Annotated User's Guide
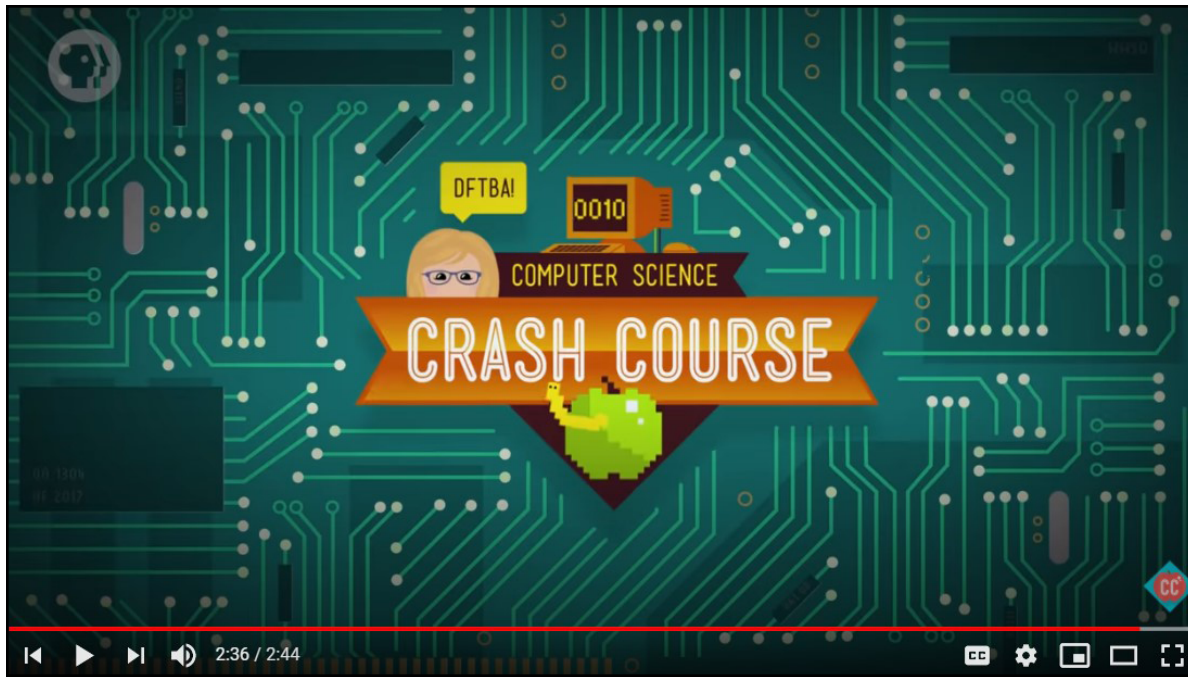# Crash Course Computer Science

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2•facility for advanced spatial technology

Crash Course Computer Science is a series produced for the Public Broadcast System (PBS) that conveys to a broad audience of individuals Computer Science's base knowledge. Each video is a fast paced presentation that very intentionally places basic Computer Science concepts into small, understandable segments. The running time for each video is between ten and fourteen minutes with the forty segments broken down into the following seven sections:

1.) The Mechanics of How Computers Work
2.) The Basics of Programming and Software
3.) Computer Hardware
4.) The Rise of Personal Computers and
   Graphics
5.) The Internet
6.) Artificial Intelligence
7.) Humans and the Future of Computing

This document is designed to function as a guide to the short episodes, helping the reader/viewer make decisions which to view when their time is limited. These short descriptive abstracts, accompanied by hyperlinked text, are to enable each person to make an informed choice as to which short episode will fulfill an immediate need. Geospatial systems and software users in no small measure employ computer science.

Clicking this link takes you to *Crash Course Computer Science's* YouTube home page.

• *https://www.youtube.com/*
   watch?v=tpIctyqH29Q&list=PL8dPuuaLjXtNlUrzyH5r6jN9uIIgZBpdo&index=1

   One should not feel compelled to view this series in its original order. Following the first episode, subsequent ones state references to previous segments when appropriate. The viewer can decide when or if to refer back to the previously mentioned episode. These are concepts geospatial professionals encounter. As such, understanding the programs and machines performing the calculations rendering one's GIS work into meaningful presentations is essential.
   This series will not turn the viewer into a computer programmer nor is it intended to. An accessible short course in Computer Science is presented here that includes extremely thoughtful and insightful presentations concerning both hardware and software.
   The following are FAST Lab choices to begin this learning process.

• *Operating Systems,* #18
• *Memory & Storage,* #19
• *Files & File Storage,* #20
• *Compression,* #21
• *Keyboard & Command Line Interfaces,* #22
• *Screens & 2D Graphics,* #23
   • *Instructions & Programming,* #8, if one's time permits

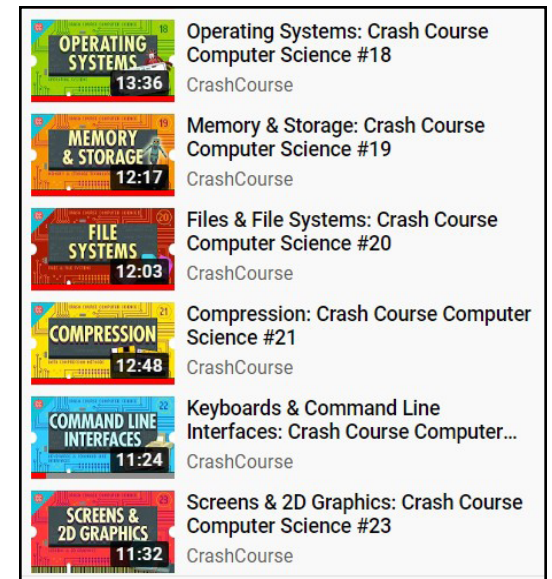**Limited Viewing Time —**
   If your time is extremely limited, then start your viewing with numbers nineteen and twenty hyperlinked directly below. Understanding of computer memory and file directory structure is extremely important when using remotely accessed desktops.

