



AP Computer Science Principles Course

Instructor Notes

UNIT NOTES: How Computers Work: Computer Architecture and Data Storage.

This unit will cover all of the topics in Computer Science Principles “big ideas” numbers 2 and 3; *Abstraction* and *Data and Information that* would not be covered in the units on *Programming* and *The Internet*. Many of the labs use free software. Here is the list of software in both Windows and Mac versions:

Windows

HxD Hex Editor <https://mh-nexus.de/en/hxd/>

Processing <http://processing.org>

7-zip <http://www.7-zip.org/download.html>

Audacity <http://www.audacityteam.org/download/>

MacIntosh

Hex Editor [iHex](#) (Note that I have been unable to get the *File / Open Drive* command to work for the [Use a hex editor to retrieve deleted data](#) lab)

Processing <http://processing.org>

zip Macs have a built in compression, control click and choose compress

Audacity <http://www.audacityteam.org/download/>

ANSWERS TO PRACTICE QUIZ QUESTIONS

Slide 146: 1. HOW ALIVE — NASA's way of asking Watney how he has survived for nearly 100 Mars days at this point. 2. CROPS? — NASA's wondering how in the world Watney was able to grow food on a planet where that's supposed to be impossible. 3. BRING SJRNR OUT — NASA'S telling Watney to bring the Sojourner rover out near the Pathfinder to try and figure out an easier means of communication.

Slide 147: A (Hexadecimal 11 is 17 in decimal, Binary 00010011 is 19 decimal)

Slide 192: C. Either True or False

Slide 224: A.

Slide 226: A

Slide 234: 1. $25 \times 50 \times 24 = 30,000$ bits. $30,000 / 8 = 3,750$ bytes. 2. Lowering or Raising all the RGB values by the same amount will preserve the color while lightening or darkening the image. For example if you take a color like cyan (0,255,255) and multiply all the values by .7 you will end up with (0,178,178) which will be a darker shade of cyan.

NOTES ON PARTICULAR LABS

Virtual Desktop, Computer Assembly and **Design your own PC** labs: Computer hardware (other than logic gates) is not tested on the AP CSP test. However, many students take computer science to learn more about computers in general. Starting the course with a computer assembly can build excitement. Students are often surprised how easy it is to build a computer or replace a failed component. Understanding computer hardware is also important in the field of computer forensics which we will visit in subsequent labs. School districts often have large numbers of obsolete computers which would be ideal for learning how to take one apart. Instructors should consider contacting their district's IT department to see if any are available.

Movie: Digital Detectives (Documentary on computer forensics in the US dept. of defense): This movie sensationalizes computer forensics with a lot more blood and guns than necessary, so I would recommend that the instructor preview the 47 minute movie. There are many good non-gratuitous scenes of disassembled computers and hard drives, and the classroom scenes where students are being trained in computer forensics are very applicable to the course.

Use a hex editor to retrieve deleted data: Small thumb drives work best for this lab (128Mb is ideal). This is a surprisingly easy lab and can generate a lot of student enthusiasm. To open an entire disk in HxD, Windows may require an administrator password. As a workaround, I've found that if I put a CD or DVD in the computer's optical drive, it doesn't ask for administrator authorization to open an entire thumb drive. Any **non-blank** CD or DVD should work.

File Carving: Make sure your students start by downloading the pictures from the internet using the links in the assignment. Also, when editing the files, precision is paramount. Recommendation is to click on the beginning or ending of the region you want to delete and then shift clicking on the other end. Because we are deleting large amounts of data in this lab, it's easy to be just a little off if you are clicking and dragging.

	Lab and/or Activity	PowerPoint slides	Enduring Understanding	Learning Objective	Computational Thinking Practice	Essential Knowledge
1-2	Virtual Desktop Lab and Answer key	1 - 39	2.3 Models and simulations use abstraction to generate new understanding and knowledge	2.3.1 Use models and simulations to represent phenomena 2.3.2 Use models and simulations to formulate, refine and test hypothesis	P3 Abstracting P2 Creating computational artifacts P1 Connecting computing P4 Analyzing problems and artifacts P5 Communicating	2.3.1A 2.3.1B 2.3.1C 2.3.1D 2.3.2A 2.3.2B 2.3.2C 2.3.2D 2.3.2E 2.3.2F 2.3.2G 2.3.2H
3-5	Computer Assembly Lab	40-63	2.2 Multiple levels of abstraction are used to write programs or to create other computational artifacts	2.2.3 Identify multiple levels of abstractions that are used when writing programs	P6 collaborating	2.2.3E 2.2.3G 2.2.3H 2.2.3I
6	Design your own PC	65 - 96	2.3 Models and simulations use abstraction to generate new understanding and knowledge	2.3.1 Use models and simulations to represent phenomena 2.3.2 Use models and simulations to formulate, refine and test hypothesis	P3 Abstracting P2 Creating computational artifacts P1 Connecting computing P4 Analyzing problems and artifacts	2.3.1A 2.3.1B 2.3.1C 2.3.1D 2.3.2A 2.3.2B 2.3.2C 2.3.2D 2.3.2E 2.3.2F 2.3.2G 2.3.2H

