Preface

Magnetic levitation (suspension) for contactless operation has been in development as an alternative to wheel-on-rail systems since Graeminger first patented an electromagnetic suspension device in 1912. This led to a number of operational and experimental magnetic trains being constructed, for both low- and high-speed operations, which are currently in service or will be in several years. The well-known Transrapid, which runs at a maximum operating speed of 430 km/h, has been successfully operating without any operational problems since it was unveiled in 2004 in Shanghai, China, showing that electromagnetic suspension technology has in fact matured beyond expectations. The low-speed system using electromagnets, Linimo, also has been carrying 20,000 passengers per day in Nagoya, Japan, and has proven its advantages by offering a high level of reliability, considerable environmental appeal and lower maintenance costs. The Incheon International Airport Urban Maglev Demonstration Line in Korea and the Beijing and Changsa urban lines under construction in China will be opened in one or two years. On April 22, 2015, the Japanese superconducting magnet train L0 attained a running speed of 603 km/h, a record for any guided vehicle, and there are plans to operate this train over a route between Tokyo and Nagoya by 2027. These applications of magnetically levitated vehicles may prove that wheel-less transport could be a promising option as a new transportation mode in the future. On the other hand, as both the speed and the ride comfort performance of conventional wheel-on-rail vehicles have been considerably improved in recent years, the specific niche for magnetic vehicles in terms of speed as well as ride comfort is narrowing. It may be that magnetic vehicles are approaching a critical point that will determine their future viability. On the other hand, magnetic levitation technology is attracting strong interest for diverse applications in which the contact-free aspect is essential—examples include an extremely clean transfer system for LCDs and semiconductors, a rope-less elevator for skyscrapers and a hover board for entertainment purposes, and prototypes for these technologies have been demonstrated. With the rapidly increasing interest in its various forms and applications, there is an opportunity for engineers to play a dominant role in the development of contact-less or wheel-less operation systems.

The objective of this monograph is to discuss the principles of magnetic levitation and its operation in a way that can be understood by readers from various backgrounds. The authors also hope to promote a discussion that can lead to an enhancement of the current magnetic levitation system's competitiveness compared to conventional systems through innovation.

For ease of understanding and application, the three kinds of magnets, i.e., permanent, superconducting magnets, and electromagnet, in wide use are presented in a definitive and comprehensive manner with example cases and descriptions of the corresponding levitation concepts and configurations. The unique properties, advantages, and limitations, as well as significant problems of each magnetic levitation scheme, are discussed. In particular, railway applications are introduced chronologically and in more detail. The reader will find the book useful in imagining their own new concepts and identifying the basic design parameters. The majority of the content in this book can be understood by a reader who has studied university-level physics only, regardless of his or her major.

Much of this work, which has been supported by the MSIP, MOLIT, and KAIA, as well as the NST, was carried out in collaboration with the author's colleagues both at the KIMM (Korea Institute of Machinery and Materials) and from academic, research, and industry organizations.

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Technical details and figures quoted in the book are based on information available in the public domain, including via the Internet. In particular, the authors thank Dr. Byung-Chun Shin, a director of Center for Urban Maglev Program, for supplying information on Korea's ECOBEE, an urban magnetic levitation train. Professor Lin Guobin of Tongi University and Professor H. Osaki of the University of Tokyo are also gratefully acknowledged for supplying information on the status of magnetic trains in China and Japan.

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