

**KINEMATIC AND DYNAMIC ANALYSES OF A
RAILWAY WHEELSET AS A
SERIAL-CHAIN MECHANICAL SYSTEM**

by

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Abstract

Railway vehicles modelling has been an evolving field for more than a century. One of the important aspects in it is the wheel-rail interaction, i.e., understanding where contact happens between a moving wheelset and rails, and how the contact forces and moments are transmitted between them. Further, the wheelset interaction with the rails can be modelled as *Constrained* where contact is always ensured, and *Unconstrained* where the wheelset can penetrate into the rails or lift-off. The literature has methods for the detection of contact points that are analytical but approximate, and those based on numerical. The latter method is typically slower. In this thesis, a novel analytical method to represent a dicone wheelset with respect to knife-edge and cylindrical rails are proposed. It extends the concepts of Denavit-Hartenberg (DH) parameters that are generally used in closed-loop mechanisms or serial-chain mechanical systems such as open-loop robotic manipulators. Exact kinematic constraints for the wheelset to always have contact with the rails are proposed along with analytical expressions for the exact points of contact for both types of rails. Further, the wheelset is proposed as a serial-chain system like a robot manipulator by considering it as the last link or the end-effector of the manipulator. The contact forces (normal and creep) and moments, which are due to the wheel-rail interaction, were applied to the end-effector as external wrench. The forward dynamics analysis of a serial manipulator that uses DeNOC (Decoupled Natural Orthogonal Complement) was then applied to the *Constrained* approach for dicone on knife-edge, and cylindrical rails, and also for the *Unconstrained* approach of actual wheel-rail profiles. The kinematic and dynamic analyses of the wheelset were implemented in a software called RailAnalyzer. It allows users to input data and visualize the resulting motion of the wheelset in the form of 3-dimensional simulation in Autodesk Inventor CAD software with a provision to plot graphs.