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GETTING STARTED WITH **Engineering**

Think
Like
an
Engineer!

Camille McCue, PhD
STEM Teacher and Tech Geek



GETTING STARTED
WITH

Engineering

Camille McCue, PhD



WILEY



GETTING STARTED WITH ENGINEERING

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CONTENTS

INTRODUCTION 1

About This Book	1
About You	3
About the Icons	4
The First Step	4

PROJECT 1: ENGINEERING 101 5

What Is Engineering?	5
Where Do Engineers Work?	5
What Are Some Engineering Fields?	6
What Is the Engineering Design Cycle?	7
What Does a Design Look Like?	8
What Is the Golden Rule of Engineering?	10
What Is the Iron Triangle of Engineering?	10
Mini Project: Classic Pocket Rocket.	12

PROJECT 2: TOUCHDOWN MARS 13

Introduction to Planetary Landers	13
Materials	15
Simulate a Landing with Technology.	16
Play with a descent to Mars	16
Control a descent to Mars.	18
Design Your Mars Lander	19
Build Your Mars Lander	21
Test Your Mars Lander	24
Improve Your Mars Lander	25
Aerospace Engineering and the Iron Triangle	25

PROJECT 3: THE CLOCK IS TICKING **27**

All Here, In Order, On Time. Let's Go!	27
Materials	29
Simulate a Simple Logistics Process	30
Simulate a More Complex Logistics Process.	32
Plan Your Industrial Engineering Process	34
Plan with a Gantt chart	34
Plan by acting it out	36
Implement Your Logistical Plan	37
Evaluate Your Success.	39
Improve Your Process	39
Iron Triangle of Engineering.	40
Gantt Charting with a Spreadsheet	40

PROJECT 4: SQUEAKY CLEAN UP **42**

Introduction to Oil Spill Clean Ups	42
Materials	44
Plan Your Oil Spill Clean-Up Process	45
Plan to contain the oil	46
Plan to skim the oil	46
Plan to use sorbents	46
Plan to disperse the oil	47
Sketch your process	48
Implement Your Clean-Up Process	49
Simulate the oil spill	49
Execute your clean-up plan	50
Evaluate Your Success.	51
Improve Your Process	52
Iron Triangle of Engineering.	53
Mini Project: Cleaning Feathers and Fur	54

PROJECT 5: LOAD THE BRIDGE**55**

Civil Engineers Build the World	.56
Introduction to Bridges	.56
Materials	.58
Model Your Bridge with Technology	.58
Design Your Truss Bridge	.63
Build Your Pasta Bridge	.66
Test Your Pasta Bridge	.68
Improve Your Bridge	.70
Civil Engineering and the Iron Triangle	.70

PROJECT 6: ELECTRIC ALIEN CAP**73**

Electronics 101	.73
Electrical circuits	.74
Symbols and schematics	.74
Series and parallel circuits.	.75
Materials	.77
Design Your Electric Alien Cap.	.79
Build Your Cap	.80
Get your components ready.	.80
Mark your circuit onto the hat	.81
Stitch the positive connections in your circuit.	.81
Stitch the ground connections in your circuit	.83
Test Your Circuit	.85
Improve Your Cap	.85
Electrical Engineering and the Iron Triangle	.85

PROJECT 7: NOW YOU'RE COOKING!**88**

Early Mechanical Engineering	.88
Archimedes the engineer	.89
Energy everywhere.	.90
The First Law of Thermodynamics	.90



Materials	.91
Design Your Solar Oven	.92
The Second Law of Thermodynamics.	.92
Oven design criteria	.92
Build Your Design	.94
Build the food chamber.	.94
Add the oven insulation	.95
Attach the solar reflector	.97
Test Your Design Plan	.98
Improve Your Cooker	.99
Solar Cooking and the Iron Triangle	100
Mini Project: Vdara Death Ray	102

PROJECT 8: ROLLER COASTER MANIA ***103***

Introduction to Roller Coasters	104
Mass in a roller coaster system.	105
Energy in a roller coaster system	105
Materials	106
Model Your Coaster with Technology.	106
Design Your Roller Coaster	112
Build Your Roller Coaster	113
Test Your Roller Coaster	116
Improve Your Roller Coaster.	117
Entertainment Engineering and the Iron Triangle	117

APPENDIX: COOL TOOLS (AND MORE!) ***120***

INTRODUCTION

SO YOU WANT TO GET STARTED WITH ENGINEERING! Engineers are people who design and invent new products and processes. They improve life by building solutions to problems in the natural world. They use tools and technologies in their daily work. And they team up on projects with scientists, government officials, and business people.