7	Binary Game	97-115	2.1 A variety of abstractions built upon binary sequences can be used to represent all digital data	2.1.1 Describe the variety of abstractions used to represent data	P3 Abstracting	2.1.1A 2.1.1B 2.1.1C 2.1.1D 2.1.1E 2.1.1G
8	Bits, Bytes and File Sizes (code.org)	116 - 122	2.1 A variety of abstractions built upon binary sequences can be used to represent all digital data 3.3 There are trade offs when representing information as digital data	2.1.1 Describe the variety of abstractions used to represent data 3.3.1 Analyze how data representation, storage, security and transmission of data involve computational manipulation of information	P4 Analyzing problems and artifacts	2.1.1A 2.1.1B 2.1.1C 2.1.1D 2.1.1E 3.3.1A 3.3.1G 3.3.1H
9	Encoding Hexadecimal Numbers (code.org)	123 - 141	2.1 A variety of abstractions built upon binary sequences can be used to represent all digital data	2.1.1 Describe the variety of abstractions used to represent data 2.1.2 Explain how binary sequences are used to represent digital data	P3 Abstracting P4 Analyzing problems and artifacts	2.1.1A 2.1.1B 2.1.1C 2.1.1D 2.1.1E 2.1.1F 2.1.1G
10	Hexadecimal in The Martian	142 - 147	2.1 A variety of abstractions built upon binary sequences can be used to represent all digital data	2.1.1 Describe the variety of abstractions used to represent data 2.1.2 Explain how binary sequences are used to represent digital data	P3 Abstracting P4 Analyzing problems and artifacts	2.1.1A 2.1.1B 2.1.1C 2.1.1D 2.1.1E 2.1.1F 2.1.1G 2.1.2D 2.1.2E 2.1.2F

