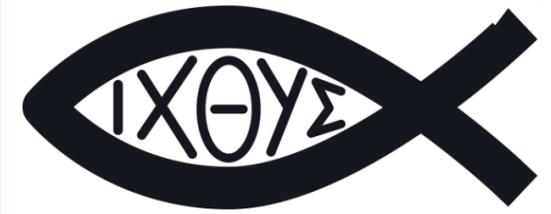


VOLUME I : SHOP BASICS, DRAWING, AND CAD

GUIDE TO SHOP AND ENGINEERING

FOR SECONDARY SCHOOL STUDENTS

By Kent Misegades
with
Michael Patrick Leahy and Anthony Gockowski



*With a Biblical
Worldview*

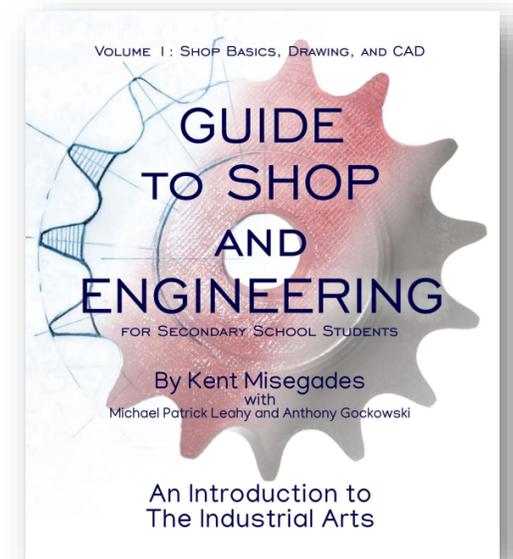
available at
LULU.com

Lecture Notes for CHAPTER 14



Contents

- Preface: The Purpose of Education, Work and these Lessons
- Introduction: So, you want to learn to make things and fix things?
- Chapter One: Preparing for these Lessons
- Chapter Two: Set Up your Workshop
- Chapter Three: Hand Tool Identification and Usage
- Chapter Four: Power Tool Identification and Usage
- Chapter Five: Shop Safety
- Chapter Six: Units and Measurements
- Chapter Seven: Engineering Lettering
- Chapter Eight: Sketching – Straight Lines
- Chapter Nine: Sketching – Circles, Arcs, Ellipses and Curves
- Chapter Ten: Sketching – Chamfers, Fillets and Rounds
- Chapter Eleven: Multi-View Drawings
- Chapter Twelve: Pictorial Views
- Chapter Thirteen: Dimensioning and Scaling



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Chapter Seventeen: What's Next?

Glossary

Key Conversion Factors Between US Customary and Metric Units

Key Conversion Factors Between Metric and US Customary Units

Graph Paper Work Sheets, Cartesian and Isometric

Single-Stroke Gothic Lettering Template

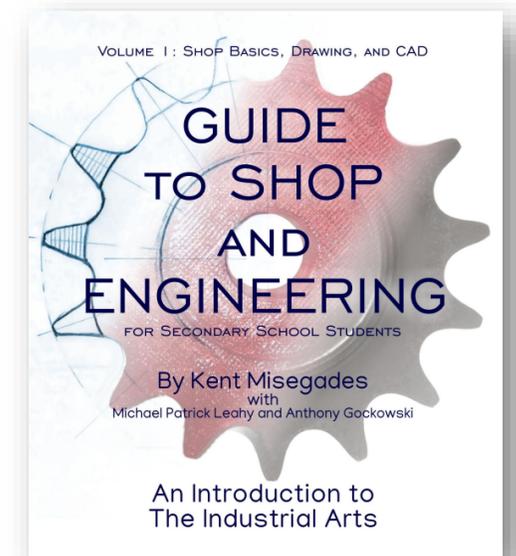
23 Shop Projects

Additional Reading

About the Author

Throughout the Guidebook: American Inventors

Throughout the Guidebook: Leading Schools



How to Use these Lecture Notes

1. **Read** the printed volume, **Shop & Engineering**, for this chapter.
2. **Gather materials** needed for this chapter's lessons, exercises and for recommended projects.
3. Use these Lecture Notes to **teach and discuss** the material. They contain more than the print version!
4. Work through all the **exercises** and check results. Correct errors and repeat until **100% correct**.
5. Take time to discuss the “**Questions to Ponder**” and “**What the Bible Says About**” sections at the end.
6. **Reinforce classroom learning** by doing one or more related **projects** in your workshop.



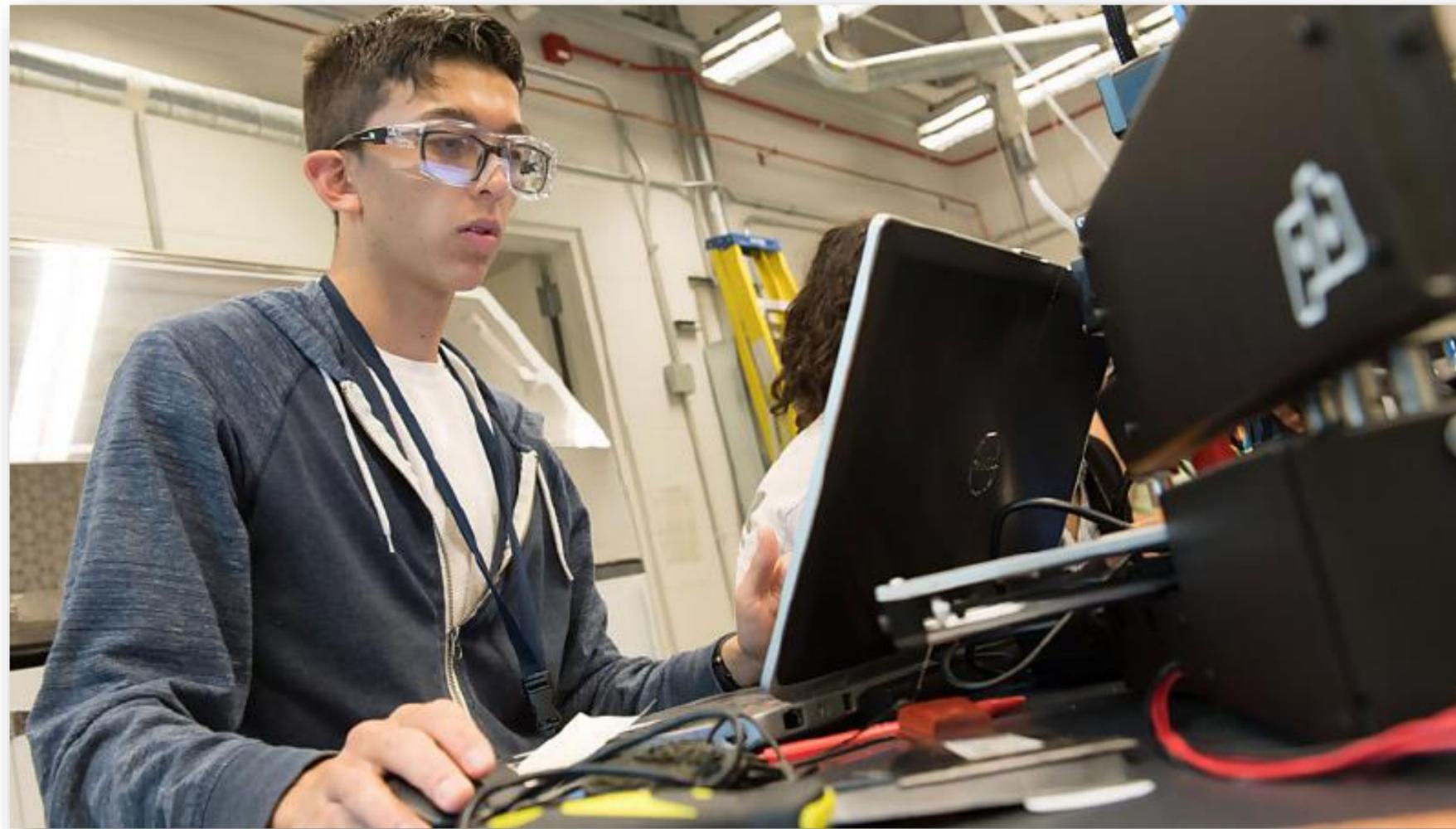
Engineering with a Biblical Worldview

- Everything in our lives is directed by **God**. At **home** and at **work**. His **wisdom and direction** for our lives is found in the **Bible**, so *of course* engineers should always have **scripture** first and foremost in their minds!
- Our **worldview** is developed as we establish beliefs about four critical topics: (from *Biblical Worldview*, Dr. J. Mulvihill)
 1. **Creation:** How did I get here? What is my purpose?
 2. **Rebellion:** What went wrong? Why is there evil and suffering?
 3. **Salvation:** What is the solution? Where do I find hope?
 4. **Restoration:** What happens in the future? How do we transform lives and change the world for the better?
- Engineers continually **face challenges** in their quest to develop products and solutions that ultimately “**transform lives and change the world for the better**”. The Bible provides many **answers**, the reason it should be found among every engineer’s **most-used reference books**.



