6.12E+00	2.99E-01	-1.47E-01
1.57E+00	1.57E+00	5.00E+00	5.00E+00	3.00E+00	1.39E-01	2.15E-01	2.46E+00	1.11E-01	1.20E-01	2.65E-01	2.35E+00	1.35E+01	5.97E+01	1.34E+01	9.66E+00	-1.28E+01	4.28E-01	-9.77E-01	2.85E+00
1.57E+00	1.57E+00	5.00E+00	5.00E+00	3.00E+00	1.16E-01	2.10E-01	2.97E+00	7.88E-02	2.70E-03	5.42E-03	1.15E-02	3.20E-03	2.64E-02	1.31E-02	5.06E+00	-2.09E-01	6.08E+00	1.08E-01	1.13E-01
1.57E+00	1.57E+00	5.00E+00	5.00E+00	3.00E+00	1.31E-01	2.53E-01	2.89E+00	8.94E-02	1.00E+00	3.44E-01	3.26E+00	1.41E+01	1.74E+01	8.49E+00	9.14E+00	3.65E+00	5.56E+00	-1.34E-01	2.36E-01
1.57E+00	1.57E+00	5.00E+00	5.00E+00	3.00E+00	1.42E-01	2.75E-01	2.90E+00	9.45E-02	1.23E-02	4.40E-03	7.09E-02	4.79E-03	9.06E-02	2.83E-03	5.07E+00	-3.51E-01	6.05E+00	9.48E-02	-1.23E-01
1.57E+00	1.57E+00	5.00E+00	5.00E+00	5.00E+00	2.69E-01	1.24E-01	3.58E-02	2.56E-04	2.90E-05	1.84E-03	1.44E-04	4.48E-03	3.29E-04	4.78E-04	5.05E+00	-1.70E-02	6.00E+00	3.07E-01	-2.74E-03
1.57E+00	1.57E+00	5.00E+00	5.00E+00	5.00E+00	2.20E-01	1.02E-01	3.13E-02	2.63E-04	1.18E-05	1.82E-03	5.94E-05	7.43E-03	8.66E-05	4.86E-03	5.05E+00	-8.35E-03	5.93E+00	3.07E-01	-1.50E-03
1.57E+00	1.57E+00	5.00E+00	5.00E+00	5.00E+00	2.30E-01	1.07E-01	3.27E-02	2.61E-04	1.52E-06	1.87E-03	8.57E-06	5.35E-03	1.32E-04	2.72E-03	5.05E+00	1.12E-02	5.95E+00	3.07E-01	-5.56E-04
1.57E+00	1.57E+00	5.00E+00	5.00E+00	5.00E+00	2.50E-01	1.15E-01	3.36E-02	2.71E-04	1.92E-06	1.86E-03	1.07E-05	6.18E-03	2.37E-04	3.65E-03	5.05E+00	1.52E-02	5.94E+00	3.07E-01	-3.86E-04
1.57E+00	1.57E+00	5.00E+00	5.00E+00	5.00E+00	2.69E-01	1.24E-01	3.52E-02	2.61E-04	1.30E-05	2.09E-03	6.75E-05	4.62E-03	7.60E-05	2.32E-03	5.05E+00	-7.41E-03	5.95E+00	3.07E-01	-1.94E-03

Varying horizontal approach angle, with varying velocity

Horizontal angle (rad)	Vertical angle (rad)	Impact velocity (ms^(-1))	Impact acceleration (ms^(-2))	Disturbance level	Average position error	Average velocity error	Average acceleration error	Average yaw error	Roll contact devi	Pitch contact dev	Yaw contact deviation	X contact deviation	Y contact deviation	Z contact deviation	X end position	Y end position	Z end position	Pitch end orientation	Yaw end orientation
0.00E+00	1.57E+00	0.00E+00	0.00E+00	0.00E+00	1.03E-01	3.20E-02	6.43E-02	1.61E-03	4.70E-06	1.64E-03	2.51E-05	2.62E-03	2.11E-05	3.70E-05	5.05E+00	-3.69E-03	6.00E+00	3.07E-01	1.24E-03
1.57E-01	1.57E+00	0.00E+00	0.00E+00	0.00E+00	1.77E-02	5.12E-03	7.35E-03	1.57E-03	3.32E-06	1.67E-03	1.58E-05	2.66E-03	1.07E-05	2.03E-04	5.05E+00	-2.74E-03	6.00E+00	3.07E-01	-6.92E-04
3.14E-01	1.57E+00	0.00E+00	0.00E+00	0.00E+00	8.97E-03	2.90E-03	2.73E-03	1.52E-03	1.47E-06	1.56E-03	7.71E-06	2.65E-03	6.94E-06	1.14E-04	5.05E+00	-2.11E-03	5.99E+00	3.07E-01	7.11E-04
3.14E-01	1.57E+00	0.00E+00	0.00E+00	0.00E+00	1.05E-02	3.41E-03	3.06E-03	1.53E-03	4.85E-07	1.55E-03	2.35E-06	2.64E-03	1.33E-06	1.16E-04	5.05E+00	9.12E-04	6.00E+00	3.07E-01	1.93E-04
4.71E-01	1.57E+00	0.00E+00	0.00E+00	0.00E+00	8.47E-03	2.74E-03	3.31E-03	1.42E-03	1.50E-06	1.57E-03	7.52E-06	2.64E-03	3.14E-05	1.12E-04	5.05E+00	-5.36E-03	5.99E+00	3.07E-01	3.48E-05
6.28E-01	1.57E+00	0.00E+00	0.00E+00	0.00E+00	8.72E-03	2.87E-03	4.09E-03	1.33E-03	1.28E-06	1.88E-03	6.63E-06	2.69E-03	2.12E-05	4.57E-04	5.05E+00	-4.28E-03	5.98E+00	3.07E-01	4.04E-04