11	Movie: Digital Detectives (Documentary on computer forensics in the US dept. of defense)	148	<p>2.1 A variety of abstractions built upon binary sequences can be used to represent all digital data</p> <p>3.2 Computing facilitates exploration and the discovery of connections in information</p> <p>3.3 There are tradeoffs when representing information as digital data</p>	<p>2.1.1 Describe the variety of abstractions used to represent data</p> <p>2.1.2 Explain how binary sequences are used to represent digital data</p> <p>3.2.1 Extract information from data to discover and explain connections or trends</p> <p>3.2.2 Determine how large data sets impact the use of computational processes to discover information and knowledge</p> <p>3.3.1 Analyze how data representation, storage, security and transmission of data involve computational manipulation of information</p>	<p>P3 Abstracting</p> <p>P1 Connecting computing</p> <p>P4 Analyzing problems and artifacts</p> <p>P6 Collaborating</p>	<p>2.1.1A</p> <p>2.1.1B</p> <p>2.1.1C</p> <p>2.1.1D</p> <p>2.1.1E</p> <p>2.1.1F</p> <p>2.1.2D</p> <p>2.1.2E</p> <p>2.1.2F</p> <p>3.2.1A</p> <p>3.2.1B</p> <p>3.2.1C</p> <p>3.2.1D</p> <p>3.2.1E</p> <p>3.2.2A</p> <p>3.2.2B</p> <p>3.2.2C</p> <p>3.2.2D</p> <p>3.2.2G</p> <p>3.3.1A</p> <p>3.3.1G</p> <p>3.3.1H</p>
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12	Use a hex editor to retrieve deleted data	149-156	<p>2.1 A variety of abstractions built upon binary sequences can be used to represent all digital data</p> <p>3.2 Computing facilitates exploration and the discovery of connections in information</p> <p>3.3 There are tradeoffs when representing information as digital data</p>	<p>2.1.1 Describe the variety of abstractions used to represent data</p> <p>2.1.2 Explain how binary sequences are used to represent digital data</p> <p>3.2.1 Extract information from data to discover and explain connections or trends</p> <p>3.2.2 Determine how large data sets impact the use of computational processes to discover information and knowledge</p> <p>3.3.1 Analyze how data representation, storage, security and transmission of data involve computational manipulation of information</p>	<p>P3 Abstracting</p> <p>P1 Connecting computing</p> <p>P4 Analyzing problems and artifacts</p>	<p>2.1.1A</p> <p>2.1.1B</p> <p>2.1.1C</p> <p>2.1.1D</p> <p>2.1.1E</p> <p>2.1.1F</p> <p>2.1.1G</p> <p>2.1.2D</p> <p>2.1.2E</p> <p>2.1.2F</p> <p>3.2.1A</p> <p>3.2.1B</p> <p>3.2.1C</p> <p>3.2.1D</p> <p>3.2.1E</p> <p>3.2.1F</p> <p>3.2.2A</p> <p>3.2.2B</p> <p>3.2.2C</p> <p>3.2.2D</p> <p>3.2.2G</p> <p>3.3.1A</p> <p>3.3.1G</p> <p>3.3.1H</p>
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13	Computer Forensics Lab and Key	157-170	<p>2.1 A variety of abstractions built upon binary sequences can be used to represent all digital data</p> <p>3.2 Computing facilitates exploration and the discovery of connections in information</p> <p>3.3 There are tradeoffs when representing information as digital data</p>	<p>2.1.1 Describe the variety of abstractions used to represent data</p> <p>2.1.2 Explain how binary sequences are used to represent digital data</p> <p>3.2.1 Extract information from data to discover and explain connections or trends</p> <p>3.2.2 Determine how large data sets impact the use of computational processes to discover information and knowledge</p> <p>3.3.1 Analyze how data representation, storage, security and transmission of data involve computational manipulation of information</p>	<p>P3 Abstracting</p> <p>P1 Connecting computing</p> <p>P4 Analyzing problems and artifacts</p>	<p>2.1.1A</p> <p>2.1.1B</p> <p>2.1.1C</p> <p>2.1.1D</p> <p>2.1.1E</p> <p>2.1.1F</p> <p>2.1.1G</p> <p>2.1.2D</p> <p>2.1.2E</p> <p>2.1.2F</p> <p>3.2.1A</p> <p>3.2.1B</p> <p>3.2.1C</p> <p>3.2.1D</p> <p>3.2.1E</p> <p>3.2.1F</p> <p>3.2.2A</p> <p>3.2.2B</p> <p>3.2.2C</p> <p>3.2.2D</p> <p>3.2.2G</p> <p>3.3.1A</p> <p>3.3.1G</p> <p>3.3.1H</p>
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14	Overflow Lab and Key	171-187	2.1 A variety of abstractions built upon binary sequences can be used to represent all digital data 3.3 There are tradeoffs when representing information as digital data 5.5 Programming uses mathematical and logical concepts	2.1.2 Explain how binary sequences are used to represent data 3.3.1 Analyze how data representation, storage, security and transmission of data involve computational manipulation of information 5.5.1 Employ appropriate mathematical and logical concepts to programming	P3 Abstracting P4 Analyzing problems and artifacts P5 Communicating	2.1.2A 2.1.2B 2.1.2C 2.1.2D 2.1.2F 3.3.1A 3.3.1G 5.5.1B
15	Logic Gates in Logic.ly and Key	188-194	2.2 Multiple levels of abstraction are used to write programs or to create other computational artifacts 5.5 Programming uses mathematical and logical concepts	2.2.3 Identify multiple levels of abstractions being used when writing programs 5.5.1 Employ appropriate mathematical and logical concepts in programming	P3 Abstracting P1 Connecting computing	2.2.3E 2.2.3F 5.5.1E 5.5.1F 5.5.1G