Volume I : Chapter 14

CAD – Introduction to Computer Aided Design



What this chapter covers:

- **Definitions**
- **Computer-Aided Design (CAD)**
- **Computer-Aided Engineering (CAE)**
- **Computer-Aided Manufacturing (CAM)**
- **Computer Numerical Control (CNC)**
- **A Brief History of CAD**
- **Getting Started with Onshape**
- **American Inventor – Hobie Alter**
- **What the Bible Says**

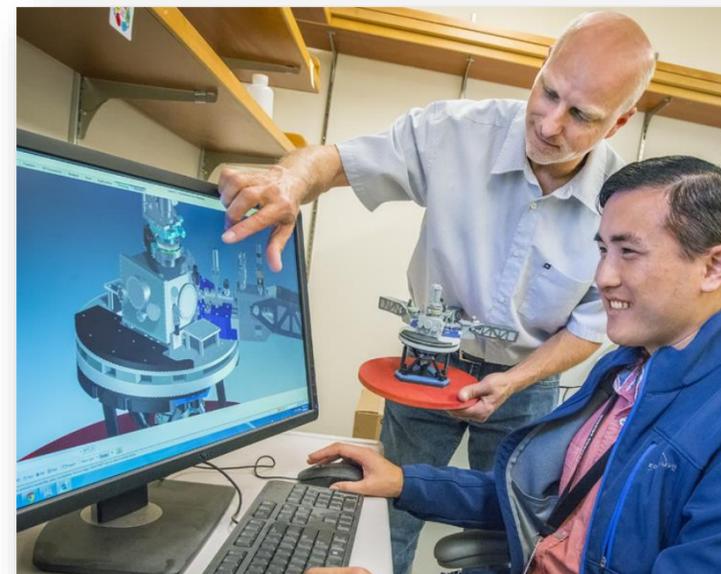
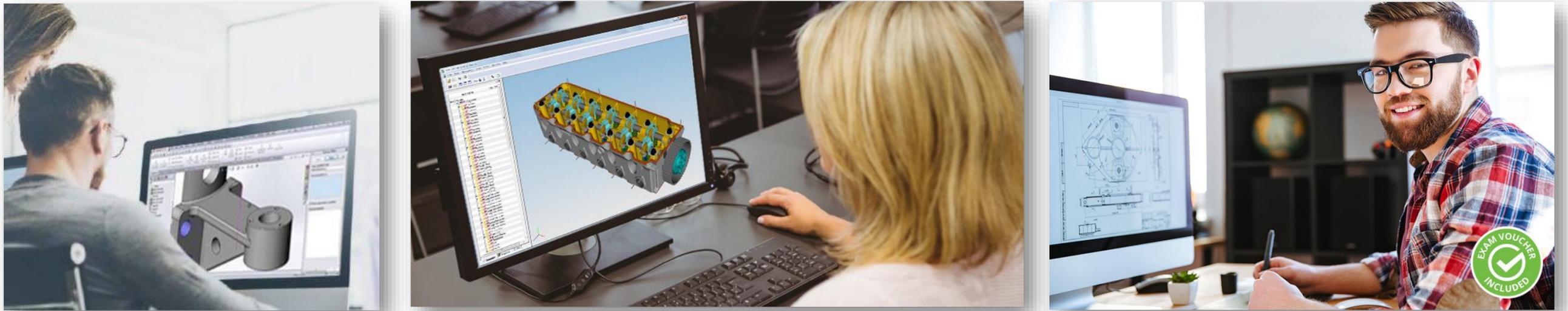


Definitions:

- **3D Printing** - the action or process of making a physical object from a three-dimensional digital model, typically by laying down many thin layers of a material in succession.
- **Additive Manufacturing** - structures are made by the addition of thousands of minuscule layers which combine to create the product. The process typically involves the use of a computer and special software which can relay messages to the printer so it “prints” in the desired shape.
- **Computer-Aided Design (CAD)** - the use of computers to create 2D and 3D designs. Common types of CAD include two-dimensional drawings and layout design and three-dimensional modeling.
- **Computer-Aided Engineering (CAE)** - the use of computer software to simulate performance in order to improve product designs or assist in the resolution of engineering problems for a wide range of industries. This includes simulation, validation and optimization of products, processes, and manufacturing tools.
- **Computer-Aided Manufacturing (CAM)** - the use of software and computer-controlled machinery to automate a manufacturing process.
- **Computer Numerical Control (CNC)** - the automated control of machining tools and 3D printers by means of a computer. A CNC machine processes a piece of material to meet specifications by following a coded programmed instruction and without a manual operator directly controlling the machining operation. **G-code and M-code** commands provide instructions to CNC machinery.
- **Subtractive Manufacturing** – traditional manufacturing methods involving material being carved or shaped into the desired product by parts of it being removed in a variety of ways.



Computer Aided Design (CAD)

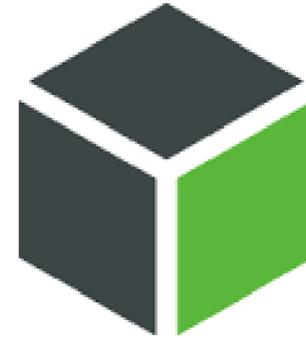


Computer-Aided Design (CAD) - the use of computers to create 2D and 3D designs. Common types of CAD include two-dimensional drawings and layout design and three-dimensional modeling.



Computer Aided Design (CAD)

Onshape
A PTC Business



creo[®]

DS
CATIA

DS
SolidWorks



AUTODESK[®]
INVENTOR[®]

SIEMENS  **NX**

 **SOLID EDGE**

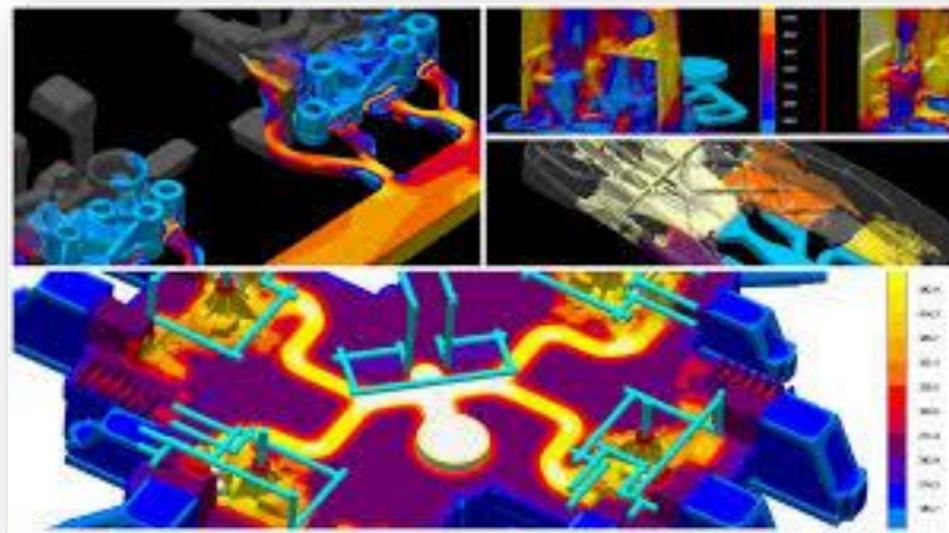
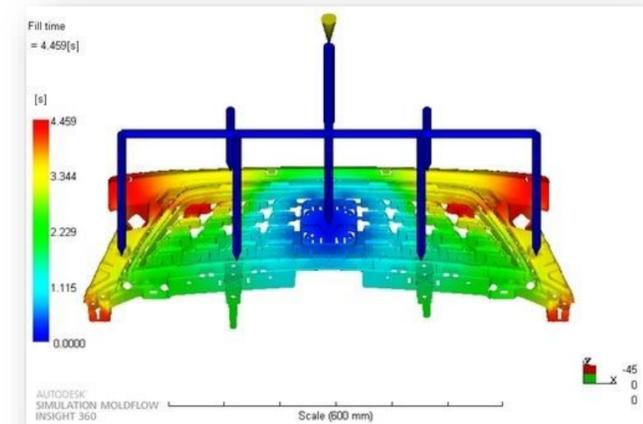
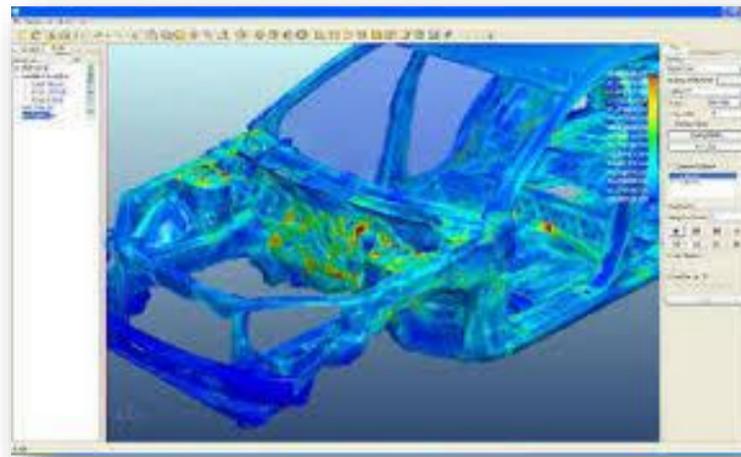
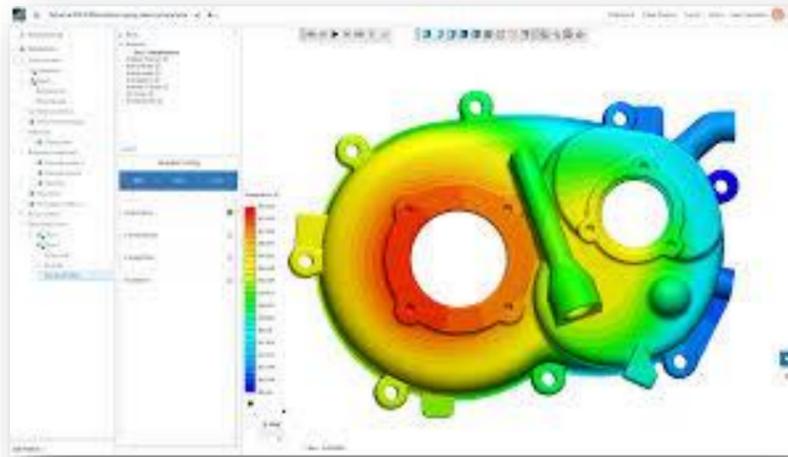