Memory & Storage: Crash Course Computer Science #19
• https://www.youtube.com/
   watch?v=TQCr9RV7twk&list=PL8dPuuaLjXtNlUrzyH5r6jN9uIIgZBpdo&index=20

*Files & File Systems: Crash Course Computer Science #20*
• https://www.youtube.com/
   watch?v=KN8YgJnShPM&list=PL8dPuuaLjXtNlUrzyH5r6jN9uIIgZBpdo&index=21

The screen above is the initial module set to view if time is limited. Below is an illustration of instructions and addressing a simple memory register.

INSTRUCTION	DESCRIPTION	ADDRESS OR REGISTERS
LOAD_A	Read RAM location into register A	4-bit RAM address
LOAD_B	Read RAM location into register B	4-bit RAM address
STORE_A	Write from register A into RAM location	4-bit RAM address
ADD	Add two registers, store value into second register	2-bit register ID, 2-bit register ID
SUB	Subtract two registers, store value into second register	2-bit register ID, 2-bit register ID
JUMP	Update instruction address register to new address (i.e. jump to address)	4-bit memory address
JUMP_NEG	If ALU result was negative, update instruction address register to new address	4-bit memory address
HALT	Program done. Halt computer.	NA

1 The Mechanics of How Computers Work—
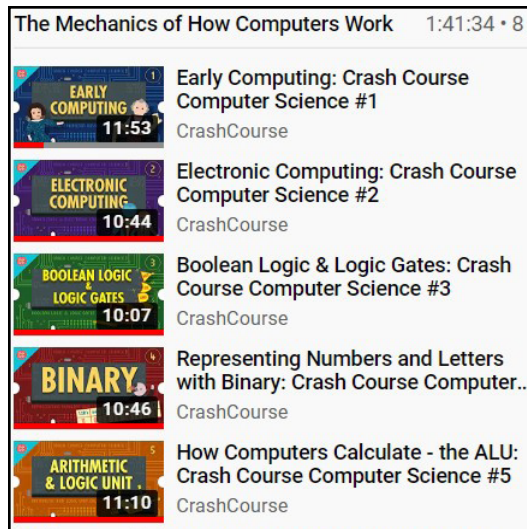
Important Note: On page two of this guide to *Crash Course Computer Science* we at the FAST Lab mention viewing the eighth episode if one's time is limited. We also want to draw the reader's attention to episode three which is where levels of abstraction are introduced. Its conceptual import for understanding geospatial programs cannot be underestimated.

1.) *Early Computing: Crash Course Computer Science #1*, presents a rapid overview of computing devices from the abacus to the beginning of the twentieth century. https://www.youtube.com/watch?v=O5nskjZ_GoI&list=PL8dPuuaLjXtNlUrzyH5r6jN9ulIgZBpdo&index=2

2.) *Electronic Computing: Crash Course Computer Science #2*, in this episode a thorough explanation of the electronic gates that make-up the on/off switches inside one's computer and how the world went from electro-mechanical devices to electronics is covered. https://www.youtube.com/watch?v=LN0ucKNX0hc&list=PL8dPuuaLjXtNlUrzyH5r6jN9ulIgZBpdo&index=3

3.) *Boolean Logic & Logic Gates: Crash Course Computer Science #3*, here the title is quite self-explanatory. However, the detail given here with incredible clarity makes this well-worth while especially if not knowing Boolean, then watch. https://www.youtube.com/watch?v=gI-qXk7XojA&list=PL8dPuuaLjXtNlUrzyH5r6jN9ulIgZBpdo&index=4

4.) *Representing Nubers and Letters with Binary: Crash Course Computer Science #4*, a quick overview of basic computer mathematics and binary numbers. https://www.youtube.com/watch?v=1GSjbWt0c9M&list=PL8dPuuaLjXtNlUrzyH5r6jN9ulIgZBpdo&index=5

5.) *How Computers Calculate—the ALU: Crash Course Computer Science #5*, This episode addresses the way computers compute viewing their computational architecture. https://www.youtube.com/watch?v=1I5ZMmrOfnA&list=PL8dPuuaLjXtNlUrzyH5r6jN9ulIgZBpdo&index=6

1 The Mechanics of How Computers Work (*continued*) —

6.) *Registers and RAM: Crash Course Computer Science #6*, in this episode the place of computer memory, specifically random access memory, is presented through demonstrating how one bit of information comes to be stored and then this processes scalable nature. Persistent memory is not covered in this episode.
https://www.youtube.com/
watch?v=fpnE6UAfbtU&list=PL8dPuuaLjXtNlUrzyH5r6jN9ulIgZBpdo&index=7

7.) *The Central Processing Unit (CPU): Crash Course Computer Science #7*, during this segment the goal is to place provide the viewer with an understanding of, as the title notes, the heart of every computer, its central processing unit.
https://www.youtube.com/
watch?v=FZGugFqdr60&list=PL8dPuuaLjXtNlUrzyH5r6jN9ulIgZBpdo&index=8

8.) *Instructions & Programs: Crash Course Computer Science #8*, the goal in this segment is to share with the viewer how a programmable piece of hardware, the CPU, is made to work employing an instruction set or program which is the essence of software and easily modifiable.
https://www.youtube.com/
watch?v=zltgXvg6r3k&list=PL8dPuuaLjXtNlUrzyH5r6jN9ulIgZBpdo&index=9

9.) *Advanced CPU Designs: Crash Course Computer Science #9*, this episode introduces the viewer to the modern CPU and its advanced instruction sets which allow for the running of the complex computations that are at the core of current-day processing. This is especially true for geospatial information processing.
https://www.youtube.com/
watch?v=rtAlC5J1U40&list=PL8dPuuaLjXtNlUrzyH5r6jN9ulIgZBpdo&index=10