16	Decode this Message and Text Compression (code.org)	195-202	<p>2.1 A variety of abstractions built upon binary sequences can be used to represent all digital data</p> <p>2.2 Multiple levels of abstraction are used to write programs or to create other computational artifacts</p> <p>3.1 People use computer programs to process information to gain insight and knowledge</p> <p>3.3 There are tradeoffs when representing information as digital data</p> <p>4.2 Algorithms can solve many, but not all computational problems</p>	<p>2.1.1 Describe the variety of abstractions used to represent data</p> <p>2.2.1 Develop an abstraction when writing a program or creating other computational artifacts</p> <p>Use models and simulations to represent phenomena</p> <p>2.3.2 Use models and simulations to formulate, refine and test hypothesis</p> <p>3.1.1 Find patterns and test hypotheses about digitally processed information to gain insight and knowledge</p> <p>3.1.3 Explain the insight and knowledge gained from digitally processed data by using appropriate visualizations, notations, and precise language</p>	<p>P3 Abstracting</p> <p>P1 Connecting computing</p>	<p>2.1.1A</p> <p>2.1.1C</p> <p>2.2.1A</p> <p>2.2.1B</p> <p>2.3.2A</p> <p>2.3.2C</p> <p>2.3.2D</p> <p>2.3.2F</p> <p>3.1.1D</p> <p>3.1.1E</p> <p>3.1.3A</p> <p>3.1.3C</p> <p>3.1.3E</p> <p>3.3.1A</p> <p>3.3.1G</p> <p>4.2.3A</p> <p>4.2.3B</p> <p>4.2.3C</p>
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				<p>3.3.1 Analyze how data representation, storage, security and transmission of data involve computational manipulation of information</p> <p>4.2.2 Explain the difference between solvable and unsolvable problems in computer science</p> <p>4.2.3 Explain the existence of undecidable problems in computer science</p>		
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17	.zip Compression Lab and Key	201-206	<p>2.1 A variety of abstractions built upon binary sequences can be used to represent all digital data</p> <p>2.2 Multiple levels of abstraction are used to write programs or to create other computational artifacts</p> <p>3.1 People use computer programs to process information to gain insight and knowledge</p> <p>3.2 Computing facilitates exploration and the discovery of connections in information</p> <p>3.3 There are tradeoffs when representing information as digital data</p>	<p>2.1.1 Describe the variety of abstractions used to represent data</p> <p>2.2.3 Identify multiple levels of abstractions being used when writing programs</p> <p>3.1.1 Find patterns and test hypotheses about digitally processed information to gain insight and knowledge</p> <p>3.2.1 Extract information from data to discover and explain connections or trends</p> <p>3.3.1 Analyze how data representation, storage, security and transmission of data involve computational manipulation of information</p>	<p>P3 Abstracting</p> <p>P4 Analyzing problems and artifacts</p>	<p>2.1.1A</p> <p>2.1.1C</p> <p>2.1.1D</p> <p>2.1.1E</p> <p>2.1.1G</p> <p>2.2.3D</p> <p>2.2.3E</p> <p>2.2.3K</p> <p>3.1.1B</p> <p>3.1.1D</p> <p>3.1.1E</p> <p>3.2.1D</p> <p>3.2.1E</p> <p>3.3.1C</p> <p>3.3.1D</p> <p>3.3.1E</p>
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18	File Carving Lab and Key	207-212	<p>2.1 A variety of abstractions built upon binary sequences can be used to represent all digital data</p> <p>2.2 Multiple levels of abstraction are used to write programs or to create other computational artifacts</p> <p>3.3 There are tradeoffs when representing information as digital data</p>	<p>2.1.2 Explain how binary sequences are used to represent data</p> <p>2.2.3 Identify multiple levels of abstractions being used when writing programs</p> <p>3.3.1 Analyze how data representation, storage, security and transmission of data involve computational manipulation of information</p>	<p>P3 Abstracting</p> <p>P4 Analyzing problems and artifacts</p> <p>P1 Connecting computing</p>	<p>2.1.2D</p> <p>2.1.2E</p> <p>2.1.2F</p> <p>2.2.3D</p> <p>2.2.3E</p> <p>2.2.3K</p> <p>3.3.1C</p> <p>3.3.1D</p> <p>3.3.1E</p> <p>3.3.1F</p> <p>3.3.1G</p>