6.28E-01	1.57E+00	0.00E+00	0.00E+00	0.00E+00	9.39E-03	3.03E-03	3.24E-03	1.51E-03	1.40E-06	1.59E-03	7.44E-06	2.65E-03	1.29E-05	1.49E-04	5.05E+00	3.18E-03	5.99E+00	3.07E-01	-6.75E-04
7.85E-01	1.57E+00	0.00E+00	0.00E+00	0.00E+00	8.93E-03	2.67E-03	2.21E-03	1.18E-03	5.06E-06	1.57E-03	2.51E-05	2.64E-03	6.44E-05	1.05E-04	5.05E+00	-7.62E-03	6.00E+00	3.07E-01	-4.53E-04
9.42E-01	1.57E+00	0.00E+00	0.00E+00	0.00E+00	9.01E-03	2.87E-03	4.52E-03	9.88E-04	2.06E-06	2.02E-03	8.84E-06	2.71E-03	5.58E-06	4.65E-04	5.05E+00	-1.97E-03	5.99E+00	3.07E-01	-5.90E-04
1.10E+00	1.57E+00	0.00E+00	0.00E+00	0.00E+00	8.68E-03	2.81E-03	3.68E-03	7.78E-04	9.54E-06	1.56E-03	5.04E-05	2.63E-03	1.15E-04	1.64E-04	5.05E+00	-9.79E-03	6.01E+00	3.07E-01	1.80E-03
1.26E+00	1.57E+00	0.00E+00	0.00E+00	0.00E+00	8.73E-03	2.53E-03	3.26E-03	5.66E-04	1.07E-05	1.62E-03	5.59E-05	2.66E-03	1.05E-04	1.68E-04	5.05E+00	-9.21E-03	6.00E+00	3.07E-01	1.91E-03
1.41E+00	1.57E+00	0.00E+00	0.00E+00	0.00E+00	8.53E-03	2.74E-03	3.25E-03	3.26E-04	3.11E-06	1.56E-03	1.61E-05	2.64E-03	2.76E-05	1.14E-04	5.05E+00	-4.70E-03	6.00E+00	3.07E-01	1.03E-03
1.57E+00	1.57E+00	0.00E+00	0.00E+00	0.00E+00	8.70E-03	2.65E-03	4.55E-03	1.34E-05	3.59E-08	1.58E-03	1.92E-07	2.65E-03	1.03E-07	1.26E-04	5.05E+00	1.93E-04	6.00E+00	2.20E-01	-9.86E-05
1.57E+00	1.57E+00	0.00E+00	0.00E+00	0.00E+00	8.78E-03	2.60E-03	3.97E-03	1.60E-05	1.68E-08	1.56E-03	6.91E-08	2.64E-03	1.94E-08	1.03E-04	5.05E+00	-9.33E-05	6.00E+00	3.07E-01	1.40E-05
1.57E+00	1.57E+00	0.00E+00	0.00E+00	0.00E+00	1.43E-02	2.85E-02	4.86E-01	1.28E-02	3.93E-04	1.62E-03	2.17E-03	2.71E-03	9.15E-04	7.25E-04	5.05E+00	1.28E-02	6.02E+00	1.69E-01	1.46E-02
1.57E+00	1.57E+00	0.00E+00	0.00E+00	0.00E+00	1.43E-02	3.11E-02	5.03E-01	2.01E-02	2.65E-04	1.62E-03	1.47E-03	2.69E-03	3.79E-04	2.85E-04	5.05E+00	-4.72E-03	5.98E+00	2.01E-01	1.10E-02
1.57E+00	1.57E+00	0.00E+00	0.00E+00	0.00E+00	1.63E-02	2.74E-02	4.85E-01	2.01E-02	9.26E-05	2.34E-03	4.10E-04	2.75E-03	3.81E-04	1.92E-03	5.05E+00	-1.76E-02	5.95E+00	3.06E-01	1.43E-02
1.57E+00	1.57E+00	0.00E+00	0.00E+00	0.00E+00	1.73E-02	3.62E-02	4.67E-01	1.55E-02	1.54E-04	1.70E-03	7.81E-04	2.65E-03	4.02E-04	1.40E-04	5.05E+00	3.05E-03	6.01E+00	2.22E-01	3.59E-02
1.57E+00	1.57E+00	0.00E+00	0.00E+00	0.00E+00	1.87E-02	3.28E-02	4.95E-01	1.96E-02	3.86E-04	1.72E-03	2.12E-03	2.71E-03	1.48E-03	1.81E-04	5.05E+00	8.32E-03	5.99E+00	2.47E-01	-6.76E-02
0.00E+00	1.57E+00	5.00E-01	0.00E+00	0.00E+00	1.02E-01	1.64E-02	5.16E-02	1.18E-03	5.63E-03	2.39E-03	3.11E-02	3.55E-03	3.22E-02	3.52E-04	5.05E+00	1.52E-01	5.98E+00	3.06E-01	-4.19E-02
1.57E-01	1.57E+00	5.00E-01	0.00E+00	0.00E+00	7.28E-02	1.10E-02	2.19E-02	1.18E-03	5.72E-03	2.31E-03	3.08E-02	3.54E-03	2.57E-02	1.74E-04	5.05E+00	1.30E-01	5.99E+00	3.06E-01	-4.21E-02
3.14E-01	1.57E+00	5.00E-01	0.00E+00	0.00E+00	1.48E-02	1.80E-03	3.79E-03	1.10E-03	6.67E-03	2.46E-03	3.14E-02	3.64E-03	1.95E-02	1.22E-03	5.05E+00	1.06E-01	5.97E+00	3.06E-01	-4.46E-02
4.71E-01	1.57E+00	5.00E-01	0.00E+00	0.00E+00	7.89E-03	1.57E-03	3.46E-03	1.07E-03	6.62E-03	2.23E-03	3.14E-02	3.63E-03	1.12E-02	1.04E-03	5.05E+00	6.00E-02	5.97E+00	3.06E-01	-4.37E-02
6.28E-01	1.57E+00	5.00E-01	0.00E+00	0.00E+00	7.23E-03	1.59E-03	3.01E-03	9.85E-04	3.73E-03	1.91E-03	1.88E-02	3.16E-03	9.17E-03	3.41E-04	5.05E+00	6.49E-02	5.98E+00	3.06E-01	-3.42E-02