Registers and RAM: Crash Course Computer Science #6
CrashCourse

The Central Processing Unit (CPU): Crash Course Computer Science #7
CrashCourse

Instructions & Programs: Crash Course Computer Science #8
CrashCourse

Advanced CPU Designs: Crash Course Computer Science #9
CrashCourse

Below is a current day Central Processing Unit which typically handles computer calculations.
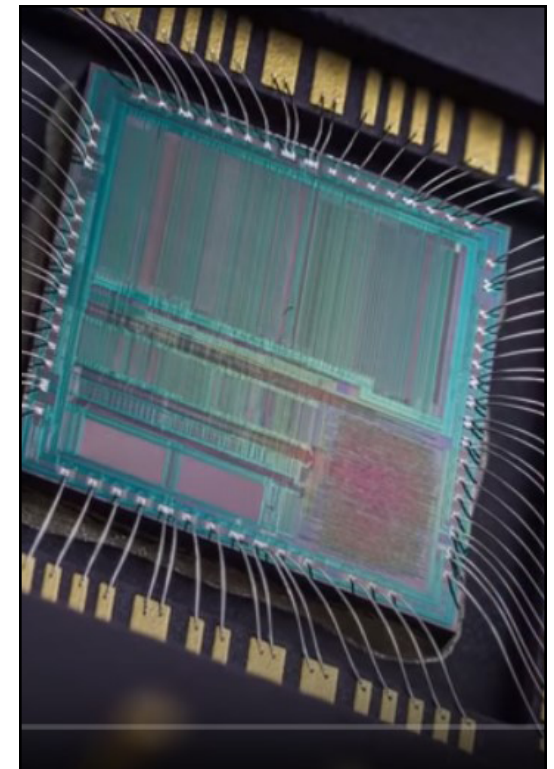
2 The Basics of Programming and Software—
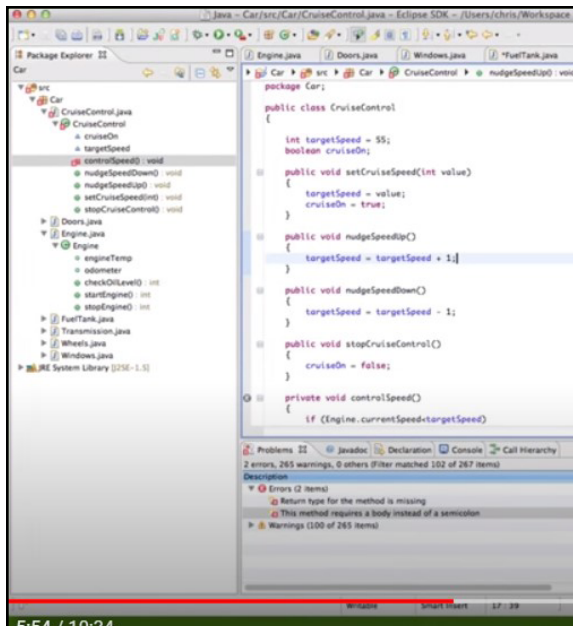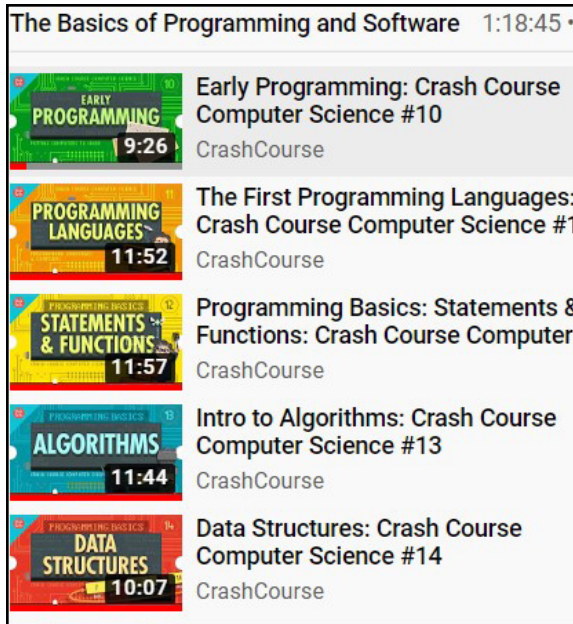
10.) *Early Programming: Crash Course Computer Science #10*, the whole of this section explains to the viewer the program's instruction sets are loaded into the computer.
https://www.youtube.com/watch?v=nwDq4adJwzM&list=PL8dPuuaLjXtNlUrzyH5r6jN9uIIgZBpdo&index=11

11.) *The First Programming Languages: Crash Course Computer Science #11*, this episode introduces software and its creation. An understanding is developed as to how a computer is programmed through the versatility of software.
https://www.youtube.com/watch?v=RU1u-js7db8&list=PL8dPuuaLjXtNlUrzyH5r6jN9uIIgZBpdo&index=12

12.) *Programming Basics: Statements & Functions: Crash Course Computer Science #12*, the viewer is now taken through an overview of building block fundamentals for statements, syntax, assignment statements, and beyond. Excellent overview!
https://www.youtube.com/watch?v=l26oaHV7D40&list=PL8dPuuaLjXtNlUrzyH5r6jN9uIIgZBpdo&index=13

13.) *Intro to Algorithms: Crash Course Computer Science #13*, this episode provides the viewer with simple, concise explanations of the concept that an algorithm, which are the "specific steps used to compute computation" (Crash Course Computer Science).
https://www.youtube.com/watch?v=rL8X2mlNHPM&list=PL8dPuuaLjXtNlUrzyH5r6jN9uIIgZBpdo&index=14

14.) *Data Structures: Crash Course Computer Science #14*, how is data made more easily read and retrieved in computers? This series' episode the ways data is structured in computers.
https://www.youtube.com/watch?v=DuDz6B4cqVc&list=PL8dPuuaLjXtNlUrzyH5r6jN9uIIgZBpdo&index=15

## 2 The Basics of Programming and Software (*continued*) —

15.) *Alan Turing: Crash Course Computer Science #15*, Alan Turing is considered the
Father of Modern Computer Science. This episode is an homage to his contributions in
a life that was cut far too short during a much less open, tolerant time.
https://www.youtube.com/
watch?v=7TycxwFmdB0&list=PL8dPuuaLjXtNlUrzyH5r6jN9ulIgZBpdo&index=16

