Preface

During the past decade, many K-12 schools, libraries, and communities have established makerspaces with 3D printers, digital die cutters, and other fabrication tools. The widespread access to makerspaces in recent years has led to a renaissance in development of physical instructional materials, such as mathematics manipulatives, science kits, and engineering projects. An *Introduction to Design through Making* provides an entry point to the process of designing and making physical objects using digital fabrication tools.

The information and activities described were developed in the *Make to Learn* laboratory at the University of Virginia. As its title suggests, this lab is based on the premise that it is possible to learn through the process of making. In engineering, the field of mechatronics encompasses three disciplines:

1. *Mechanical Engineering*

   The field of mechanical engineering includes the process of designing a mechanical mechanism using Computer Assisted Design (CAD) software and fabricating the components of the mechanism using tools such as laser cutters, 3D printers, and CNC milling machines.

2. *Electrical Engineering*

   Electronic sensors and actuators are incorporated into a fabricated mechanism to guide its movement and functions.

3. *Computer Science*

   A microcontroller is a small, special-purpose computer designed to control physical objects. The microcontroller is programmed to use information from sensors to guide the motion of actuators.

In commercial applications, the design process leads to industrial manufacturing resulting in mass production of the mechanism. Parallel processes occur in makerspaces, but the goal is often the learning that occurs through design process rather than mass manufacturing of the object.

The first section of this book provides a brief introduction to application of the disciplines described above to design processes in makerspaces. The chief difference between industrial and educational applications is scale. A CNC milling machine can cost tens of thousands of dollars and can require several years of training for efficient operation. A digital die cutter employs similar principles but costs a few hundred dollars and can used effectively after an hour or two training.

The second section of the book explores the design of mechanisms involving sight, sound, and motion. The area of sight describes the historical evolution of mechanical and digital animation, culminating in a design challenge involving fabrication and construction of a mechanical animation machine. The area of motion describes the historical evolution of electric motors that now permeate every aspect of our lives, culminating in a design challenge involving design and construction of a mechanism incorporating an electric motor. The area of sound describes the evolution and principles underlying loudspeakers, culminating in a design challenge involving design and construction of a working speaker and subsequent analysis of its fidelity through construction of a frequency response curve. The process of designing and making these objects incorporates the fields of engineering, science, mathematics, and human perception.