7.85E-01	1.57E+00	5.00E-01	0.00E+00	0.00E+00	7.61E-03	2.05E-03	3.80E-03	8.78E-04	3.81E-03	1.95E-03	1.85E-02	3.18E-03	6.28E-03	5.11E-04	5.05E+00	4.20E-02	5.98E+00	3.06E-01	-3.36E-02
9.42E-01	1.57E+00	5.00E-01	0.00E+00	0.00E+00	7.38E-03	2.00E-03	4.88E-03	7.27E-04	1.80E-03	1.74E-03	8.88E-03	2.88E-03	3.22E-03	2.45E-04	5.05E+00	3.12E-02	5.99E+00	3.06E-01	-2.31E-02
1.10E+00	1.57E+00	5.00E-01	0.00E+00	0.00E+00	7.62E-03	1.68E-03	3.04E-03	7.48E-04	1.52E-03	1.73E-03	7.46E-03	2.85E-03	2.20E-03	2.39E-04	5.05E+00	2.00E-02	5.99E+00	3.06E-01	-2.12E-02
1.26E+00	1.57E+00	5.00E-01	0.00E+00	0.00E+00	7.59E-03	1.56E-03	4.24E-03	3.82E-04	6.81E-04	1.65E-03	3.39E-03	2.73E-03	8.85E-04	1.49E-04	5.05E+00	9.12E-03	5.99E+00	3.07E-01	-1.41E-02
1.41E+00	1.57E+00	5.00E-01	0.00E+00	0.00E+00	7.33E-03	1.95E-03	3.92E-03	2.74E-04	8.77E-05	1.66E-03	4.21E-04	2.67E-03	1.35E-04	2.20E-04	5.05E+00	5.66E-03	5.99E+00	3.07E-01	-4.92E-03
1.57E+00	1.57E+00	5.00E-01	0.00E+00	0.00E+00	7.57E-03	1.39E-03	4.25E-03	1.17E-05	3.37E-09	1.56E-03	1.73E-08	2.64E-03	3.85E-07	1.38E-04	5.05E+00	6.25E-04	6.01E+00	3.07E-01	-1.48E-05
0.00E+00	1.57E+00	1.00E+00	0.00E+00	0.00E+00	1.37E-01	3.06E-02	6.58E-02	2.23E-03	1.73E-02	5.84E-03	1.08E-01	7.61E-03	1.04E-01	1.56E-04	5.05E+00	2.73E-01	6.00E+00	3.05E-01	-7.01E-02
1.57E-01	1.57E+00	1.00E+00	0.00E+00	0.00E+00	1.87E-01	4.42E-02	1.12E-01	7.65E-03	1.84E-02	6.64E-03	1.16E-01	7.77E-03	7.13E-02	4.24E-01	5.05E+00	1.85E-01	5.32E+00	3.05E-01	-7.73E-02
3.14E-01	1.57E+00	1.00E+00	0.00E+00	0.00E+00	1.46E-01	3.43E-02	7.16E-02	4.87E-03	1.61E-02	4.36E-03	9.48E-02	6.59E-03	6.96E-02	2.84E-02	5.05E+00	2.09E-01	5.83E+00	3.05E-01	-6.86E-02
4.71E-01	1.57E+00	1.00E+00	0.00E+00	0.00E+00	9.08E-02	2.22E-02	6.16E-02	2.58E-03	8.22E-03	3.62E-03	5.28E-02	4.49E-03	2.70E-02	3.58E-04	5.05E+00	1.13E-01	5.98E+00	3.06E-01	-4.63E-02
6.28E-01	1.57E+00	1.00E+00	0.00E+00	0.00E+00	9.45E-02	2.64E-02	8.25E-02	2.85E-03	8.28E-03	3.57E-03	5.08E-02	4.41E-03	1.91E-02	2.01E-04	5.05E+00	7.74E-02	6.01E+00	3.06E-01	-4.34E-02
7.85E-01	1.57E+00	1.00E+00	0.00E+00	0.00E+00	5.77E-02	1.61E-02	7.35E-02	1.56E-03	8.49E-03	3.25E-03	4.99E-02	4.32E-03	1.61E-02	3.74E-04	5.05E+00	6.03E-02	6.02E+00	3.06E-01	-4.95E-02
9.42E-01	1.57E+00	1.00E+00	0.00E+00	0.00E+00	3.62E-02	8.71E-03	7.67E-02	1.04E-03	5.59E-03	2.75E-03	3.25E-02	3.60E-03	9.06E-03	6.21E-04	5.05E+00	3.21E-02	6.02E+00	3.06E-01	-4.04E-02
1.10E+00	1.57E+00	1.00E+00	0.00E+00	0.00E+00	7.40E-02	2.50E-02	1.03E-01	1.45E-03	3.31E-03	2.32E-03	1.93E-02	3.15E-03	4.74E-03	2.62E-04	5.05E+00	9.94E-03	6.02E+00	3.06E-01	-2.84E-02
1.26E+00	1.57E+00	1.00E+00	0.00E+00	0.00E+00	3.38E-02	8.89E-03	8.81E-02	5.57E-04	1.69E-03	1.84E-03	9.13E-03	2.86E-03	2.19E-03	1.43E-04	5.05E+00	5.25E-03	6.01E+00	3.06E-01	-2.11E-02
1.41E+00	1.57E+00	1.00E+00	0.00E+00	0.00E+00	1.01E-02	1.92E-03	5.92E-03	2.52E-04	4.50E-04	1.76E-03	2.44E-03	2.67E-03	6.29E-04	2.17E-04	5.05E+00	-8.86E-03	6.01E+00	3.07E-01	-1.07E-02
1.57E+00	1.57E+00	1.00E+00	0.00E+00	0.00E+00	1.60E-02	2.93E-02	4.87E-01	2.19E-02	1.87E-04	1.68E-03	1.04E-03	2.64E-03	4.43E-04	3.85E-04	5.05E+00	-5.05E-02	6.02E+00	2.22E-01	7.94E-02
1.57E+00	1.57E+00	1.00E+00	0.00E+00	0.00E+00	1.95E-02	3.03E-02	4.95E-01	1.43E-02	1.53E-04	1.85E-03	7.34E-04	2.63E-03	1.77E-04	1.20E-04	5.05E+00	-8.20E-03	6.02E+00	1.18E-01	1.63E-02