AUTODESK[®]
AUTOCAD[®]

Leading Software Tool Providers



Computer Aided Engineering (CAE)



Computer-Aided Engineering (CAE) - the use of computer software to simulate performance in order to improve product designs or assist in the resolution of engineering problems for a wide range of industries. This includes simulation, validation and optimization of products, processes, and manufacturing tools.



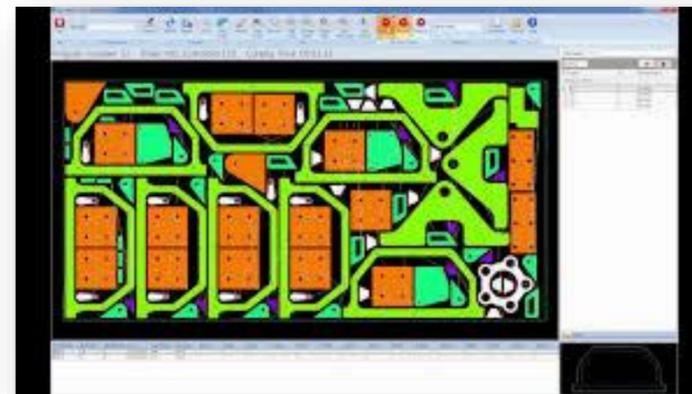
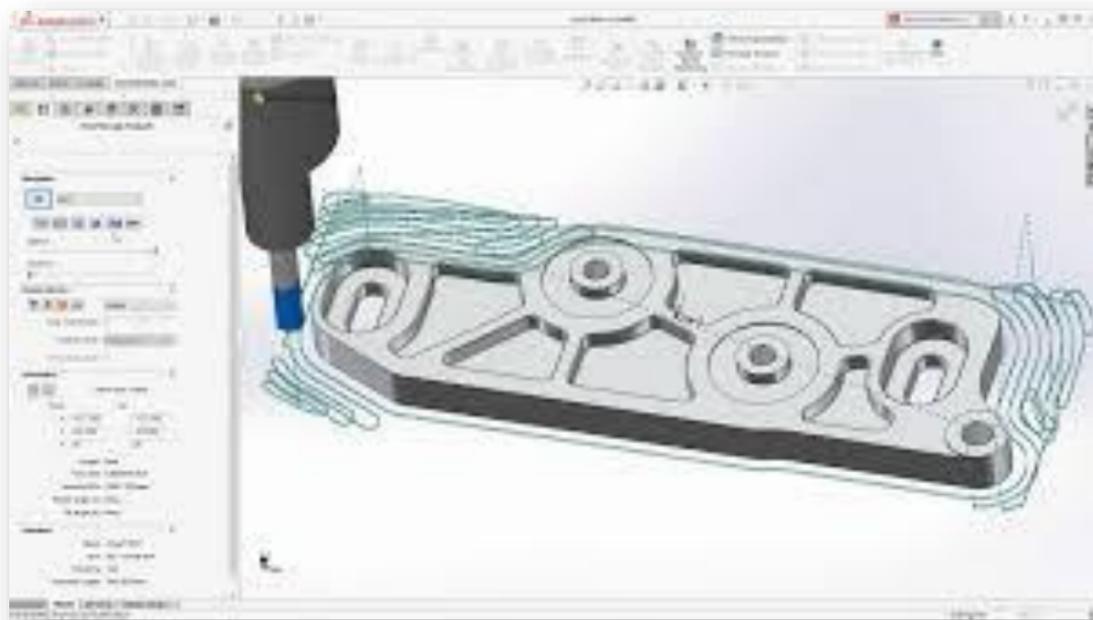
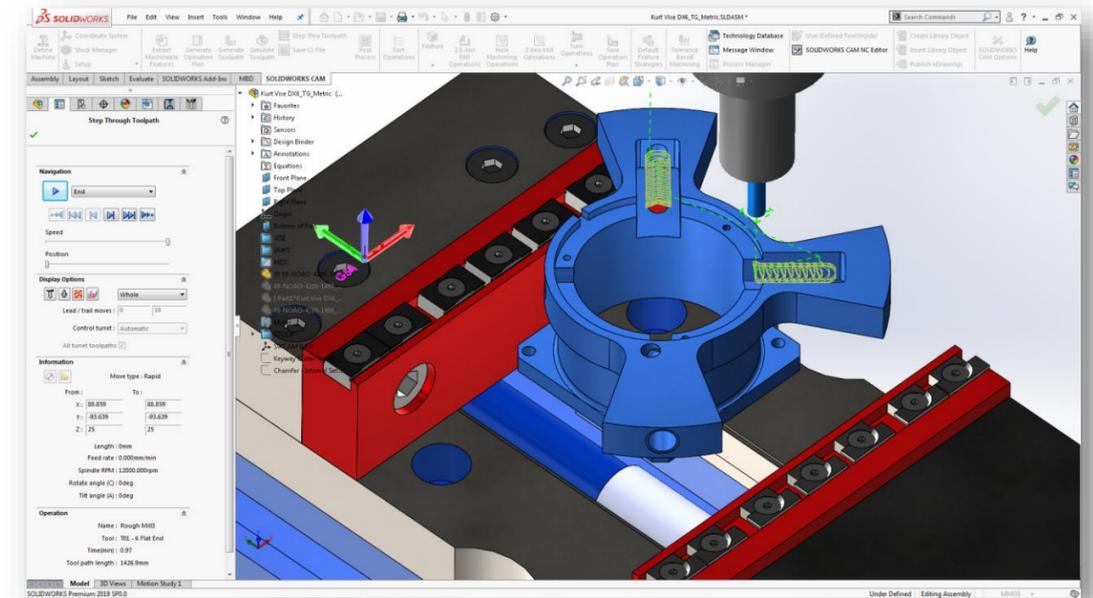
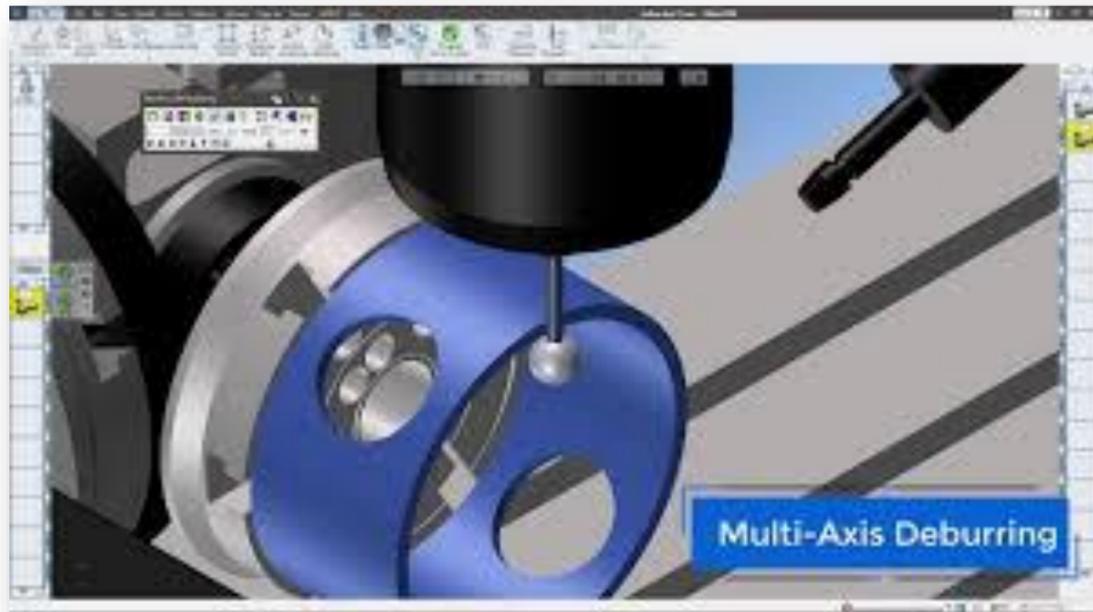
Computer Aided Engineering (CAE)



Leading Software Tool Providers



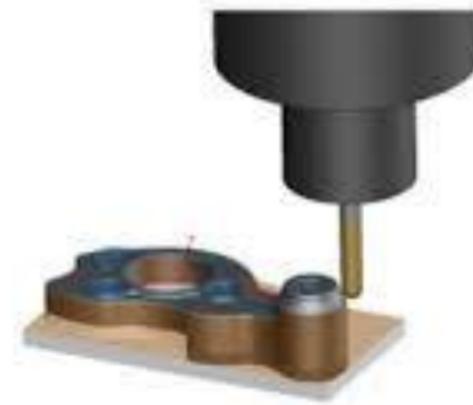
Computer Aided Manufacturing (CAM)



Computer-Aided Manufacturing (CAM) - the use of software and computer-controlled machinery to automate a manufacturing process.