16.) *Software Engineering: Crash Course Computer Science #16*, NASA Scientist Margaret
Hamilton named the disciplinary tool set for computing and computers Software
Engineering. This episode covers this tool set very clearly.
https://www.youtube.com/
watch?v=O753uuutqH8&list=PL8dPuuaLjXtNlUrzyH5r6jN9ulIgZBpdo&index=17
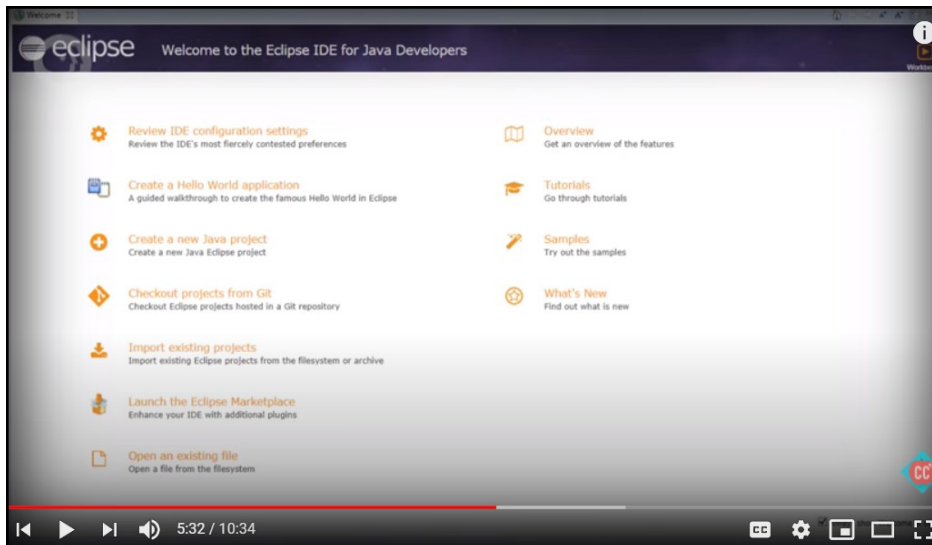
*The above is an example of the clarity with which the illustrations
are presented in the Crash Course.*

*Once one finishes viewing this module, their understanding as to
what and how programming works is immeasurably improved. This
example presents the current practices in place.*
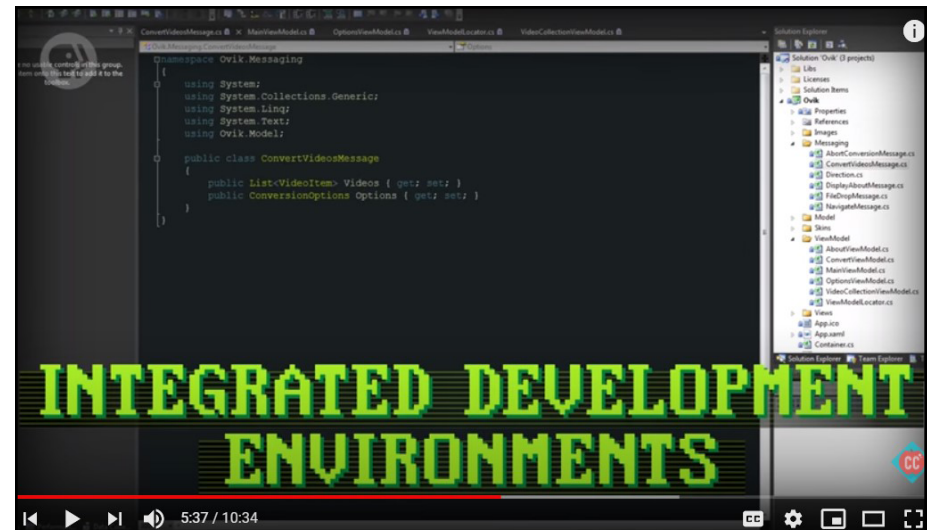
3 Computer Hardware—

17.) *Integrated Circuits & Moore's Law: Crash Course Computer Science #17*, the expansion of sophisticated software applications has been made possible by an incredible growth in new computer hardware. This episode tours through this. https://www.youtube.com/watch?v=6-tKOHICqrI&list=PL8dPuuaLjXtNlUrzyH5r6jN9uIIgZBpdo&index=18

18.) *Operating Systems: Crash Course Computer Science #18*, with the exponential growth in hardware speed and processing power from early on, computers had to be able to manage operations themselves and manage other programs. This signaled the operating system's birth which with its development is presented on this video. https://www.youtube.com/watch?v=26QPDBe-NB8&list=PL8dPuuaLjXtNlUrzyH5r6jN9uIIgZBpdo&index=19

19.) *Memory & Storage: Crash Course Computer Science #19*, memory is typically volatile memory. For permanence nonvolatile storage is called for. This episode takes the viewer from punch tape and cards through to current nonvolatile storage drives with succinct, clear explanations as to how each item works. https://www.youtube.com/watch?v=TQCr9RV7twk&list=PL8dPuuaLjXtNlUrzyH5r6jN9uIIgZBpdo&index=20

20.) *Files & Systems: Crash Course Computer Science #20*, this segment is one of the two must watch segments noted earlier in this document. This segment is tagged as must watch because it clearly explains how big blocks of digital data are stored to become computer files which then become organized into a usable and accessible file system. https://www.youtube.com/watch?v=KN8YgJnShPM&list=PL8dPuuaLjXtNlUrzyH5r6jN9uIIgZBpdo&index=21

3 Computer Hardware (*continued*)—

21.) *Compression: Crash Course Computer Science #21* this episode explains the process of getting one's digital files as small as possible. Its goal is to get the stored information encoded into as few bits as possible. This is another extremely important concept to understand conceptually.
https://www.youtube.com/watch?v=OtDxDvCpPL4&list=PL8dPuuaLjXtNlUrzyH5r6jN9uIIgZBpdo&index=22

