The field of beam physics touches many areas of physics, engineering and the sciences. In general terms, beams describe ensembles of particles with initial conditions similar enough to be treated together as a group so that the motion is a weakly nonlinear perturbation of a chosen reference particle. Particle beams are used in a variety of areas, ranging from electron microscopes, particle spectrometers, medical radiation facilities, powerful light sources and astrophysics to large synchrotrons and storage rings such as the LHC at CERN.

An Introduction to Beam Physics is based on lectures given at Michigan State University’s Department of Physics and Astronomy, the online VUBeam program, the U.S. Particle Accelerator School, the CERN Academic Training Programme and various other venues. It is accessible to beginning graduate and upper-division undergraduate students in physics, mathematics and engineering. The book begins with a historical overview of methods for generating and accelerating beams, highlighting important advances through the eyes of their developers using their original drawings. The book then presents concepts of linear beam optics, transfer matrices, the general equations of motion and the main techniques used for single- and multi-pass systems. Some advanced nonlinear topics, including the computation of aberrations and a study of resonances, round out the presentation.

Features
- Provides an introduction to the physics of beams from a historical perspective
- Describes the production, acceleration and optics of beams
- Discusses transfer matrices and maps for particle accelerators and other weakly nonlinear dynamical systems
- Covers various important devices used for imaging and repetitive systems, including electron microscopes, spectrometers and storage rings
- Incorporates some advanced material such as aberration integrals and the treatment of resonances

An Introduction to Beam Physics

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Preface

This volume provides an introduction to the physics of beams. This field touches many other areas of physics, engineering and the sciences, and in turn benefits from numerous techniques also used in other disciplines. In general terms, beams describe ensembles of particles with initial conditions similar enough to be treated together as a group, so that the motion is a weakly nonlinear perturbation of that of a chosen reference particle.

Applications of particle beams are very wide, including electron microscopes, particle spectrometers, medical irradiation facilities, powerful light sources, astrophysics – to name a few – and reach all the way to the largest scientific instruments built by man, namely, large colliders like LHC at CERN.

The text is based on lectures given at Michigan State University’s Department of Physics and Astronomy, the online VUBeam program, the US Particle Accelerator School, the CERN Academic Training Programme, and various other venues. Selected additional material is included to round out the presentation and cover other significant topics.

The material is at a level to be accessible to students of physics, mathematics and engineering at the beginning graduate or upper division undergraduate level and can be viewed as an introductory companion to the more advanced Modern Map Methods in Particle Beam Physics by M. B., published by Academic Press. Emphasis has been placed on showing major concepts in their original incarnations and through historic figures. Finally, some of the sections and chapters that contain more advanced material are marked by a * symbol and can be omitted in a first reading.

Many organizations and individuals have helped directly and indirectly at various stages in the development of this book. MSU’s Physics and Astronomy Department provided an environment of support for this and other books, the VUBeam program, as well as many of our other activities.

For two decades of continuous financial support that were instrumental to the success of the book, the VUBeam program, and indeed much of our research, we are grateful to the US Department of Energy, and in particular to Dr. Dave Sutter, the long-term coordinator of their beam physics activities.

K. M. would like to thank her daughter Kazuko for her own great interest in physics and science and much encouragement during the finalization of this text.

W. W. would like to thank Dr. D. Robin for his encouragement, Dr. E. Forest for stimulating discussions on various aspects of beam dynamics such as normal form theory, and his wife Juxiang Teng for her unwavering support
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throughout this project.

All of us want to thank Béla Erdélyi, Gabi Weizman, Pavel Snopok and He Zhang for thoughtful comments about the material. We also are thankful to many authors, national laboratories and publishers allowing us to reproduce published figures. The details are described in the corresponding figure captions.

Last but not least, we are very grateful to the entire staff of Taylor & Francis for their continuous support, in particular to Francesca McGowan for her great interest and productive comments.

Martin Berz
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The field of beam physics touches many areas of physics, engineering and the sciences. In general terms, beams describe ensembles of particles with initial conditions similar enough to be treated together as a group so that the motion is a weakly nonlinear perturbation of a chosen reference particle. Particle beams are used in a variety of areas, ranging from electron microscopes, particle spectrometers, medical radiation facilities, powerful light sources and astrophysics to large synchrotrons and storage rings such as the LHC at CERN.

An Introduction to Beam Physics is based on lectures given at Michigan State University’s Department of Physics and Astronomy, the online VUBeam program, the U.S. Particle Accelerator School, the CERN Academic Training Programme and various other venues. It is accessible to beginning graduate and upper-division undergraduate students in physics, mathematics and engineering. The book begins with a historical overview of methods for generating and accelerating beams, highlighting important advances through the eyes of their developers using their original drawings. The book then presents concepts of linear beam optics, transfer matrices, the general equations of motion and the main techniques used for single- and multi-pass systems. Some advanced nonlinear topics, including the computation of aberrations and a study of resonances, round out the presentation.

Features
• Provides an introduction to the physics of beams from a historical perspective
• Describes the production, acceleration and optics of beams
• Discusses transfer matrices and maps for particle accelerators and other weakly nonlinear dynamical systems
• Covers various important devices used for imaging and repetitive systems, including electron microscopes, spectrometers and storage rings
• Incorporates some advanced material such as aberration integrals and the treatment of resonances