Computer Aided Manufacturing (CAM)



Leading Software Tool Providers



Computer Numerical Control (CNC)



Computer Numerical Control (CNC) - the automated control of machining tools and 3D printers by means of a computer. A CNC machine processes a piece of material to meet specifications by following a coded programmed instruction and without a manual operator directly controlling the machining operation. G-code and M-code commands provide instructions to CNC machinery.



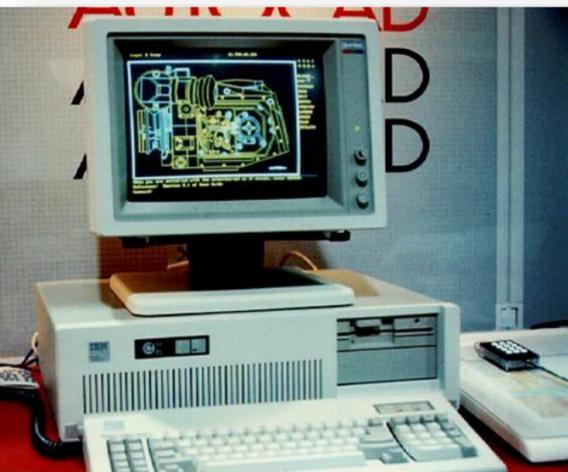
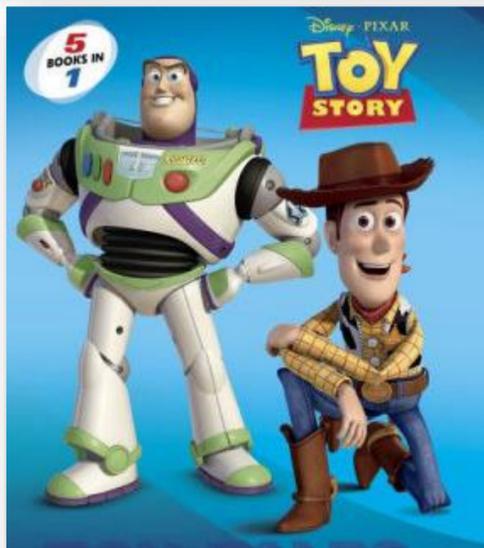
A Brief History of CAD



- CAD was born as a direct result of the Soviet Union's **first atomic bomb**, the RDS-1, in 1949. Following this, the United States embarked on a massive defense program called **SAGE** (Semi-Automatic Ground Environment).
- Information from radar systems across North America (and on "Texas Towers" out in the ocean) was fed into the world's largest computers, the **AN/FSQ-7**, built by IBM at a cost of \$10b in 1954 (\$97b in 2020).
- SAGE was the first computer system to use **interactive graphic displays**, called CRTs (Cathode Ray Tubes). Operators could select a target (blip of light) on the screen to get details on it and, if necessary, could initiate a course of action, including shoot-down by jet interceptors or ground-based missiles.



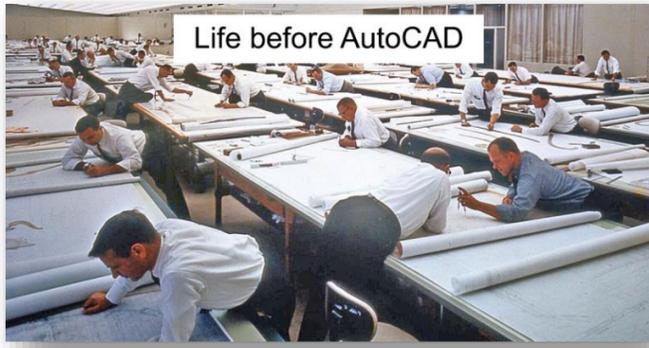
A Brief History of CAD



- One of the many smart young engineers involved with SAGE was **Ivan Edward Sutherland** (left) from Hastings, Nebraska. Among his many contributions was **SKETCHPAD**, the subject of his Ph.D. work at MIT in 1963. Sutherland developed the **light pen** as well as the interactive computer programs employed by SAGE and is considered the **Father of Computer Graphics**.
- Sutherland continued his research into interactive computer graphics at **Harvard, the University of Utah and California Institute of Technology**, where he and his students made countless important breakthroughs in computing technology that spawned companies such as **Adobe, Evans and Sutherland, Pixar, Silicon Graphics and Sun Microsystems**.
- Early in his career Sutherland collaborated with engineers at **General Motors** to apply his work to the practical application of computerized drafting. When the company **Autodesk** introduced the first CAD product **AutoCAD** in **1982**, it was quickly adopted by the automotive industry.



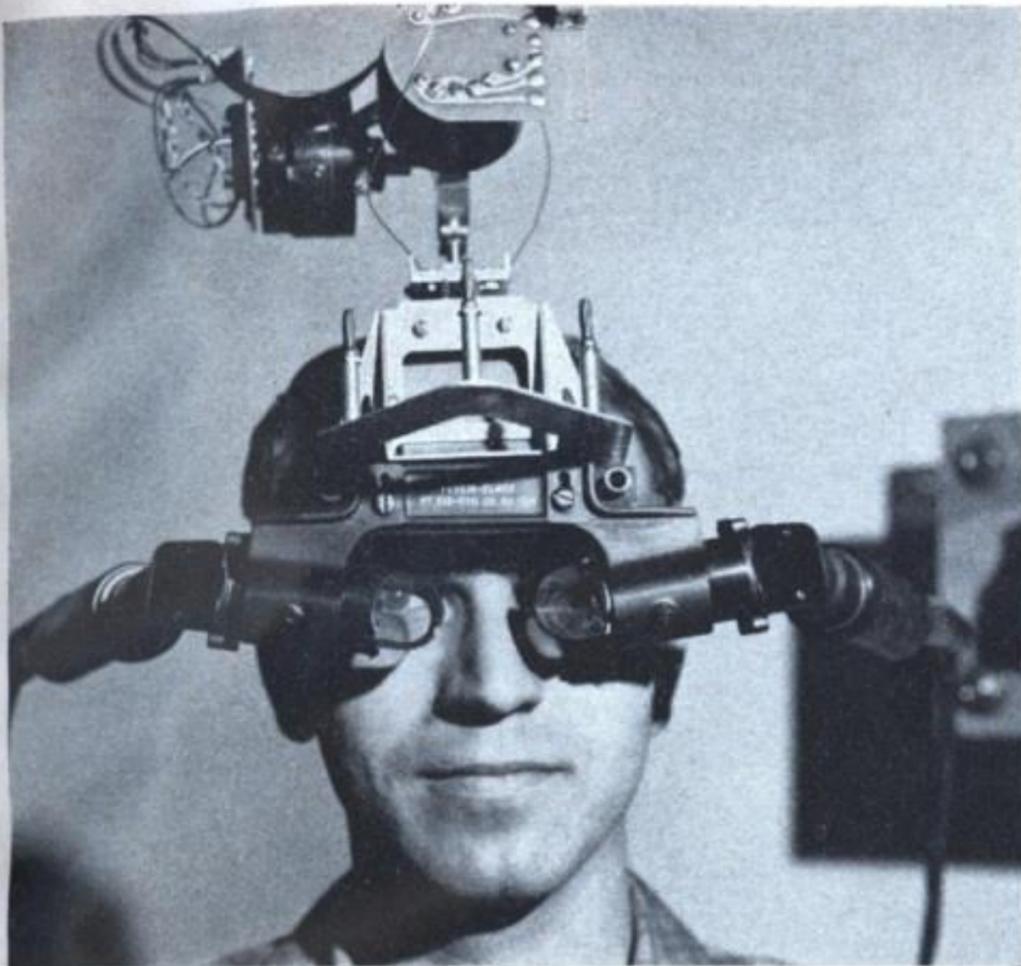
A Brief History of CAD



- MIT's **Jon Hirschtick** saw the opportunity to use the latest Windows-based PCs for CAD in the early 1990s and formed **SolidWorks Corporation** in December 1993, resulting in the release of their first product, **SolidWorks 95** approximately two years later.
- Numerous companies today offer CAD packages, as shown in the previous slides. Most are designed for **specific markets**.
- Compared to early programs that were essentially computerized drawing programs focused on **2D drawings**, CAD programs today are called **Solid Modelers**. Users create their designs from the outset as three-dimensional parts. Parts are then combined to make assemblies.
- CAD developers have more recently taken advantage of **cloud computing**. For instance former SolidWorks CEOs **Jon Hirschtick** and **John McEleney** established the company **Onshape** in November 2012 with the goal of taking full advantage of emerging cloud computing. In December 2015, Onshape launched its first full commercial release.