1.57E+00	1.57E+00	1.00E+00	0.00E+00	0.00E+00	2.23E-02	3.78E-02	4.88E-01	1.90E-02	1.08E-04	1.73E-03	4.96E-04	2.62E-03	1.46E-04	7.17E-04	5.05E+00	1.35E-02	6.02E+00	3.02E-01	-1.73E-02
1.57E+00	1.57E+00	1.00E+00	0.00E+00	0.00E+00	3.64E-02	1.02E-02	9.38E-02	1.90E-05	2.26E-07	1.79E-03	1.24E-06	2.61E-03	1.90E-05	2.05E-04	5.05E+00	4.29E-03	6.01E+00	3.07E-01	-2.17E-04
1.57E+00	1.57E+00	1.00E+00	0.00E+00	0.00E+00	4.27E-02	3.32E-02	5.72E-01	2.12E-02	1.27E-04	2.78E-03	6.50E-04	2.63E-03	4.96E-04	1.30E-04	5.06E+00	2.56E-02	6.01E+00	1.40E-01	-1.60E-02
1.57E+00	1.57E+00	1.00E+00	0.00E+00	0.00E+00	6.13E-02	4.83E-02	5.97E-01	2.13E-02	4.27E-05	3.72E-03	2.37E-04	2.65E-03	2.80E-05	2.18E-04	5.06E+00	8.37E-03	6.01E+00	5.24E-02	8.99E-03
0.00E+00	1.57E+00	1.50E+00	0.00E+00	0.00E+00	2.24E-01	7.86E-02	1.91E-01	9.21E-03	1.26E-01	1.60E-01	1.41E+00	1.37E+00	7.25E+00	1.84E+01	7.12E+00	-4.77E+00	4.27E-01	-5.55E-01	-2.90E+00
1.57E-01	1.57E+00	1.50E+00	0.00E+00	0.00E+00	2.51E-01	9.02E-02	1.76E-01	1.52E-02	1.45E-01	2.18E-01	2.03E+00	1.40E+00	9.04E+00	2.24E+01	3.79E+00	-5.24E+00	4.97E-01	4.27E-02	-1.04E+00
3.14E-01	1.57E+00	1.50E+00	0.00E+00	0.00E+00	8.90E-02	2.84E-02	6.54E-02	3.02E-03	1.23E+00	2.81E-01	3.42E+00	8.94E+00	6.18E+00	1.95E+01	7.53E+00	-4.66E+00	9.97E-02	5.14E-04	-2.04E+00
4.71E-01	1.57E+00	1.50E+00	0.00E+00	0.00E+00	1.01E-01	3.69E-02	9.52E-02	4.14E-03	1.77E-01	2.06E-01	1.60E+00	9.21E+00	4.78E+01	1.62E+01	8.84E+00	-1.05E+01	4.28E-01	4.79E-02	1.02E+00
6.28E-01	1.57E+00	1.50E+00	0.00E+00	0.00E+00	4.69E-02	1.61E-02	8.88E-02	2.13E-03	1.32E-02	3.44E-03	7.40E-02	4.78E-03	1.93E-02	1.07E-02	5.05E+00	3.28E-02	5.89E+00	3.05E-01	-2.42E-02
9.42E-01	1.57E+00	1.50E+00	0.00E+00	0.00E+00	1.60E-02	4.89E-03	1.03E-02	1.47E-03	1.22E-02	3.09E-03	6.59E-02	4.98E-03	1.60E-02	6.16E-04	5.05E+00	4.16E-02	5.98E+00	3.06E-01	-5.59E-02
1.10E+00	1.57E+00	1.50E+00	0.00E+00	0.00E+00	4.02E-02	1.56E-02	1.30E-01	1.27E-03	9.49E-03	3.08E-03	5.32E-02	4.43E-03	1.76E-02	2.37E-03	5.05E+00	-7.69E-02	6.05E+00	3.06E-01	-4.89E-02
1.26E+00	1.57E+00	1.50E+00	0.00E+00	0.00E+00	2.16E-02	6.04E-03	6.39E-02	7.89E-04	5.11E-03	2.16E-03	2.70E-02	3.40E-03	7.38E-03	2.25E-03	5.05E+00	-3.77E-02	6.04E+00	3.06E-01	-3.68E-02
1.41E+00	1.57E+00	1.50E+00	0.00E+00	0.00E+00	6.99E-02	3.47E-02	1.48E-01	7.79E-04	8.60E-04	1.80E-03	4.70E-03	2.73E-03	2.59E-03	4.04E-05	5.05E+00	-3.95E-02	6.00E+00	3.06E-01	-1.14E-02
0.00E+00	1.57E+00	2.00E+00	0.00E+00	0.00E+00	8.04E-02	3.07E-02	1.12E-02	2.69E-03	2.51E+00	1.09E-01	1.94E+00	8.29E+01	2.19E+00	1.43E+01	1.85E+01	1.22E+00	4.85E-02	1.40E-03	-2.30E+00
1.57E-01	1.57E+00	2.00E+00	0.00E+00	0.00E+00	1.25E-01	4.14E-02	5.93E-02	3.76E-03	5.71E-02	9.02E-02	6.00E-01	1.11E+01	3.97E+00	6.21E+00	1.33E+01	-4.12E+00	5.07E-01	1.36E+00	3.41E-01
3.14E-01	1.57E+00	2.00E+00	0.00E+00	0.00E+00	7.32E-02	2.53E-02	7.32E-02	3.32E-03	4.12E-02	1.69E-02	2.67E-01	2.08E-02	1.15E-01	9.41E-02	5.05E+00	2.19E-01	5.68E+00	3.02E-01	-1.23E-01
4.71E-01	1.57E+00	2.00E+00	0.00E+00	0.00E+00	9.18E-02	3.75E-02	1.06E-01	4.13E-03	1.57E-01	8.92E-02	9.32E-01	1.65E+01	2.21E+00	9.44E+00	1.32E+01	1.97E+00	4.05E-01	-5.47E-01	2.97E+00