22.) *Keyboards & Command Line: Crash Course Computer Science #22* with this episode the human-computer experience becomes the focus. Previously the information being covered dealt mostly intra-computer data sharing. For the next couple of episodes the subject examine the input/output devices making up the human-computer interaction. This episode explores the command line interface.
https://www.youtube.com/watch?v=4RPtJ9UyHS0&list=PL8dPuuaLjXtNlUrzyH5r6jN9uIIgZBpdo&index=23
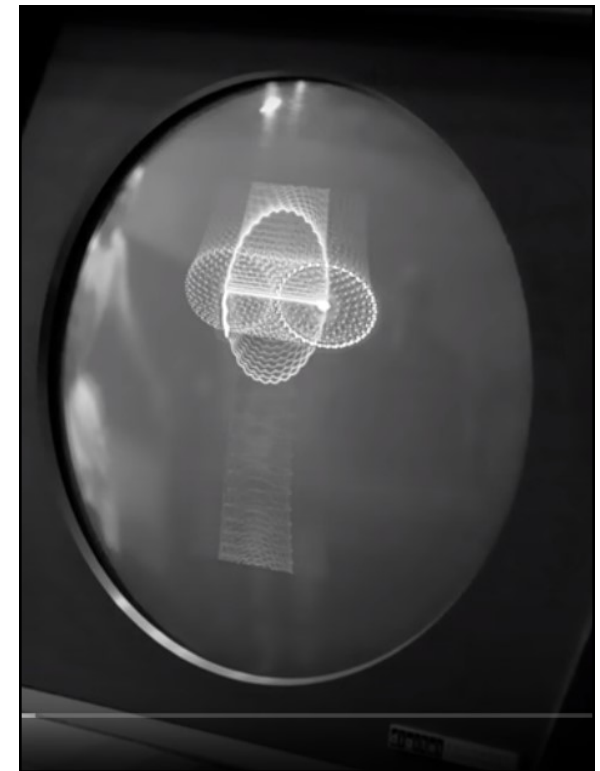
23.) *Screens & 2D Graphics: Crash Course Computer Science #23*, Starting in the very early 1960s an inexorable change to graphical user interfaces begin. What we accept as the normal way to display digital data starts with this shift from printed output and cathode-ray tubes be used to monitor processing flow changes which are temporary begins to display screens. This episode provides a whirlwind tour through those developments.
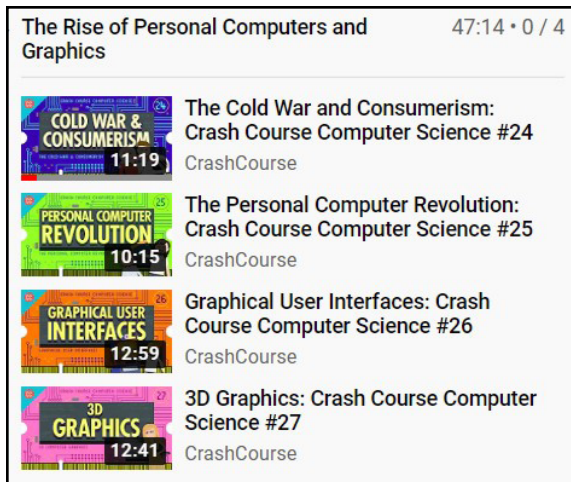https://www.youtube.com/watch?v=7Jr0SFMQ4Rs&list=PL8dPuuaLjXtNlUrzyH5r6jN9uIIgZBpdo&index=24
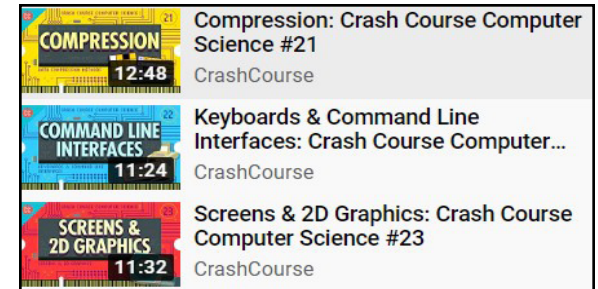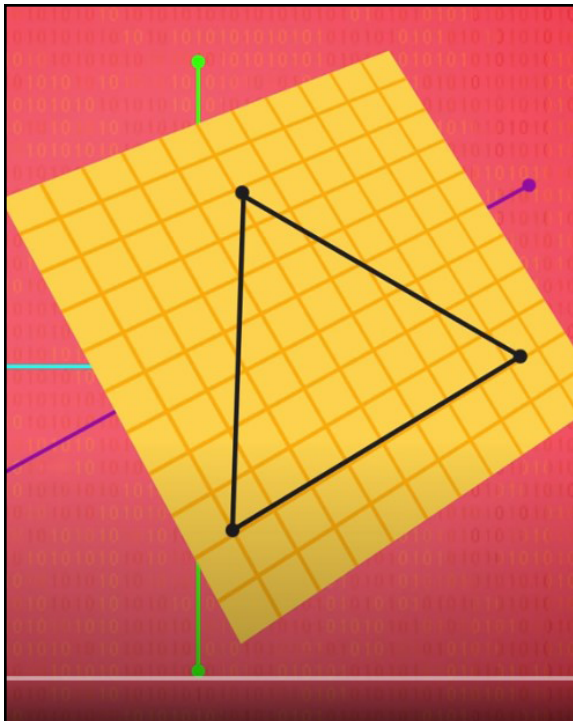

The computer monitor pictured directly below shows a very early rendering of computer graphics. It is from the early 1960s as can be noted from the round cathode-ray tube.

4 The Rise of Personal Computers and Graphics—

Below is a demonstration of a computer matrix for rendering concepts in three dimensions.