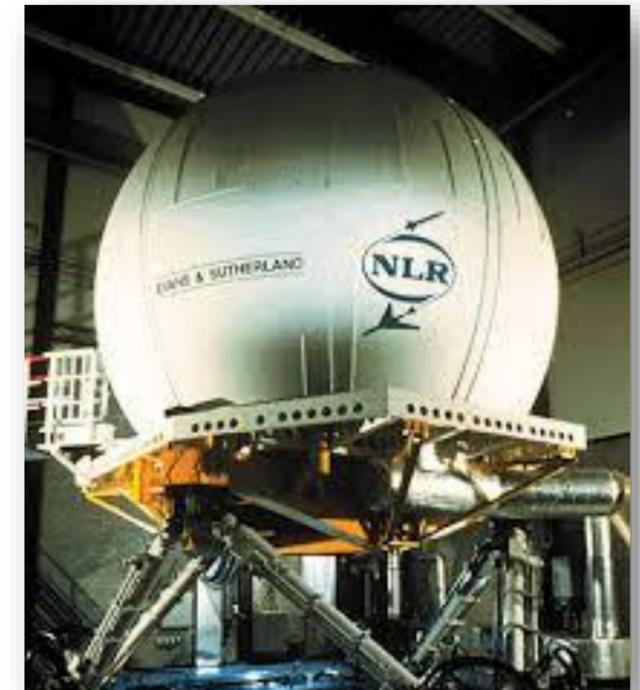


Ivan Edward Sutherland



▲ 3-D trip inside a drawing, via computer graphics

Slip this display device on your head and you see a computer-generated 3-D image of a room before your eyes. Move your head and your perspective changes, just as though you were actually inside the room. Architects could use the device to draw buildings in three dimensions; realtors could use it to show buyers the interiors of homes without even leaving the office. Dr. Ivan Sutherland, University of Utah, invented the device, essentially a computer-graphics version of the old stereoscope.



Dr. Ivan Sutherland, decades ahead of his time, is rightfully called 'The father of computer graphics.' When asked, "How could you possibly have done the first interactive graphics program, the first non-procedural programming language, the first object-oriented software system, all in one year?" He replied: "Well, I didn't know it was hard."



EVANS & SUTHERLAND



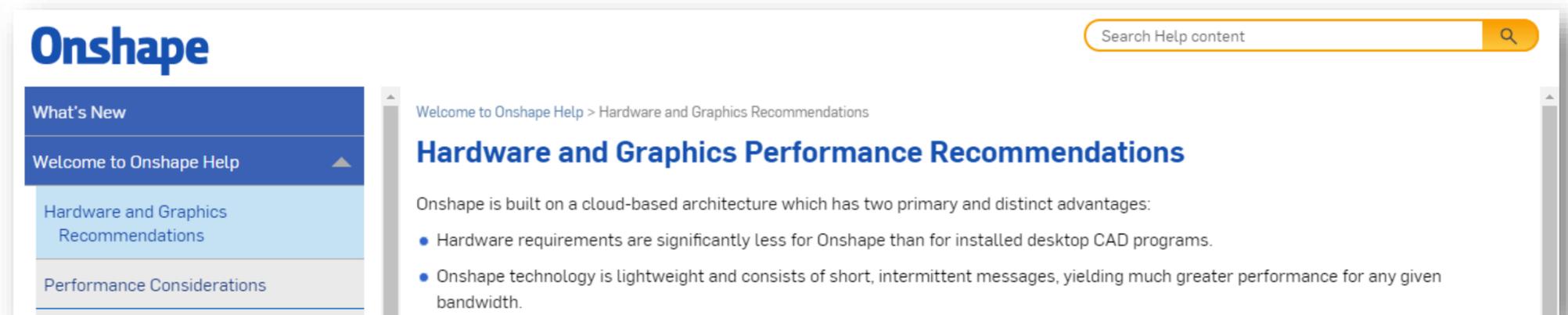
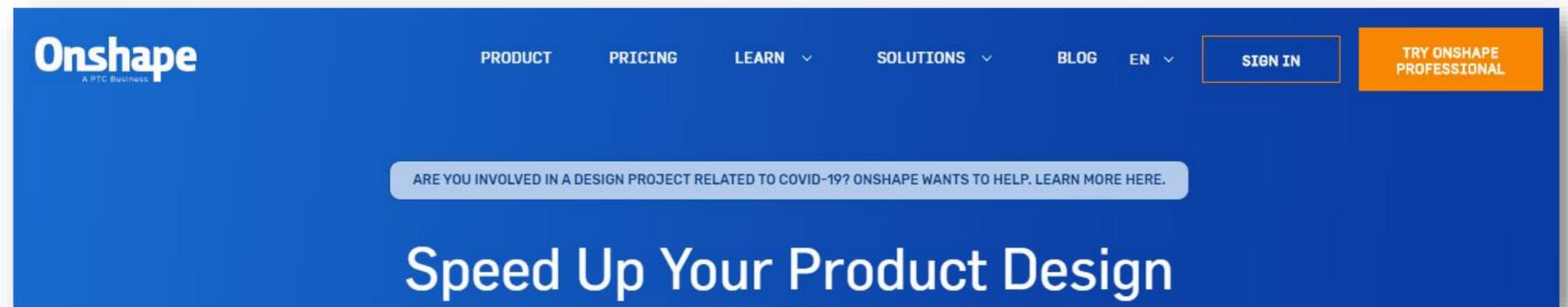
Getting Started with Onshape

- Chosen for this curriculum due to **availability on the cloud** and **no cost for educational use**. Outstanding legacy from the founders of SolidWorks. Acquisition by CAD leader PTC in late 2019 makes Onshape a mainstream industrial CAD tool.
- **First Step** – Review Onshape capabilities at onshape.com
- **Second Step** – Review “Hardware and Graphics Performance Recommendations” to assure that your computer is adequate.
- **Third Step** – Create a unique account at onshape.com



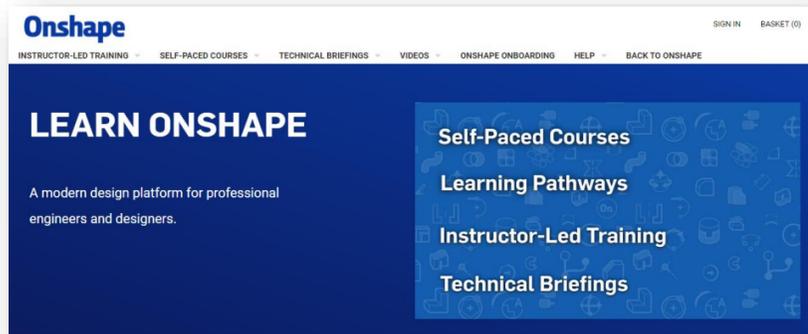
CAD

- Parts, Assemblies, Drawings
- Configurations
- Standard content libraries
- Managed in-context design
- Simultaneous sheet metal tools
- Import / Export industry file formats
- Intelligent custom features





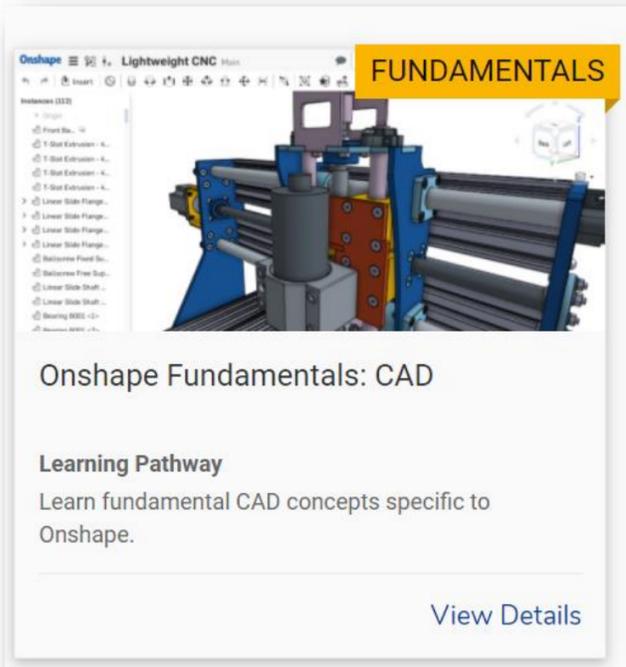
Getting Started with Onshape



- Onshape provides a number of ways to learn its numerous functionalities. The best place to start is in the **Learning Center**, see the large link to it in the upper right-hand corner of the Onshape screen once you have the program running in your browser. **Watch the short video** there to describe what is available. We'll be using here the **Self-Paced Courses**.



- To make good use of Onshape you must work through the **first six Onshape Fundamentals Lessons**: Navigating Onshape, Introduction to Sketching, Part Design using Part Studios, Multi-Part Part Studios, Onshape Assemblies, and Detailed Drawings.

