The complexity of designing a controller for an Autonomous Underwater Vehicle (AUV) has been examined in detail in this dissertation, with particular attention paid to heave motion, yaw motion, propeller performance, and trajectory tracking. By reducing reliance on conventional control surfaces, a novel four-ballast tank mechanism has been devised, revolutionizing AUV manoeuvrability. The study begins with a thorough investigation of the heave motion dynamics. The problem of the hull drag coefficient has been addressed utilizing a dual-methodology approach that combines rigorous CFD analysis with MATLAB-Simulink equations and Ansys-Fluent. The use of PID and PI controllers for depth control, in particular, emphasizes how much better PID is at managing higher-order dynamics.

In this study, a four-bladed B-series propeller has been used for the forward movement of the AUV. The open-water behavior of a B-series four-bladed propeller and submarine hull drag has been studied numerically using the SST k-ω turbulence model in the ANSYS-Fluent software platform. For validation purposes, the results of propeller coefficients obtained from numerical simulation have been compared with the experimental data of Bernitsas et al. (1981). For the comparison it has been estimated that the maximum difference between the thrust coefficients is 6.52% and torque coefficients is 7.5 % which means the numerical results have good accuracy. From the submarine hull analysis, it has been found that as the submarine speed increases drag on the hull also increases, and around the advance ratio (J) of 0.9 the submarine hull drag exceeds the thrust generated by the propeller when the propeller is rotating at its maximum speed. This means the maximum limiting speed of the submarine lies when

J is around 0.9 which meets the demand for this submarine model. Hence it can be concluded that this propeller is suitable for the submarine used in the present study.

Additional research into the physics of yaw motion reveals the complex link between forward velocity, yawing moments, and rudder tilt angle. The Ansys-Fluent software platform has been used to find the relation. It has been found that the yawing moment increases initially with the tilt angle of the rudder, reaching a peak before declining due to stalling effects. Furthermore, the yawing moment has been observed to rise with increasing forward velocity. The identification of critical angles for rudder stalling offers valuable information regarding the ideal operational range. A yaw motion dynamics governing equation is formulated based on the numerical analysis and implemented in MATLAB Simulink. A comprehensive comparison between two control systems: the Proportional-Integral (PI) and the combined Proportional-Integral-Derivative (PID) methods has been conducted for solving the yaw motion dynamics governing equation. The PID-Controller has exhibited superior performance characteristics, with notable reductions in oscillations and errors when compared with the PI-Controller. Furthermore, when the system has been subjected to a trapezoidal input demand, the PID controller has emerged as the optimal choice, outperforming its counterpart consistently. This finding underscores the potential advantages of incorporating an integral component into the control strategy for such applications.

The dissertation further establishes the intricate challenges associated with trajectory tracking for an AUV operating in a 2-D plane. The dynamics and kinematic framework of the AUV have been formulated and line-of-sight guidance has been proposed. For enhanced path-following tracking precision, sliding mode controllers on the 2-D plane are devised by employing both the cross-track error and the line-of-sight approach. This ensures both robustness and precise control, especially when confronted

with large errors. The controller's effectiveness has been evaluated by using four distinct trajectories: linear, linear with sharp turns, curved, and circular. Additionally, stability analysis has been performed to assess the resilience of the controllers against sudden underwater disturbances. Further, perturbation has been introduced in the simulations to simulate real-world conditions more accurately. The results of the simulations confirm the controllers' capability to accurately track various paths from a given starting point.