24.) *The Cold War and Consumerism: Crash Course Computer Science #24*, an examination of the world before the rise of personal computers during the 1970s in this episode. The intersection of the Cold War, Space Race, and Consumerism are explored. While this episode can be skipped initially, it is well-worth visiting later.
https://www.youtube.com/
watch?v=m8i38Yq1wX4&list=PL8dPuuaLjXtNlUrzyH5r6jN9ulIgZBpdo&index=25

25.) *The Personal Computer Revolution: Crash Course Computer Science #25*, again another episode that is quite worth one's time investment but could be skipped due to one's limited time. It does cover extremely well how the Personal Computer revolution was born as the technological capacity to place all the computer parts onto one circuit board.
https://www.youtube.com/
watch?v=M5BZou6C01w&list=PL8dPuuaLjXtNlUrzyH5r6jN9ulIgZBpdo&index=26

26.) *Graphical User Interfaces: Crash Course Computer Science #26*, in this episode the viewer goes under the programming hood to understand how GUI's developed and most important how the programming works. For the developing GIS professional this is an important understanding to have.
https://www.youtube.com/
watch?v=XIGSJshYb90&list=PL8dPuuaLjXtNlUrzyH5r6jN9ulIgZBpdo&index=27

27.) *3DGraphics: Crash Course Computer Science #27*, this episode is a must watch after viewing the third section and Episode 26 here. It offers an excellent brief explanation of how 3D items are rendered onto a flat surface. One item to notice is the similarity between historical cartography, GIS presentations, and 3D rendering basics.
https://www.youtube.com/
watch?v=TEAtmCYYKZA&list=PL8dPuuaLjXtNlUrzyH5r6jN9ulIgZBpdo&index=28

5 The Internet —

28.) *Computer Networks: Crash Course Computer Science #28*, starting with this episode the subsequent two present the ever expanding concept of computer networking. This portion examines the basic concepts deployed in computer networks and their development.
https://www.youtube.com/
watch?v=3QhU9jd03a0&list=PL8dPuuaLjXtNlUrzyH5r6jN9uIIgZBpdo&index=29

29.) *The Internet: Crash Course Computer Science #29*, in this next episode the viewer moves up in the cyber pipeline and expands to the large distributed network known as the Internet. LANs, WANs, and beyond are covered. For the developing geospatial professional episodes twenty-eight, twenty-nine, and thirty are must watches.
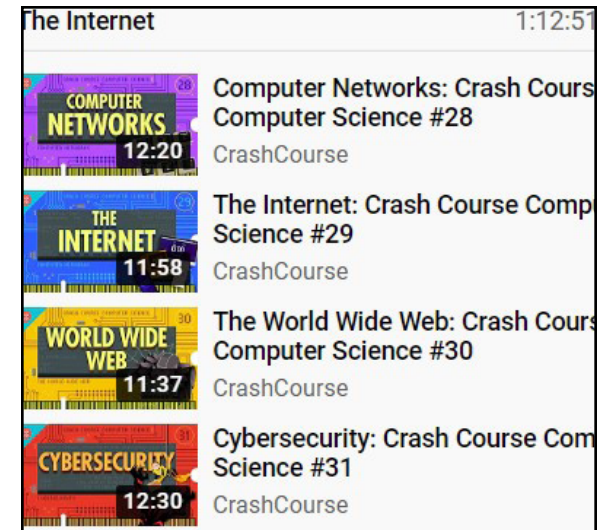https://www.youtube.com/
watch?v=AEaKrq3SpW8&list=PL8dPuuaLjXtNlUrzyH5r6jN9uIIgZBpdo&index=30

30.) *The World Wide Web: Crash Course Computer Science #30*, this final segment concerning networks covers the World Wide Web which runs on top of the Internet as the world's largest distributed computer network. It is accessed using web browsers and in this segment the viewer get a concise yet thorough explanation.
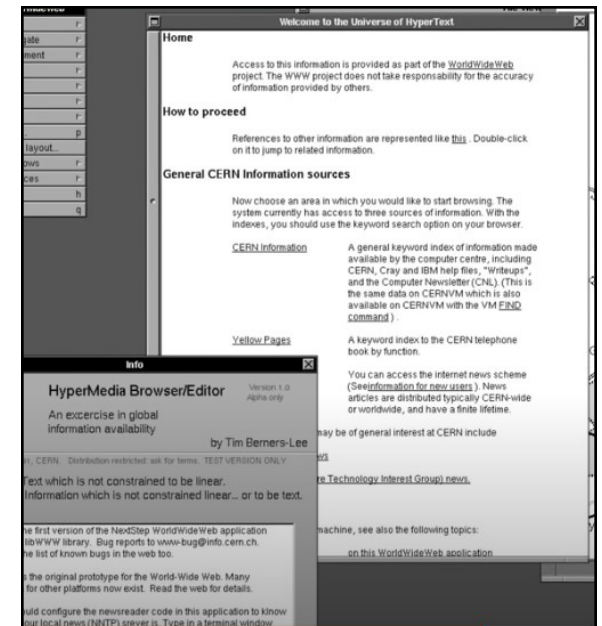https://www.youtube.com/
watch?v=guvsH5OFizE&list=PL8dPuuaLjXtNlUrzyH5r6jN9uIIgZBpdo&index=31

31.) *Cybersecurity: Crash Course Computer Science #31*, since not all players in the virtual world of computers plays by the rules, cyber security has proven itself to be essential. As noted in this segment's introduction cyber security professionals are somewhat aking to the Jedi Order as they bring safety to our shared cyberverse.
https://www.youtube.com/
watch?v=bPVaOlJ6ln0&list=PL8dPuuaLjXtNlUrzyH5r6jN9uIIgZBpdo&index=32

Below are some of the early HTML instruction explanations for use on the World Wide Web.

5 The Internet (*continued*)—

Important Note: Section Five is another important section to view in its entirety. Its six episodes thoroughly grounds the viewer in the basics of how the Internet and World Wide Web work together and connect. The segments covering Cyber Security are must watch items as well and we highly recommend!

32.) *Hackers & Cyber Attacks: Crash Course Computer Science #32*, this episode addresses not how one might become a malicious hacker but how the classic methods are employed. Upon finishing the viewer will understand that ignoring to their software, especially the operating system is not in anyone's best interest. Learn the difference between a White Hat, Black Hat, or Hacktivists and the methods employed to protect computer network systems from theft, exploitation, and mayhem through their vulnerabilities. Another must watch episode concerning computing security.
https://www.youtube.com/watch?v=_ GzE99AmAQU&list=PL8dPuuaLjXtNlUrzyH5r6jN9ulIgZBpdo&index=33