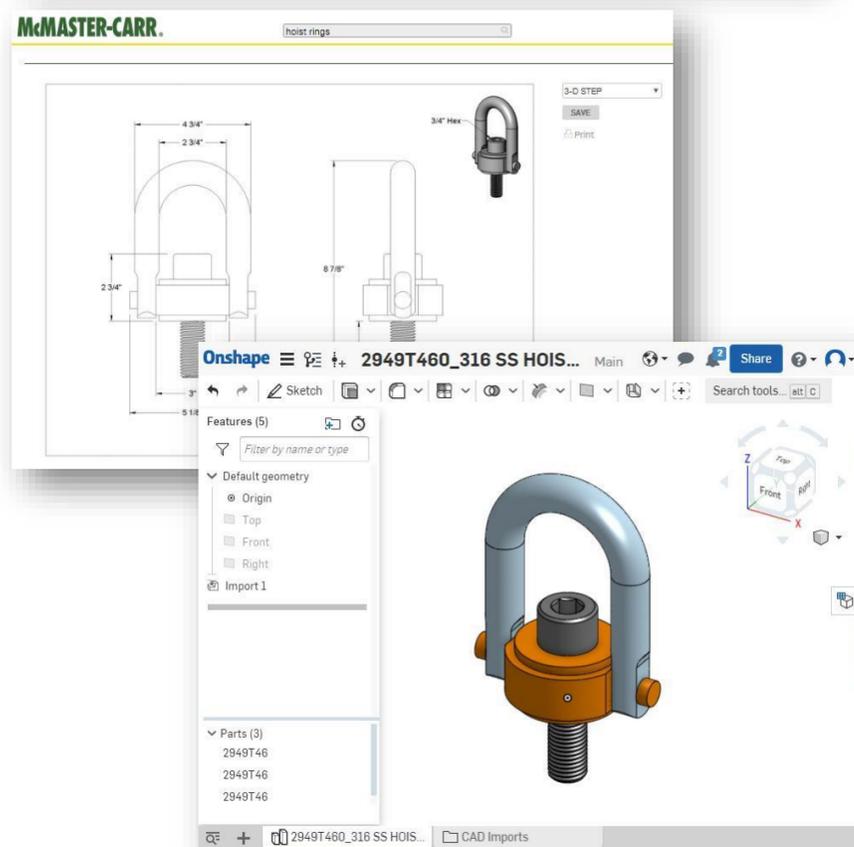
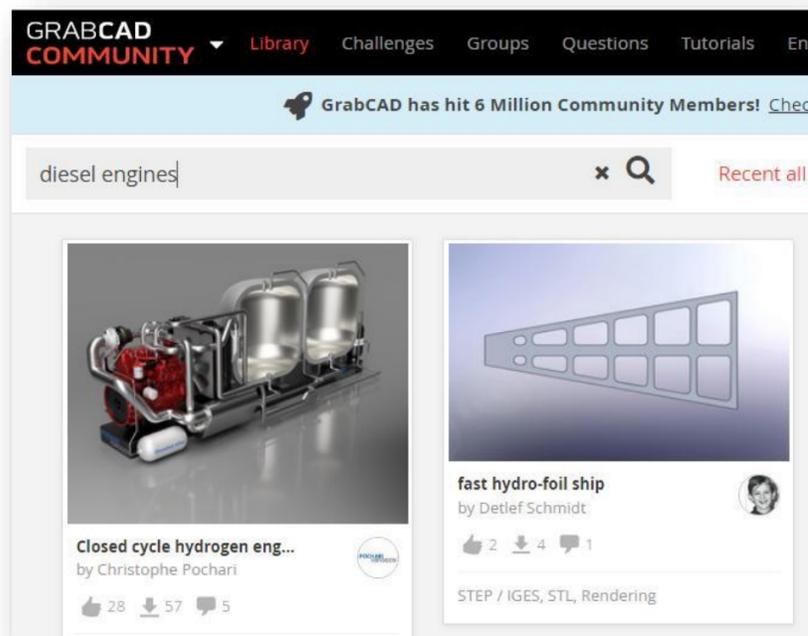


- When you have successfully completed the **Onshape Fundamentals Lessons** you will receive an official **Certificate of Completion** from Onshape. **This is important!** Industry-accepted certificates are increasingly used by companies when they consider people for employment.





Getting Started with Onshape



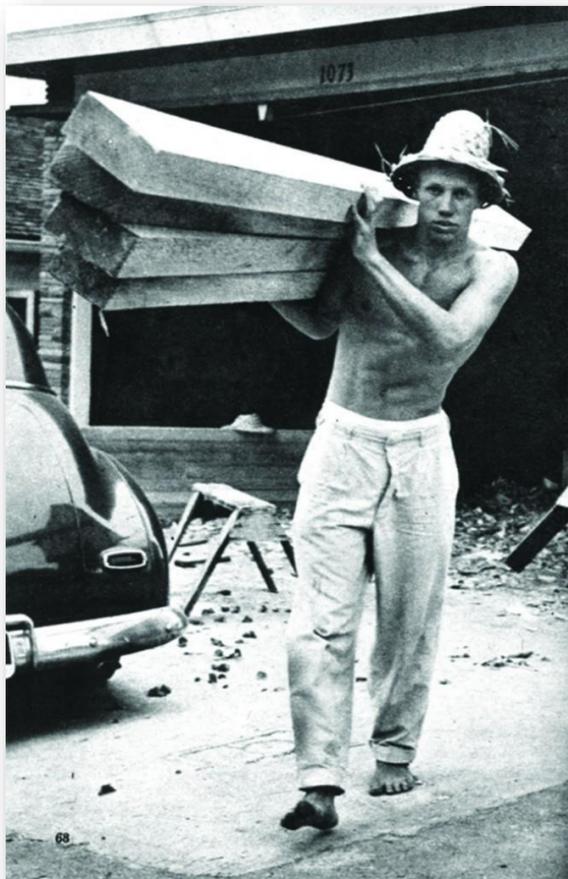
- Once you have completed Onshape Fundamentals lessons, test your knowledge by **recreating the orthographic drawings** from the chapters on sketching and drawings.
- Explore the program to learn how to output your **drawings to PDF files**, **images** to various graphics formats, and your 3D models to **STEP-format files**, a universal format supported by all CAD programs.
- Try loading **existing CAD models** in STEP format found at web sites such as **GrabCAD** or from industrial supplier **McMaster-Carr**.
- See if you can **export surfaces** from your 3D models in **STL format**, what we'll be using for **3D Printing** in the next chapter.
- Look at more **advanced lessons** in the Learning Center, and descriptions of **add-ons** to Onshape, found in the App Store (see the link next to the Learning Center button).



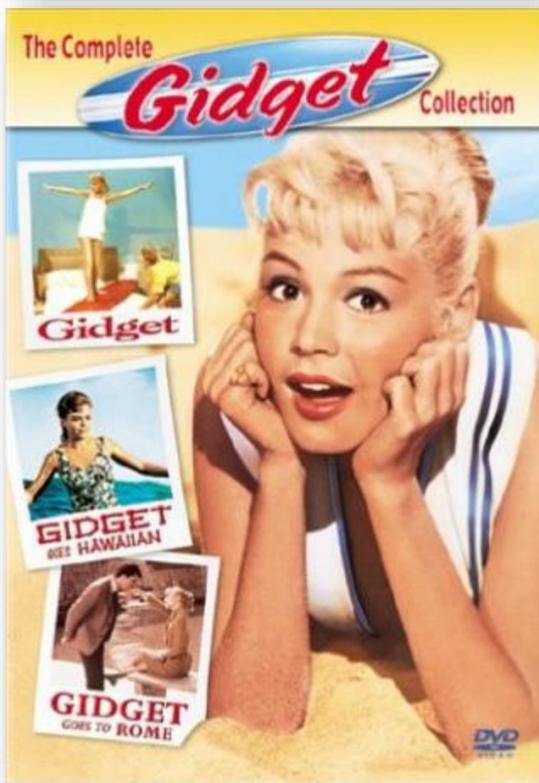
American Inventor – Hobart “Hobie” Alter



- Born in **1933** in Ontario, CA. His father, **Hobart Romig Alter** was a WWI veteran, second-generation **orange grower** and member of the California legislature whose family immigrated to the US in the mid 19th century from **Darmstadt, Germany**.
- During his teenage years, the Alter family spent the summers in their home in **Laguna Beach** on Gaviota Drive, directly off the Oak Street Beach of the Pacific Ocean.
- At **age 14**, Hobie became interested in the new sport of **surfing**. Lacking surf shops where he could buy one, he used his **school woodshop skills** and love of woodworking to construct his first board, made from balsa wood. Based on traditional designs from Hawaii, the board was **nine feet long**, huge by today's standard.
- At **age 17**, Hobie started a business in the Laguna Beach home garage, adding other “shapers” to keep up with demand. Running out of room at home, and with the support of his father, Hobie opened America's **Hobie Surf Shop** in Dana Point in **1954, at age 21**. It was one of the first such shops in the USA.