6.28E-01	1.57E+00	2.00E+00	0.00E+00	0.00E+00	1.18E-02	5.21E-03	9.11E-03	2.79E-03	1.49E-01	7.93E-02	1.55E+00	3.86E+01	3.28E+00	1.09E+01	1.64E+01	-2.04E+00	7.89E-01	-2.66E-01	-2.13E+00
7.85E-01	1.57E+00	2.00E+00	0.00E+00	0.00E+00	4.33E-02	1.68E-02	1.34E-01	2.62E-03	1.74E-01	8.09E-02	6.94E-01	2.17E+01	3.14E+01	1.38E+01	1.35E+01	-6.80E+00	3.07E-01	2.39E-02	1.81E+00
9.42E-01	1.57E+00	2.00E+00	0.00E+00	0.00E+00	1.18E-01	6.07E-02	1.81E-01	4.18E-03	2.14E-01	2.06E-01	2.00E+00	3.45E-01	8.35E+01	1.70E+01	3.16E+00	-1.39E+01	4.07E-01	2.14E-01	6.38E-01
1.10E+00	1.57E+00	2.00E+00	0.00E+00	0.00E+00	7.29E-02	3.72E-02	1.77E-01	2.21E-03	1.74E-02	4.94E-03	1.04E-01	5.99E-03	1.45E-01	4.63E-03	5.05E+00	-3.30E-01	6.07E+00	3.04E-01	-1.18E-02
1.26E+00	1.57E+00	2.00E+00	0.00E+00	0.00E+00	7.28E-02	3.87E-02	1.91E-01	1.62E-03	1.04E-02	2.57E-03	5.44E-02	4.54E-03	2.88E-02	4.28E-04	5.05E+00	-1.33E-01	5.98E+00	3.06E-01	-4.59E-02
1.41E+00	1.57E+00	2.00E+00	0.00E+00	0.00E+00	1.07E-01	6.09E-02	2.18E-01	1.13E-03	2.07E-03	1.88E-03	1.10E-02	2.90E-03	5.57E-03	6.27E-04	5.05E+00	-5.67E-02	5.97E+00	3.06E-01	-1.89E-02
1.57E+00	1.57E+00	2.00E+00	0.00E+00	0.00E+00	5.46E-02	4.38E-02	6.55E-01	1.92E-02	1.30E-04	1.72E-03	5.97E-04	2.65E-03	1.99E-03	1.70E-03	5.06E+00	4.57E-02	6.04E+00	1.12E-01	-1.38E-02
1.57E+00	1.57E+00	2.00E+00	0.00E+00	0.00E+00	6.03E-02	4.21E-02	6.24E-01	1.82E-02	6.82E-04	2.21E-03	3.67E-03	2.71E-03	1.19E-03	8.14E-05	5.06E+00	-2.44E-02	6.01E+00	1.29E-01	-3.57E-02
1.57E+00	1.57E+00	2.00E+00	0.00E+00	0.00E+00	1.00E-01	6.70E-02	6.82E-01	1.71E-02	3.79E-04	3.88E-03	1.98E-03	2.77E-03	4.35E-04	8.42E-04	5.06E+00	9.79E-03	5.98E+00	7.93E-02	-4.06E-02
1.57E+00	1.57E+00	2.00E+00	0.00E+00	0.00E+00	1.00E-01	5.73E-02	2.06E-01	6.64E-05	6.49E-07	1.69E-03	3.50E-06	2.60E-03	6.60E-05	1.71E-05	5.05E+00	7.97E-03	6.00E+00	3.07E-01	-3.32E-04
1.57E+00	1.57E+00	2.00E+00	0.00E+00	0.00E+00	1.16E-01	7.99E-02	6.85E-01	2.14E-02	4.87E-04	4.12E-03	2.68E-03	2.72E-03	3.53E-03	4.60E-05	5.05E+00	5.76E-02	6.00E+00	5.91E-02	-3.55E-02
1.57E+00	1.57E+00	2.00E+00	0.00E+00	0.00E+00	1.39E-01	9.74E-02	6.80E-01	1.79E-02	5.75E-04	4.47E-03	3.07E-03	2.74E-03	5.96E-04	1.61E-04	5.05E+00	-2.48E-02	6.00E+00	3.76E-02	3.22E-02

Varying vertical approach angle, with varying velocity

Horizontal angle (rad)	Vertical angle (rad)	Impact velocity (ms^(-1))	Impact acceleration (ms^(-2))	Disturbance level	Average position error	Average velocity error	Average acceleration error	Average yaw error	Roll contact devi	Pitch contact dev	Yaw contact deviation	X contact deviation	Y contact deviation	Z contact deviation	X end position	Y end position	Z end position	Pitch end orientation	Yaw end orientation
1.57E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.95E-01	1.19E-01	2.75E-01	2.41E-04	1.83E-07	1.77E-03	9.82E-07	2.61E-03	1.14E-05	2.41E-03	5.05E+00	-3.28E-03	5.95E+00	3.07E-01	2.11E-04
1.57E+00	1.78E-16	0.00E+00	0.00E+00	0.00E+00	9.80E-02	2.97E-02	5.92E-02	2.21E-05	8.71E-09	1.72E-03	4.57E-08	2.61E-03	2.09E-07	8.33E-04	5.05E+00	-4.28E-04	6.03E+00	3.07E-01	4.32E-05
1.57E+00	1.57E-01	0.00E+00	0.00E+00	0.00E+00	2.51E-02	8.78E-03	1.40E-02	3.90E-06	3.77E-09	1.59E-03	1.94E-08	2.63E-03	7.33E-09	5.29E-04	5.05E+00	4.83E-05	5.98E+00	3.07E-01	3.17E-05
1.57E+00	1.57E-01	0.00E+00	0.00E+00	0.00E+00	5.34E-02	1.58E-02	2.27E-02	3.07E-06	3.80E-07	1.66E-03	2.12E-06	2.62E-03	1.02E-05	5.24E-04	5.05E+00	3.08E-03	6.02E+00	3.07E-01	1.32E-05