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19	B&W Pixelation Widget (code.org)	213 - 218	<p>2.1 A variety of abstractions built upon binary sequences can be used to represent all digital data</p> <p>2.2 Multiple levels of abstraction are used to write programs or to create other computational artifacts</p> <p>3.2 Computing facilitates exploration and the discovery of connections in information</p> <p>3.3 There are tradeoffs when representing information as digital data</p>	<p>2.1.1 Describe the variety of abstractions used to represent data</p> <p>2.1.2 Explain how binary sequences are used to represent data</p> <p>2.2.1 Develop an abstraction when writing a program or creating other computational artifacts</p> <p>2.2.3 Identify multiple levels of abstractions being used when writing programs</p> <p>3.2.1 Extract information from data to discover and explain connections or trends</p> <p>3.3.1 Analyze how data representation, storage, security and transmission of data involve computational manipulation of information</p>	<p>P3 Abstracting</p> <p>P4 Analyzing problems and artifacts</p> <p>P1 Connecting computing</p>	<p>2.1.1A</p> <p>2.1.1B</p> <p>2.1.1C</p> <p>2.1.1D</p> <p>2.1.1E</p> <p>2.1.1F</p> <p>2.1.1G</p> <p>2.1.2D</p> <p>2.2.3D</p> <p>3.2.1G</p> <p>3.2.1H</p> <p>3.2.1I</p> <p>3.3.1A</p> <p>3.3.1C</p> <p>3.3.1D</p>
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20	Metadata in .mp3 Files and Key	219-225	<p>2.1 A variety of abstractions built upon binary sequences can be used to represent all digital data</p> <p>2.2 Multiple levels of abstraction are used to write programs or to create other computational artifacts</p> <p>3.2 Computing facilitates exploration and the discovery of connections in information</p>	<p>2.1.1 Describe the variety of abstractions used to represent data</p> <p>2.1.2 Explain how binary sequences are used to represent data</p> <p>2.2.3 Identify multiple levels of abstractions being used when writing programs</p> <p>3.2.1 Extract information from data to discover and explain connections or trends</p>	<p>P3 Abstracting</p> <p>P4 Analyzing problems and artifacts</p>	<p>2.1.1A</p> <p>2.1.1B</p> <p>2.1.1C</p> <p>2.1.1D</p> <p>2.1.1E</p> <p>2.1.1F</p> <p>2.1.1G</p> <p>2.1.2D</p> <p>2.2.3D</p> <p>3.2.1G</p> <p>3.2.1H</p> <p>3.2.1I</p>
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21	Encoding Color Images Lab (code.org)	226-232	<p>2.1 A variety of abstractions built upon binary sequences can be used to represent all digital data</p> <p>2.2 Multiple levels of abstraction are used to write programs or to create other computational artifacts</p> <p>3.2 Computing facilitates exploration and the discovery of connections in information</p> <p>3.3 There are tradeoffs when representing information as digital data</p>	<p>2.1.1 Describe the variety of abstractions used to represent data</p> <p>2.1.2 Explain how binary sequences are used to represent data</p> <p>2.2.1 Develop an abstraction when writing a program or creating other computational artifacts</p> <p>2.2.3 Identify multiple levels of abstractions being used when writing programs</p> <p>3.2.1 Extract information from data to discover and explain connections or trends</p> <p>3.3.1 Analyze how data representation, storage, security and transmission of data involve computational manipulation of information</p>	<p>P3 Abstracting</p> <p>P4 Analyzing problems and artifacts</p> <p>P1 Connecting computing</p>	<p>2.1.1A</p> <p>2.1.1B</p> <p>2.1.1C</p> <p>2.1.1D</p> <p>2.1.1E</p> <p>2.1.1F</p> <p>2.1.1G</p> <p>2.1.2D</p> <p>2.2.3D</p> <p>3.2.1G</p> <p>3.2.1H</p> <p>3.2.1I</p> <p>3.3.1A</p> <p>3.3.1C</p> <p>3.3.1D</p>
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22	Personal Favicon Project (code.org)	233 - 234	2.2 Multiple levels of abstraction are used to write programs or to create other computational artifacts	2.2.1 Develop an abstraction when writing a program or creating other computational artifacts	P3 Abstracting P2 Creating computational artifacts P1 Connecting computing P5 Communicating	2.2.3A 2.2.1B
23	Lossy Text Compression and File Formats Lab (code.org)	235 - 238	2.1 A variety of abstractions built upon binary sequences can be used to represent all digital data 2.2 Multiple levels of abstraction are used to write programs or to create other computational artifacts 3.2 Computing facilitates exploration and the discovery of connections in information 3.3 There are tradeoffs when representing information as digital data	2.1.1 Describe the variety of abstractions used to represent data 2.2.3 Identify multiple levels of abstractions being used when writing programs 3.2.1 Extract information from data to discover and explain connections or trends 3.3.1 Analyze how data representation, storage, security and transmission of data involve computational manipulation of information	P3 Abstracting P4 Analyzing problems and artifacts P1 Connecting computing	2.1.1A 2.1.1C 2.1.1D 2.1.1E 2.1.1G 2.2.3D 2.2.3E 3.2.1E 3.3.1A 3.3.1C 3.3.1E 3.3.1G