Preface

Medium energy electron synchrotrons (see page 1) used for the production of high energy photons from synchrotron radiation is an accelerator growth industry. Many of these accelerators have been built or are under construction to satisfy the needs of synchrotron light users throughout the world. Because of the long beam lifetimes required for these synchrotrons, these medium energy accelerators require the highest quality magnets of various types. Other accelerators, for instance low and medium energy boosters for high energy physics machines and electron/positron colliders, require the same types of magnets.

Because of these needs, magnet design lectures, originally organized by Dr. Klaus Halbach and later continued by Dr. Ross Schlueter and Jack Tanabe, were organized and presented periodically at biennual classes organized under the auspices of the US Particle Accelerator School (USPAS). These classes were divided among areas of magnet design from fundamental theoretical considerations, the design approaches and algorithms for permanent magnet wigglers and undulators and the design and engineering of conventional accelerator magnets. The conventional magnet lectures were later expanded for the internal training of magnet designers at LLNL at the request of Lou Bertolini. Because of the broad nature of magnet design, Dr. S. Y. Lee, the former Director of the Particle Accelerator School, saw the need for a specialized course covering the various aspects of the design, engineering and fabrication of conventional magnets. This section of the class was isolated and augmented using the LLNL developed material resulting in the class on conventional magnet design. Conventional magnets are defined (for the purposes of this publication) as magnets whose field shape is dominated by the shape of the iron magnet yoke and are excited by coils, usually wound from solid or hollow water-cooled copper or aluminum conductors.

Dr. S. Y. Lee and Dr. Helmut Wiedemann, past and current Directors of USPAS, encouraged the author to write a text for the purpose of consolodating the lecture notes used in the USPAS course. This publication collects the lecture notes, written for the first course in the USPAS conventional magnet design course and evolved over subsequent presentations of this same course, and organizes the material roughly divided among two parts. One part is theoretical and computational and attempts to provide a foundation for later chapters which exploit the expressions and algorithms for the engineering and design calculations required to specify magnet conceptual designs. A chapter is devoted to the description and use of one of many magnet codes used to characterize the two dimensional field resulting from various magnet cross-sections. A chapter is included which exploits the two-dimensional theory and applies the mathematics to techniques and systems for magnet measurement. The second part of this publication ranges to practical issues associated with the fabrication of components, assembly, installation and alignment of magnets. This section also includes fabrication practices which respond to personnel and equipment protection needs.

Required design calculations are supplemented by examples and problems. A CD is included with tools provided to simplify the computation of some of the more tedious relationships. This CD also includes useful photographs and pictures describing the high volume production of typical magnet types, which if included in the publication will add too many pages and increase the cost of publication.

Styles among those facing similar problems will result in a wide variation of individual magnet designs. Designs and technologies will evolve and improve. This publication provides a snapshot of the present technology and presents as examples the magnet designs developed in response to the needs of several projects, the Advanced Light Source at LBNL, PEPII Low Energy Ring and SPEAR3 synchrotron light source at SLAC and the Australian Light Source, currently under construction in Melbourne. In each example, the reasons for fabrication design decisions are itemized and rationalized as much as is reasonable. The examples presented in this publication are provided as starting points which can be used as a design basis for magnets required for future projects. It is hoped that the listing of some design choices and the motivation for these choices will be useful. It is the intention of the author to publish a document collecting and archiving the tools and techniques learned from the past masters in the craft and to provide a useful reference for future magnet designers.