1.57E+00	3.14E-01	0.00E+00	0.00E+00	0.00E+00	3.09E-02	9.07E-03	6.02E-03	2.32E-06	8.00E-09	1.56E-03	4.37E-08	2.63E-03	2.60E-08	1.97E-04	5.05E+00	1.26E-04	6.01E+00	3.07E-01	4.92E-05
1.57E+00	3.14E-01	0.00E+00	0.00E+00	0.00E+00	1.74E-02	6.07E-03	5.43E-03	1.17E-06	3.60E-08	1.90E-03	1.62E-07	2.69E-03	3.10E-07	7.71E-04	5.05E+00	5.29E-04	5.97E+00	3.07E-01	7.88E-05
1.57E+00	4.71E-01	0.00E+00	0.00E+00	0.00E+00	1.59E-02	5.92E-03	1.17E-02	1.35E-04	5.60E-08	1.67E-03	2.35E-07	2.64E-03	7.20E-08	4.12E-03	5.05E+00	1.19E-04	5.93E+00	3.07E-01	7.01E-05
1.57E+00	4.71E-01	0.00E+00	0.00E+00	0.00E+00	2.80E-02	8.55E-03	2.01E-02	2.52E-06	5.42E-09	1.59E-03	2.01E-08	2.62E-03	1.18E-07	3.59E-05	5.05E+00	3.42E-04	6.00E+00	3.07E-01	-1.56E-05
1.57E+00	6.28E-01	0.00E+00	0.00E+00	0.00E+00	1.45E-02	5.75E-03	5.36E-03	4.50E-06	2.12E-08	1.70E-03	1.06E-07	2.67E-03	1.02E-06	6.41E-04	5.05E+00	-9.77E-04	5.97E+00	3.07E-01	1.59E-05
1.57E+00	6.28E-01	0.00E+00	0.00E+00	0.00E+00	2.75E-02	8.71E-03	2.19E-02	1.88E-05	1.26E-08	1.65E-03	6.31E-08	2.62E-03	9.10E-08	1.79E-03	5.05E+00	2.49E-04	6.04E+00	3.07E-01	-3.39E-05
1.57E+00	7.85E-01	0.00E+00	0.00E+00	0.00E+00	1.25E-02	4.61E-03	8.70E-03	4.38E-05	9.25E-08	1.85E-03	3.90E-07	2.68E-03	7.96E-07	3.61E-03	5.05E+00	8.45E-04	5.94E+00	3.07E-01	9.69E-05
1.57E+00	7.85E-01	0.00E+00	0.00E+00	0.00E+00	2.39E-02	7.27E-03	6.80E-03	1.10E-05	2.05E-08	1.57E-03	1.05E-07	2.65E-03	7.22E-07	1.19E-04	5.05E+00	-8.25E-04	5.99E+00	3.07E-01	5.32E-05
1.57E+00	1.73E+00	0.00E+00	0.00E+00	0.00E+00	1.19E-02	3.94E-03	1.36E-02	1.53E-05	2.38E-08	1.56E-03	1.16E-07	2.63E-03	2.26E-07	7.24E-04	5.05E+00	4.21E-04	6.02E+00	3.07E-01	-1.98E-06
1.57E+00	1.88E+00	0.00E+00	0.00E+00	0.00E+00	1.52E-02	5.07E-03	1.31E-02	1.01E-05	5.38E-08	1.56E-03	2.81E-07	2.64E-03	7.53E-07	4.84E-04	5.05E+00	-8.14E-04	6.02E+00	3.07E-01	1.35E-04
1.57E+00	2.04E+00	0.00E+00	0.00E+00	0.00E+00	1.82E-02	5.57E-03	8.94E-03	2.25E-05	3.20E-08	1.60E-03	1.58E-07	2.65E-03	1.56E-06	3.37E-04	5.05E+00	-1.24E-03	5.98E+00	3.07E-01	-3.32E-05
1.57E+00	7.85E-01	5.00E-01	0.00E+00	0.00E+00	1.25E-02	2.59E-03	1.14E-02	3.46E-06	1.13E-08	1.69E-03	6.02E-08	2.61E-03	3.30E-08	7.49E-04	5.05E+00	-1.13E-04	6.03E+00	3.07E-01	3.34E-05
1.57E+00	1.73E+00	5.00E-01	0.00E+00	0.00E+00	1.12E-02	1.80E-03	5.54E-03	5.75E-06	3.79E-09	1.93E-03	1.89E-08	2.70E-03	3.43E-07	3.92E-04	5.05E+00	5.88E-04	5.99E+00	3.07E-01	-3.63E-05
1.57E+00	1.88E+00	5.00E-01	0.00E+00	0.00E+00	1.49E-02	2.38E-03	7.45E-03	2.88E-04	1.49E-08	1.91E-03	6.33E-08	2.70E-03	1.26E-06	4.21E-04	5.05E+00	1.12E-03	6.00E+00	3.07E-01	1.37E-05
1.57E+00	2.04E+00	5.00E-01	0.00E+00	0.00E+00	1.85E-02	3.75E-03	2.93E-02	8.52E-06	7.04E-08	1.59E-03	3.68E-07	2.65E-03	2.61E-06	5.77E-04	5.05E+00	1.56E-03	5.97E+00	3.07E-01	-5.75E-05
1.57E+00	2.20E+00	5.00E-01	0.00E+00	0.00E+00	2.18E-02	3.60E-03	1.63E-02	1.07E-05	2.38E-07	2.25E-03	1.22E-06	2.72E-03	2.64E-07	3.65E-03	5.05E+00	1.17E-04	5.94E+00	3.07E-01	2.73E-04
1.57E+00	2.36E+00	5.00E-01	0.00E+00	0.00E+00	2.48E-02	4.14E-03	1.76E-02	3.60E-06	3.62E-08	2.93E-03	1.90E-07	2.75E-03	3.92E-07	1.36E-02	5.05E+00	5.83E-04	5.88E+00	3.07E-01	-1.25E-04