American Inventor – Hobart “Hobie” Alter



- In the 1950s, the large aerospace industry in southern California made increasing use of **fiberglass materials**. With balsa becoming scarce and demand for boards increasing, several groups began experimenting with it for surfboards.
- In 1958 Hobie, a self-taught, innovative engineer, working with one of his shapers, **Gordon “Grubby” Clark**, developed the first such foam and fiberglass boards, which were lighter, faster and more responsive than wooden ones. Clark went on to establish **“Clark Foam”**, which remained a major supplier of foam blanks to the industry for the next 50 years.
- In 1959, Columbia Pictures released the first of the **“Gidget”** (Girl-Midget) series of popular movies focused on teenage surfing. This resulted in **rapid growth** in industry, which could only have been met through the new **foam/fiberglass** production methods from Hobie. (The Gidget movies were based on the true story of Kathy Kohner Zuckerman, written by her father, playwright Frederick Kohner.)



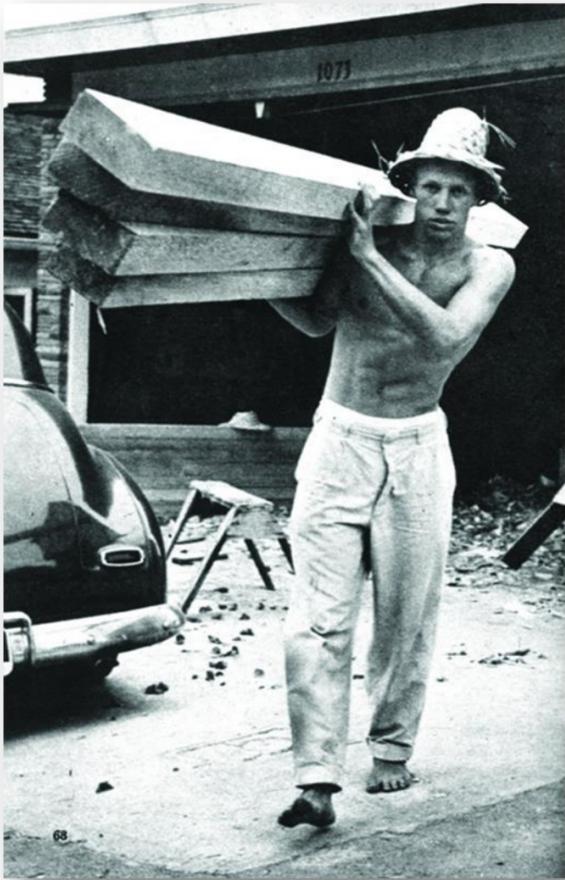
American Inventor – Hobart “Hobie” Alter



- While attending a boat show in 1961, when Hobie was **28**, Hobie’s booth was by chance located next to a maker of **catamaran sailboats**. Interested in the novel design, based on Polynesian sailboats, Hobie began development of what would become the **Hobie Cat** line of sailboats, first introduced in **1967**.
- Hobie Cats could be easily transported by trailer, were relatively light stable and fast. As with surfing a decade earlier, Hobie **revolutionized sailing**, making it more affordable, safe and fun for more people. The Hobie Cat is the world’s most popular cat.
- In the subsequent decades with Hobie and his sons running his business, Alter developed **many popular products** including skateboards, radio-controlled model aircraft (Hobie Hawk), kayaks, MirageDrive—pedal-powered underwater fins, sunglasses, stand-up paddleboards and pedalboards, and others.
- As a **teenager**, Hobie and his friends discussed their **plans for life**: “Instead of talking about what we might do, let’s first come up with a list of rules: “We won’t wear suits and ties, we won’t wear hard shoes, and we won’t work regular hours that might interrupt our surf time.”



Hobie – The Ideal Startup Company



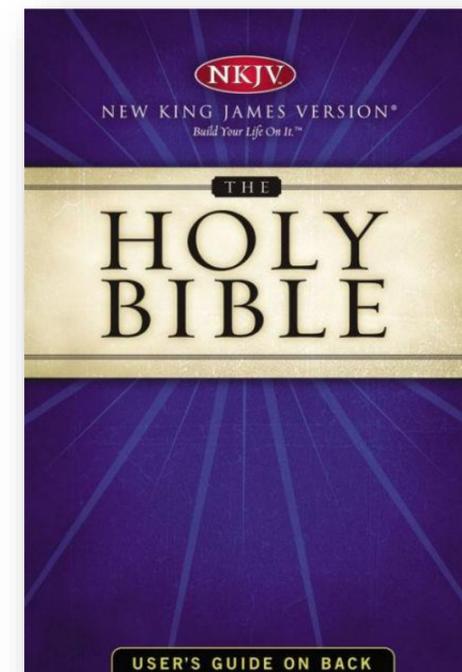
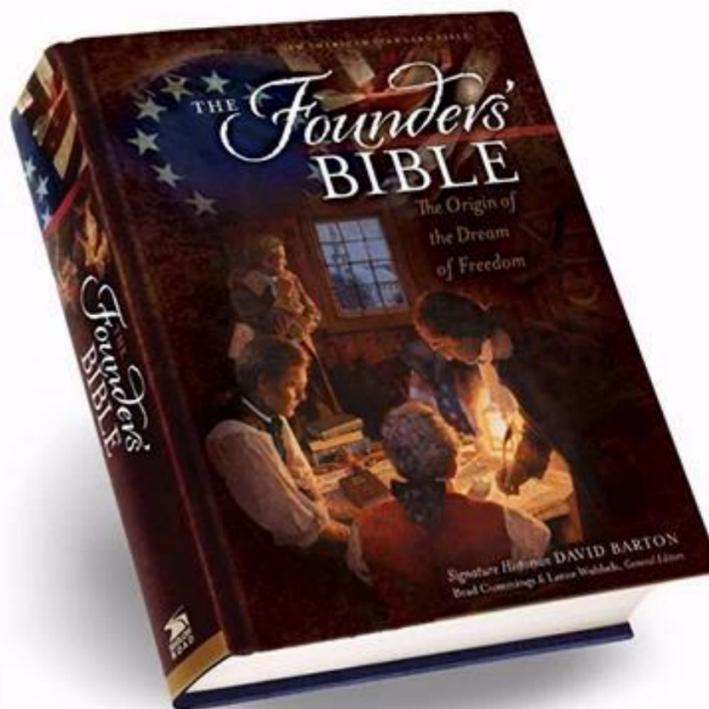
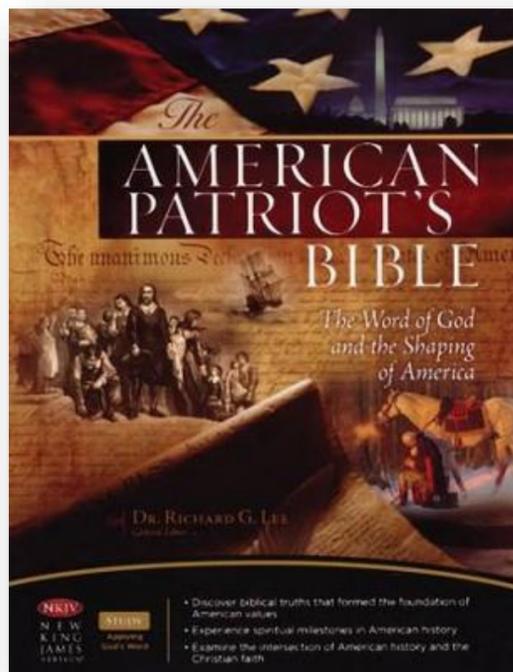
- As a boy, Hobart Alter enjoyed **outdoor sports**, especially in the summers at the family's home directly on the Pacific ocean beach. He also enjoyed **woodworking**, which he learned in school and practiced in the family garage.
- Through a friend, Hobie tried surfing, and liked it. Since surf shops did not yet exist, he was forced to make his own surfboard from balsa wood and using his **woodworking skills and tools**.
- When his teenage friends asked him to make them a surfboard, a **business was born** in the family garage and across their yard.
- Hobie's **parents** supported their son's **God-given passion**, and his **entrepreneurship**. Instead of forcing him to attend college after high school, they loaned him the money needed for his **first surf shop** on nearby Dana Point, popular with surfers.
- Hobie's **friends** became his first **business partners**, sharing his passion for water sports and making a business by providing others with affordable boards and other surfing-related products, such as skateboards, sailboats, sunglasses, kayaks, etc.
- Hobie and his colleagues **never stopped innovating**, the secret to a successful, long-term business. Why not do the same?



What does the Bible

Bible

say about this chapter?



Questions to Ponder

- While computer-based design and engineering tools have helped engineers improve productivity and product quality dramatically in recent decades, they are no substitute for first knowing the fundamentals. Compare this to your own maturation as a human being: starting as a helpless infant, progressing to crawling, eventually walking, running, cycling, driving and perhaps one day rocketing to the moon. Can humans today achieve success without first mastering the fundamentals of life *and* faith? American engineers sent men to the moon long before CAD and similar tools existed. How was this possible?
- The Amish and Mennonites in America are famous for hard-working families, productive farms and successful businesses that have a Biblical worldview. Many do not use cars, power from a utility, the computer or the Internet, yet their populations continue to rise. How is this possible in an era of widespread use of computer and telecommunications technology? Can we as engineers learn any lessons from them?
- Hobart “Hobie” Alter started his company while still in high school and did not attend college. Yet he was one of the most innovative designers of watersports products in the world. How was he able to achieve success with such a modest start? What roles did his hobbies, family and friends play?