33.) *Cryptography: Crash Course Computer Science #33*, with this episode the presentation focuses on cryptography. Since no computer security system in foolproof a Defense in Depth strategy is employed. These many layers are akin to getting to the ruler in their castle. One must "dodge the archers, cross the moat, scale the walls, avoid the hot soil, get over the ramparts, and defeat the guards" (Crash Course Computer Science). Cryptographic processes provide a significant tool set to protect computing systems.
https://www.youtube.com/ watch?v=jhXCTbFnK8o&list=PL8dPuuaLjXtNlUrzyH5r6jN9ulIgZBpdo&index=34
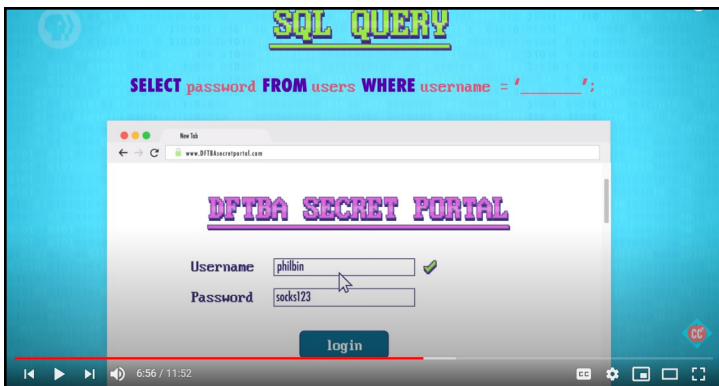
On the left is a Structured Query Language (SQL) security protocol.

On the right is another security measure graphic.

6 Artificial Intelligence—

34.) *Machine Learning & Artificial Intelligence: Crash Course Computer Science #34*, through this episode one understands we are beginning to witness computers that learn through trial and error. This segment gives viewers an understanding of how the essence of machine learning can go beyond storing data to making predictions and decisions about data is coming to pass.
https://www.youtube.com/watch?v=z-EtmaFJieY&list=PL8dPuuaLjXtNlUrzyH5r6jN9ulIgZBpdo&index=35

35.) *Computer Vision: Crash Course Computer Science #35*, for slightly more than fifty years computer scientists have been working to develop visual recognition skills in computers. However, capturing pictures with extreme fidelity is not necessarily the same as having vision. Presented is an overview of how pixel data becomes vision.
https://www.youtube.com/watch?v=-4E2-0sxVUM&list=PL8dPuuaLjXtNlUrzyH5r6jN9ulIgZBpdo&index=36

36.) *Natural Language Processing: Crash Course Computer Science #36*, this subject, N.L.P., combines linguistics and computer science. The viewer gets a journey-person's differentiation between computer languages and natural language. From there the web of semantic information is quickly and simply explained
https://www.youtube.com/watch?v=fOvTtapxa9c&list=PL8dPuuaLjXtNlUrzyH5r6jN9ulIgZBpdo&index=37

37.) *Robots: Crash Course Computer Science #37*, for many in the geospatial world the idea of robots and the use of robotics is not typically considered. After finishing with this segment the expansive use of geolocation potential becomes apparent to the viewer. While not directly addressed geospatial considerations are ever present.
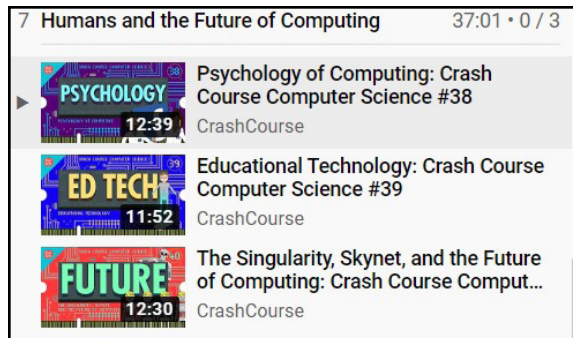https://www.youtube.com/watch?v=3XkL0qQ21Oo&list=PL8dPuuaLjXtNlUrzyH5r6jN9ulIgZBpdo&index=38
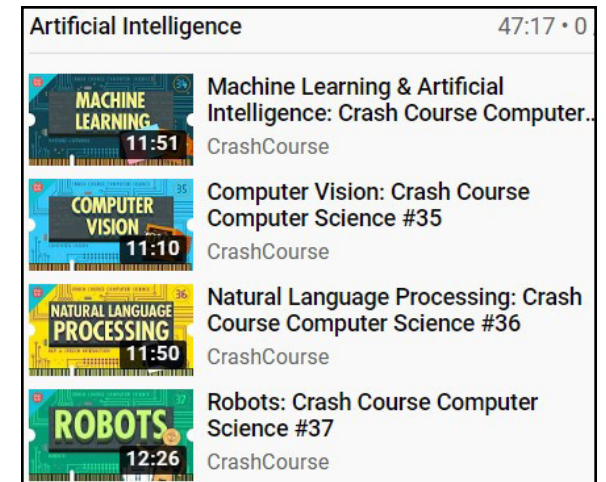
Below is a nearly current robot iteration that demonstrates our move forward in robotics.

7 Artificial Intelligence—

38.) *Psychology of Computing: Crash Course Computer Science #38*, the past segments have focused on computers. In this one the focus shifts to one that examines the social, psychological, and computer resources that turn computers into incredibly useful human tools.
https://www.youtube.com/watch?v=DEHsvQ3Ylwg&list=PL8dPuuaLjXtNlUrzyH5r6jN9ulIgZBpdo&index=39

39.) *Educational Technology: Crash Course Computer Science #39*, provides some statistics that when these episodes were produced in 2017there were 1.3 billion websites and Google alone conducted just over four billion searches with YouTube delivering 3.5 million videos per minute. Some of those searches and videos were for education purposes. This segment covers some strategies that computer science employs for developing computer tools the supplement interactive, in-class, hands-on, and directed conversation learning.
https://www.youtube.com/watch?v=zTi3_l5h5PQ&list=PL8dPuuaLjXtNlUrzyH5r6jN9ulIgZBpdo&index=40

40.) *The Singularity, Skynet, and the Future of Computing: Crash Course Computer Science #40*, in this final episode the viewer is treated to a speculative look at computing of the future. The term singularity was used by John Von Neumann to describe, in the 1950s. This segment suggest the almost limitless potential that exists before human kind with as our computer tools become more powerful. Paul Allen is mentioned with his idea that the singularity can be moderated by a complexity brake. What is important here for the geospatial student and professional is that every tool set is becoming more useful. Soon our computing systems could become ubiquitous and that avenue may become the boon being looked for.
https://www.youtube.com/watch?v=5TNAz1HYg18&list=PL8dPuuaLjXtNlUrzyH5r6jN9ulIgZBpdo&index=41