Many grand challenges await you in the world of engineering: making better use of solar energy; creating new types of transportation; securing cyberspace; designing better medicines; providing the world with clean drinking water; applying the function of the brain to computers; inventing new ways to teach people; and improving virtual reality. It's never too early to start, so roll up your sleeves and get ready to work as a junior engineer!

ABOUT THIS BOOK

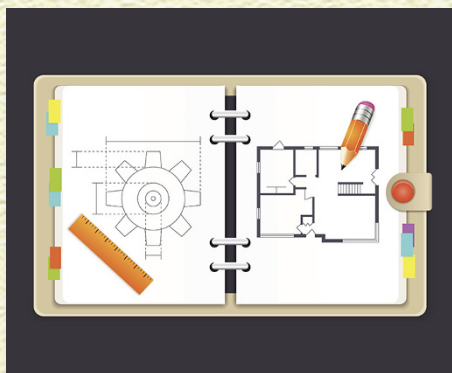
Engineering is a hands-on field. When you work in engineering, you will use your body as much as you use your brain. In this book, you have opportunities to do both! Sometimes you'll use your eyes and your fingers to work in a small, careful way. An example is using a needle and thread to sew a wearable electronic circuit with LED lights and a battery onto a baseball cap. Other times, you'll use your lungs, legs, and arms to work in a big, athletic way. An example is blowing up balloons to serve as air bags on a Mars lander, and then running up the stairs and hurling the lander off the second floor to (what I hope is) a soft landing on the planetary surface below.

But you'll also use your brain quite a bit. You'll do some online research to learn about engineering projects that have been done before — and how they succeeded or failed. You'll use computer simulations to tinker with a product or a process to learn how it operates. In this way, you can try different ways of

building or different ways of conducting a process — before you do them in the real world. You'll brainstorm and draw design plans in your design notebook and then write down how those plans perform and how you can improve them.

Here's what you need to do the projects in this book:

- » A computer running a modern version of a Windows or Mac OS X operating system
- » A reasonably fast Internet connection
- » Some household items, such as foil pans, scissors, a trash bag, tape, a marble, a meter stick, clear plastic wrap, tape, a dog leash, kitty litter, cotton balls, an ear syringe, a thermometer, liquid dishwashing soap, and a kitchen scale (plus a few more items)
- » Some food items, such as marshmallows, graham crackers, canola oil, and assorted pasta
- » Some home improvement store items, such as foam tubing, PVC elbows, string, sand, and perlite
- » Some craft store items, such as craft foam, pipe cleaners, hay, a hot-glue gun, feathers, and faux fur
- » One specialty purchase (LilyTwinkle electronics kit for \$20) and, optionally, the use of a 3D printer
- » Some safety gear, namely goggles, protective gloves, and a face mask
- » One design notebook, which can be any notebook with paper or graph paper, to draw designs and write evaluations of your products and processes



and how to improve them; you can also print photos of your work and paste them into your notebook (optional)

If you're reading this as an ebook, you can click web addresses, such as www.dummies.com, to visit that website.

Every project follows the Engineering Design Cycle, or Engineering Cycle. This process is different from the Scientific Method, which you probably learned in school. I explain the Engineering Cycle in Project 1.

My design sketches are meant to spark your imagination. Your engineering designs may look very much the same or very different from my designs. Your ideas are valuable and I want you to have faith in them. Brainstorm, invent, and build!

Finally, every project wraps up with a section called the Iron Triangle of Engineering. This section helps you think about what real engineers consider when doing that type of project.