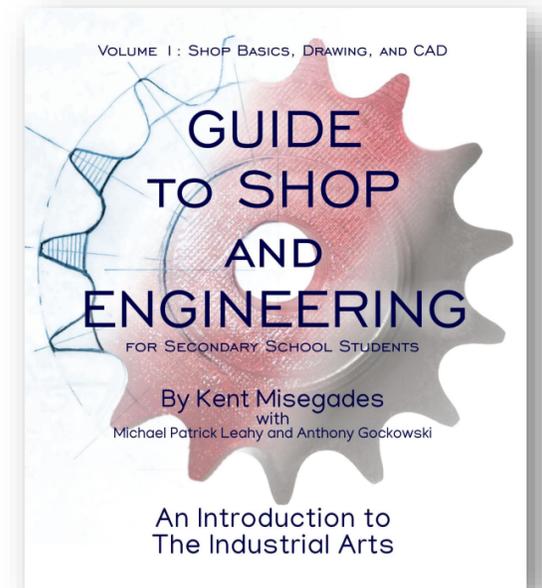


What the Bible says about

- **Learning, some quotes:** “The capacity to learn is a gift; The ability to learn is a skill; The willingness to learn is a choice.” “Develop a passion for learning. If you do, you will never cease to grow.” “The expert in anything was once a beginner.” “Learning is the only thing the mind never exhausts, never fears, and never regrets.” **Proverbs 12:15** “The way of fools seems right to them, but the wise listen to advice.” **1 Corinthians 13:11** “When I was a child, I spoke like a child, I thought like a child, I reasoned like a child. When I became a man, I gave up childish ways.” **James 1:5** “If any of you lacks wisdom, let him ask God, who gives generously to all without reproach, and it will be given him.”
- **Athletic Competition: 2 Timothy 2:5** “An athlete is not crowned unless he competes according to the rules.” **1 Timothy 4:8** “For while bodily training is of some value, godliness is of value in every way, as it holds promise for the present life and also for the life to come.” **Proverbs 20:29** “The glory of young men is their strength, but the splendor of old men is their gray hair.”



Volume I : Chapter 14



EXERCISES



Exercises – Chapter Fourteen

Exercise 1 : Introduction to Computer-Aided Design

In Chapter Fourteen you were introduced to Computer-Aided Design through the program Onshape.

- 1 . For this exercise, you are to work through the entire Onshape self-paced course called Fundamentals. See the instructions on this in Chapter Fourteen.
2. At the successful conclusion, you will have earned a certificate of completion, your first (of many, hopefully) credentials as engineer. Print out your certificate, frame it, and hang it where all will see your accomplishment.
3. In the months and years to come, create a gallery of such credentials to provide evidence to others of your skills.



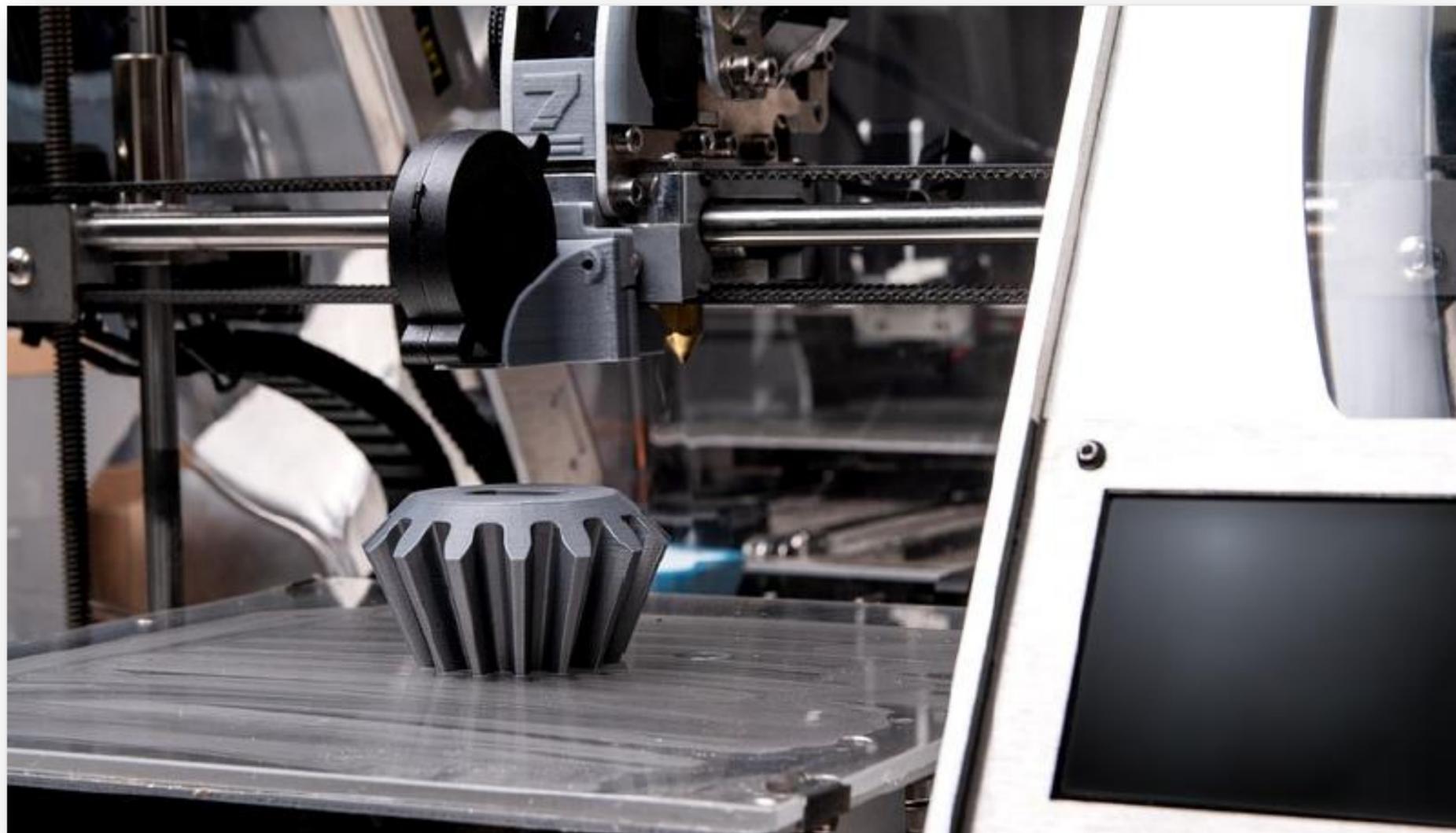
Recommended Shop Projects

Volume I : Chapter 14



End of Volume I : Chapter 14

Next: Chapter 15, 3D Print your CAD Designs



These Lessons Inspired By

RenewaNation

Helping Children Develop a Biblical Worldview



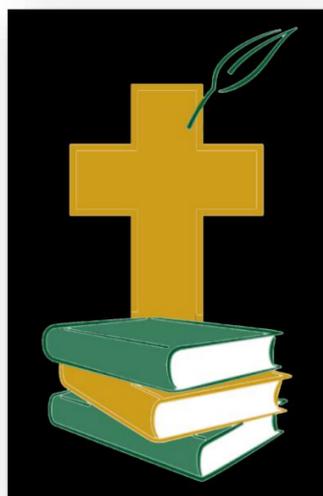
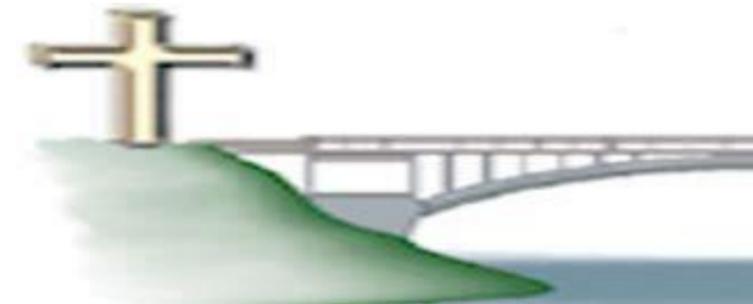
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BOB JONES
UNIVERSITY
EST. 1927



The Author – Kent Paul Misegades



The author's 1952 Cessna 170B



Glen-L "Tuffy" built by author

- Christian, Husband, Father, Grandfather
- 40+ years engineering experience, much as manager, director and business owner
- Pilot, aircraft & boat builder since teenage years
- BSc Mechanical Engineering, Auburn University - *War Eagle!*
- MSc Applied Aerodynamics, Von Karman Institute for Fluid Dynamics
- Helped establish world-class K-12 schools, Thales Academies
- Co-founded world-class apprenticeships, NCTAP.org
- Developed and taught high school shop & engineering curricula
- Passion is flying, sailing, designing & making things - and teaching young people skills
- Founder and President of AeroSouth.net, Seven Lakes, North Carolina