The screen above is typical of the creative and clever graphics employed throughout this series and its content does not require explanation. What is displayed below is an overall layout of a modern processor.
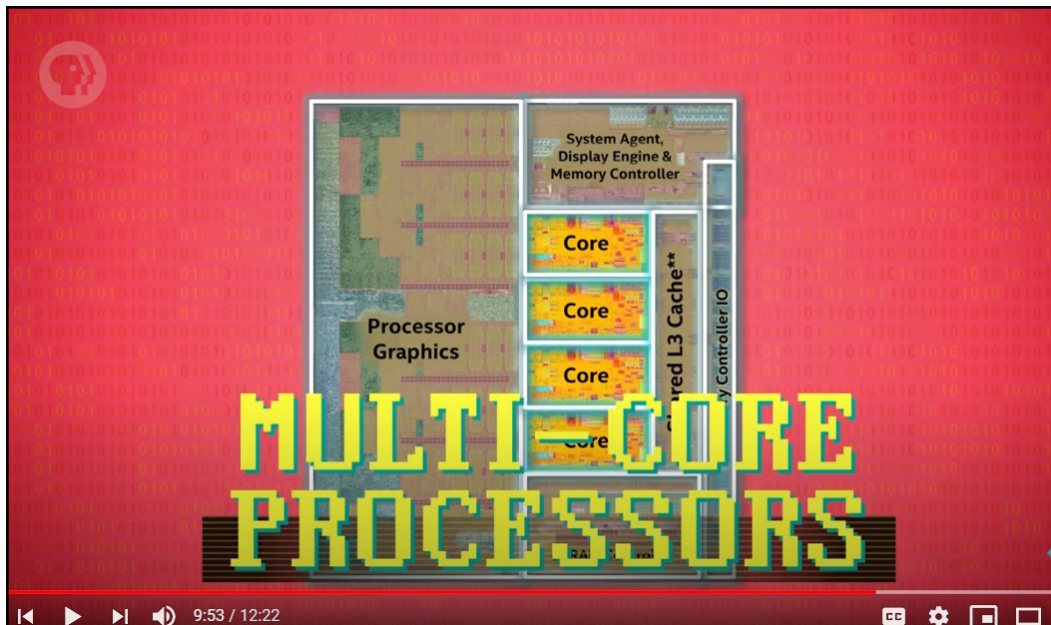

This series was produced for the Public Broadcasting System, PBS, and as the viewer will note released and presented during calendar year 2017. All the graphics presented within this document were captured from the *Crash Course Computer Science* series and those images remain the property of the Public Broadcasting System. The FAST Lab uses them in a fashion consistent with the Doctrine of Fair Use. This Lab and the University of Colorado Denver are not the creators of these graphics.

Our suggestion is as above, that each student take the time during the course of their geospatial studies to watch the series in its entirety. The computers that are the venues for our current panoply of digital tools perform tasks that were incredibly time-consuming even twenty-five to thirty years before 2020. Understanding the basics of Computer Science allows the geospatial data analyst that better understanding which can lead to more productive outcomes.

We at the Facility for Advanced Spatial Technology think geospatial tools can be employed for the betterment of all disciplines. The only limiting factor is one's capacity to think beyond their known and explore the expansive spatial universe that awaits discovery.
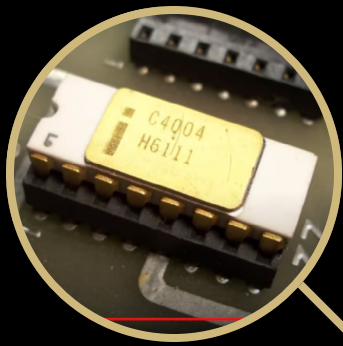
The Facility for Advanced Spatial Technology, FAST Lab, is located on the Auraria Campus, the University of Colorado Denver.
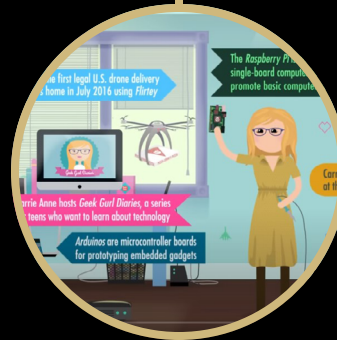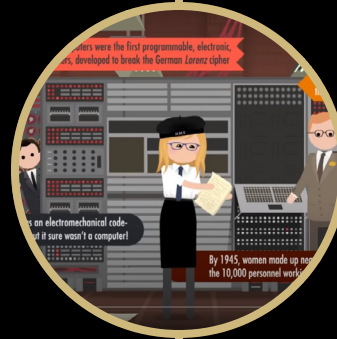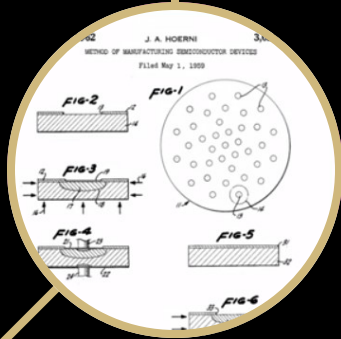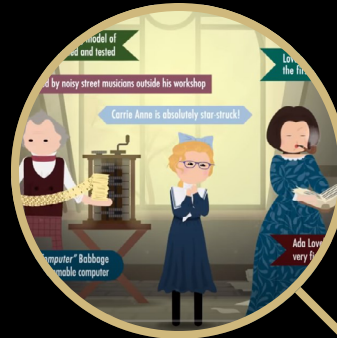
The FAST Lab is open to all University of Colorado Denver Students. It is an interdisciplinary laboratory making geospatial tools readily available for all students within the College of Arts and Sciences, College of Architecture and Planning, College of Engineering and Design Computing, School of Public Affairs, and the School of Education and Human Development. It supports and encourages developing cross-disciplinary geospatial solutions.