1.57E+00	2.51E+00	5.00E-01	0.00E+00	0.00E+00	2.89E-02	4.28E-03	1.75E-02	7.17E-06	8.14E-08	3.12E-03	3.75E-07	2.80E-03	3.07E-07	9.52E-03	5.05E+00	4.34E-04	5.90E+00	3.07E-01	-1.33E-04
1.57E+00	2.67E+00	5.00E-01	0.00E+00	0.00E+00	3.46E-02	4.66E-03	1.72E-02	2.86E-04	6.82E-08	2.70E-03	3.52E-07	2.76E-03	2.54E-06	7.01E-03	5.05E+00	1.54E-03	5.91E+00	3.07E-01	-1.34E-04
1.57E+00	2.83E+00	5.00E-01	0.00E+00	0.00E+00	3.66E-02	5.87E-03	3.22E-02	2.37E-04	1.17E-07	2.56E-03	3.97E-07	2.73E-03	1.30E-06	1.21E-02	5.05E+00	-1.08E-03	5.88E+00	3.07E-01	-7.90E-05
1.57E+00	2.98E+00	5.00E-01	0.00E+00	0.00E+00	1.06E-01	2.13E-02	5.27E-02	7.55E-06	1.32E-07	1.77E-03	6.26E-07	2.65E-03	1.95E-06	7.31E-03	5.05E+00	1.36E-03	5.91E+00	3.07E-01	8.07E-05
1.57E+00	3.14E+00	5.00E-01	0.00E+00	0.00E+00	2.50E-01	5.72E-02	1.90E-01	3.07E-05	4.63E-08	1.70E-03	2.58E-07	2.61E-03	4.30E-07	7.46E-03	5.05E+00	5.55E-04	5.91E+00	3.07E-01	-8.38E-05
1.57E+00	7.85E-01	1.00E+00	0.00E+00	0.00E+00	9.67E-02	3.35E-02	1.25E-01	1.37E-05	1.74E-09	1.80E-03	1.05E-08	2.61E-03	1.47E-07	5.97E-03	5.05E+00	3.80E-04	6.08E+00	3.07E-01	2.72E-06
1.57E+00	1.73E+00	1.00E+00	0.00E+00	0.00E+00	6.47E-02	2.22E-02	1.13E-01	1.99E-05	2.04E-07	1.63E-03	1.09E-06	2.64E-03	4.37E-06	8.39E-04	5.05E+00	-1.97E-03	6.02E+00	3.07E-01	1.94E-04
1.57E+00	1.88E+00	1.00E+00	0.00E+00	0.00E+00	2.18E-02	4.70E-03	2.52E-02	1.61E-05	3.69E-08	1.81E-03	2.08E-07	2.61E-03	2.74E-06	2.66E-05	5.05E+00	1.62E-03	6.00E+00	3.07E-01	1.25E-05
1.57E+00	2.04E+00	1.00E+00	0.00E+00	0.00E+00	7.37E-02	2.42E-02	1.29E-01	1.67E-05	6.76E-08	1.66E-03	3.63E-07	2.62E-03	8.53E-07	6.77E-05	5.05E+00	-8.43E-04	6.01E+00	3.07E-01	1.19E-04
1.57E+00	2.20E+00	1.00E+00	0.00E+00	0.00E+00	3.17E-02	6.82E-03	3.51E-02	1.53E-05	1.99E-07	1.72E-03	1.10E-06	2.61E-03	1.24E-05	6.82E-04	5.05E+00	3.43E-03	5.97E+00	3.07E-01	-1.63E-04
1.57E+00	2.36E+00	1.00E+00	0.00E+00	0.00E+00	1.01E-01	3.47E-02	1.41E-01	1.32E-05	4.44E-09	1.65E-03	2.45E-08	2.62E-03	1.81E-07	4.05E-04	5.05E+00	4.16E-04	5.98E+00	3.07E-01	8.22E-06
1.57E+00	2.51E+00	1.00E+00	0.00E+00	0.00E+00	1.18E-01	4.13E-02	1.45E-01	1.16E-05	7.17E-08	1.64E-03	3.77E-07	2.63E-03	2.20E-06	6.42E-03	5.05E+00	1.45E-03	5.92E+00	3.07E-01	5.74E-05
1.57E+00	2.67E+00	1.00E+00	0.00E+00	0.00E+00	1.38E-01	4.88E-02	1.58E-01	2.02E-04	3.20E-07	2.02E-03	1.45E-06	2.67E-03	1.34E-05	2.00E-02	5.05E+00	3.62E-03	5.85E+00	3.07E-01	8.87E-05
1.57E+00	2.83E+00	1.00E+00	0.00E+00	0.00E+00	1.80E-01	6.63E-02	1.46E-01	1.24E-05	1.96E-07	3.62E-03	7.51E-07	2.78E-03	1.72E-07	5.90E-02	5.05E+00	1.96E-04	5.75E+00	3.07E-01	1.73E-04
1.57E+00	2.98E+00	1.00E+00	0.00E+00	0.00E+00	2.28E-01	8.98E-02	2.24E-01	3.13E-05	3.48E-07	5.07E-03	1.39E-06	2.88E-03	7.38E-07	1.87E-01	5.05E+00	6.80E-04	5.56E+00	3.07E-01	-2.27E-04
1.57E+00	3.14E+00	1.00E+00	0.00E+00	0.00E+00	1.96E-01	7.43E-02	1.55E-01	4.50E-05	1.84E-07	1.62E-03	9.94E-07	2.62E-03	7.38E-06	2.00E-02	5.05E+00	2.64E-03	5.86E+00	3.07E-01	-6.98E-05
1.57E+00	1.73E+00	1.50E+00	0.00E+00	0.00E+00	1.28E-02	4.31E-03	1.23E-02	2.98E-05	1.05E-06	1.64E-03	5.36E-06	2.61E-03	4.97E-05	9.06E-04	5.05E+00	6.89E-03	6.03E+00	3.07E-01	-2.64E-05
1.57E+00	1.88E+00	1.50E+00	0.00E+00	0.00E+00	3.85E-02	1.49E-02	1.65E-01	1.39E-04	7.22E-08	1.59E-03	3.88E-07	2.64E-03	5.89E-07	1.21E-04	5.05E+00	-6.66E-04	6.00E+00	3.07E-01	1.37E-04