ABOUT YOU

Every junior engineer has to start somewhere. When I wrote this book, I assumed that you can

- » **Type on a computer and use a mouse.** Your experience can be on a Windows or a Mac system. The simulations you use in this book are computer based (not apps on a mobile device).
- » **Read and follow directions.** Each project consists of a sequence of steps to follow. Try to complete the steps mostly as written to get the best results. However, you can make some changes to the steps to match new designs you create.
- » **Do a little math and measurement.** Engineers must measure things such as length and mass. In this book, I use the metric system for measurements. Engineers also do computations such as dividing to find a ratio. If you want, you can use a calculator to help you compute. I don't use any formulas, but as you gain new skills you should be ready to use these, too!

- » **Follow safety rules and ask an adult for help when you need it.** Engineering is all about safety — putting on your safety gear, looking out for danger, asking for help, and using equipment responsibly. Your development as a junior engineer starts with safe behavior.
- » **Bounce back from failure.** *Failure* is a word many grown-ups don't like to say to kids, but it is an important part of engineering. When you design and test ideas, some will succeed and others will fail. Thomas Edison, inventor of the light bulb, said this about failure: "I have not failed 700 times. I have succeeded in proving that those 700 ways will not work. When I have eliminated the ways that will not work, I will find the way that will work."



Courtesy of bilhagolan/Getty

ABOUT THE ICONS

As you read through the projects in this book, you'll see two icons. The icons point out different things:



This icon marks potential problems or dangers.



This icon marks helpful information or guidance.

THE FIRST STEP

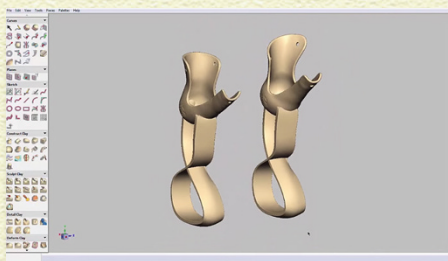
Whether you view yourself as a future engineer or you just love to tinker and learn new things, your exploration of the projects in this book is a great first step towards fun and rewarding work. Good luck as you enter the world of engineering!

PROJECT 1 ENGINEERING 101

WELCOME TO ENGINEERING! You are beginning an adventure that explores the fun and rewarding field of engineering. Because engineering is not a class most kids see on their school schedules, we'll start with a crash course in Engineering 101.

WHAT IS ENGINEERING?

Engineering is work that uses science, math, and technology to create products and processes. The mission of engineering work is to help humanity and our world. Many times, the goal is to solve an urgent problem, such as building a bridge or setting up a communications network after a disaster. Sometimes, the goal of engineering is to help other living creatures, such as developing *prosthetic* (artificial) legs for a dog born with missing or malformed limbs. Other times, the goal of engineering is to make a process work better and faster, such as scheduling the gates that airplanes use in an airport.



Courtesy of 3D Systems

WHERE DO ENGINEERS WORK?

Engineers work in all types of settings, all over the world. Sometimes engineers work inside, using a computer to design a product. Sometimes they work outside, using special construction equipment to build a structure. Sometimes they work alone, but most of the time engineers work in teams.

6 PROJECT 1 ENGINEERING 101

Engineers share information with each other when the knowledge and experience of one group can help another group. This was the case when NASA engineers helped the government of Chile rescue 33 miners who were trapped underground. NASA's experience working in hard-to-reach places and in creating rescue capsules contributed to the success in saving the miners.



Courtesy of Hugo Infante/Government of Chile

WHAT ARE SOME ENGINEERING FIELDS?

Many types of engineering exist, and each field offers exciting challenges to solve. Here are a few engineering fields and the products or processes with which they work:

- » **Aerospace:** Build airplanes and spacecraft
- » **Architectural:** Construct buildings, skyscrapers, and landmarks
- » **Biomedical:** Build devices that function with living bodies
- » **Chemical/materials:** Create new products such as medicines, plastics, and fuels
- » **Civil/structural:** Build dams, roads, and bridges
- » **Computer:** Make computers and smart devices
- » **Electrical:** Build electronic equipment; generate and distribute electricity to homes and factories
- » **Environmental:** Focus on pollution control and recycling