1.57E+00	2.04E+00	1.50E+00	0.00E+00	0.00E+00	4.38E-02	1.71E-02	1.67E-01	3.74E-05	5.38E-07	1.74E-03	3.00E-06	2.61E-03	4.00E-05	1.25E-05	5.05E+00	6.19E-03	6.00E+00	3.07E-01	-1.98E-04
1.57E+00	2.20E+00	1.50E+00	0.00E+00	0.00E+00	3.28E-02	1.08E-02	5.53E-02	2.49E-05	2.55E-07	1.58E-03	1.36E-06	2.63E-03	2.21E-05	1.01E-03	5.05E+00	4.64E-03	5.97E+00	3.07E-01	-1.82E-04
1.57E+00	2.51E+00	1.50E+00	0.00E+00	0.00E+00	9.75E-02	4.38E-02	1.84E-01	1.13E-05	1.94E-08	1.62E-03	1.02E-07	2.63E-03	2.96E-06	9.35E-04	5.05E+00	1.71E-03	5.97E+00	3.07E-01	-1.02E-04
1.57E+00	2.67E+00	1.50E+00	0.00E+00	0.00E+00	8.13E-02	3.36E-02	1.67E-01	6.37E-06	7.33E-08	1.69E-03	3.49E-07	2.65E-03	2.65E-06	3.99E-03	5.05E+00	1.60E-03	5.93E+00	3.07E-01	5.42E-05
1.57E+00	2.83E+00	1.50E+00	0.00E+00	0.00E+00	1.71E-01	8.55E-02	2.18E-01	1.31E-04	1.48E-07	3.18E-03	7.52E-07	2.76E-03	2.63E-06	4.90E-02	5.05E+00	-1.51E-03	5.77E+00	3.07E-01	1.81E-04
1.57E+00	2.98E+00	1.50E+00	0.00E+00	0.00E+00	3.44E-01	1.84E-01	4.60E-01	5.28E-03	5.40E+00	2.09E-01	3.34E+00	2.17E+01	1.81E+01	2.56E+01	1.03E+01	-5.20E+00	7.69E-02	-7.44E-02	2.03E+00
1.57E+00	7.85E-01	2.00E+00	0.00E+00	0.00E+00	1.12E-01	5.32E-02	2.16E-01	3.74E-05	1.64E-06	1.61E-03	8.85E-06	2.63E-03	9.99E-05	1.30E-02	5.05E+00	9.74E-03	6.11E+00	3.07E-01	-3.45E-04
1.57E+00	1.73E+00	2.00E+00	0.00E+00	0.00E+00	4.90E-02	2.36E-02	2.03E-01	2.03E-04	2.10E-07	1.60E-03	1.08E-06	2.62E-03	1.68E-05	1.07E-04	5.05E+00	4.07E-03	6.00E+00	3.07E-01	9.64E-05
1.57E+00	1.88E+00	2.00E+00	0.00E+00	0.00E+00	6.12E-02	2.91E-02	2.20E-01	8.11E-05	9.20E-07	1.61E-03	4.77E-06	2.63E-03	5.96E-06	1.51E-04	5.05E+00	-2.15E-03	6.00E+00	3.07E-01	-1.19E-05
1.57E+00	2.04E+00	2.00E+00	0.00E+00	0.00E+00	1.11E-01	6.22E-02	2.51E-01	4.75E-05	1.07E-07	1.63E-03	5.54E-07	2.62E-03	1.48E-05	1.33E-04	5.05E+00	3.81E-03	5.99E+00	3.07E-01	-1.80E-04
1.57E+00	2.20E+00	2.00E+00	0.00E+00	0.00E+00	4.38E-02	1.55E-02	8.10E-02	5.08E-05	5.92E-07	1.69E-03	3.26E-06	2.62E-03	4.32E-05	2.53E-05	5.05E+00	6.47E-03	6.00E+00	3.07E-01	-1.17E-04
1.57E+00	2.36E+00	2.00E+00	0.00E+00	0.00E+00	1.40E-01	7.52E-02	2.59E-01	2.97E-05	8.45E-10	1.67E-03	4.74E-09	2.62E-03	1.09E-06	4.10E-04	5.05E+00	1.04E-03	5.98E+00	3.07E-01	2.91E-05
1.57E+00	2.51E+00	2.00E+00	0.00E+00	0.00E+00	1.57E-01	8.32E-02	2.54E-01	2.73E-04	3.35E-07	1.65E-03	1.76E-06	2.63E-03	1.95E-05	7.96E-03	5.05E+00	4.31E-03	5.91E+00	3.07E-01	-1.99E-04
1.57E+00	2.67E+00	2.00E+00	0.00E+00	0.00E+00	1.06E-01	4.98E-02	2.25E-01	1.66E-05	1.16E-07	1.62E-03	6.33E-07	2.62E-03	1.12E-05	2.85E-03	5.05E+00	3.29E-03	5.94E+00	3.07E-01	-1.17E-04
1.57E+00	2.83E+00	2.00E+00	0.00E+00	0.00E+00	5.02E-02	1.55E-02	6.58E-02	5.01E-06	4.09E-07	7.23E-03	2.00E-06	3.06E-03	9.58E-06	3.74E-02	5.05E+00	2.93E-03	5.79E+00	3.07E-01	-2.67E-04
1.57E+00	2.98E+00	2.00E+00	0.00E+00	0.00E+00	1.94E-01	1.01E-01	2.32E-01	2.88E-05	8.23E-01	5.69E-01	2.49E+00	2.36E+01	1.66E+01	2.49E+01	-6.34E+00	-2.30E+00	8.39E-01	2.85E-02	-2.08E-01
1.57E+00	3.14E+00	2.00E+00	0.00E+00	0.00E+00	1.87E-01	9.47E-02	2.05E-01	8.73E-04	5.18E+00	6.37E-01	3.88E+00	7.67E+00	1.65E-01	2.79E+01	9.21E-01	-7.31E-02	1.00E-01	3.79E-05	6.29E-01
1.57E+00	3.14E+00	2.00E+00	0.00E+00	0.00E+00	1.06E-01	4.51E-02	1.68E-01	2.95E-06	1.12E-06	5.49E-03	5.62E-06	2.96E-03	6.06E-06	3.44E-02	5.05E+00	2.04E-03	5.80E+00	3.07E-01	-5.77E-04